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Matthias Rehm
Jelle Saldien
Stefania Manca *Editors*

Project and Design Literacy as Cornerstones of Smart Education

Proceedings of the 4th International Conference on Smart Learning Ecosystems and Regional Development

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Preface

We are proud to present the proceedings of the Fourth International Conference on Smart Learning Ecosystems and Regional Developments (SLERD 2019). Following a successful first edition in the East of Europe—Timisoara, Romania (2016)—a second edition in the West—Aveiro, Portugal (2017)—and a third edition in the North—Aalborg, Denmark (2018)—the fourth edition was in the South—Rome, Italy (2019)—covering all four cardinal points of the old continent. This fourth edition was co-organized by ASLERD, in collaboration with the Institute of Educational Technology of the National Research Council of Italy, Quasar Design University, ISIA Rome, and the University of Rome Tor Vergata's SPFS Department with the endorsement of the Ph.D. program in cultural heritage, learning and territory, in May 22–24, 2019.

The conference welcomed researchers and practitioners from all over the world involved in the development of smart learning ecosystems, as engines of social innovation and territorial development. At the core, the adjective smart comprises terms like intelligent, purpose oriented, supportive, artful, clever and the like. Thus, smart does not necessarily include the usage of technology (neither does it exclude technology!). Smart is referred to learning ecosystems in ASLERD and SLERD contexts and, thus, does not simply mean "technology enhanced" (to include expert systems or AI). The smartness is a more complex multilayered construct related to the well-being of the players operating in the ecosystems that hopefully are also in relation to the territory (see Declaration of Timisoara, the Wikipedia page of ASLERD[1], the proceedings of the previous SLERD conferences published by Springer and the special issues (N.16, N.17, N.20, N.27, N.31, N.35 and N.39 in preparation) devoted to SLERD by IxD&A Journal). Smartness is affected by the improvement of any relevant aspects of the learning processes and ecosystem functioning, especially if connected with territorial development and social innovation. Technologies are in this sense mediators. Hopefully, they should be included but they are not a "sine qua non".

[1] https://en.wikipedia.org/wiki/ASLERD

The achievement of the learning ecosystems' smartness is a process that needs a long-term vision, multidisciplinary competences, an attitude to understand people and contexts and to mediate point of views and a dynamic resilience to keep on track to achieve, step by step, the foreseen goals: in short, a design literacy from which emerge projects and processes capable to reify them, all aimed at achieving a people-centered smart education, social innovation and territorial development.

Overall, we received 31 unique submissions from 18 countries, demonstrating the global interest for this research area and for the SLERD 2019 conference. Out of the total submissions, after a rigorous double-blind peer review and meta-review process, we accepted 12 full papers and 7 short papers. Additionally, we included five extended abstracts to show the breadth of the work in this research community. To complement the oral presentations of the papers, the SLERD 2019 program also included presentations of the best ideas from the 2019 international and local student contests (not included in these proceedings). These competitions challenged local and international students to propose ideas and proofs of concept/prototypes to make learning ecosystems smarter. The selected scientific papers aim to understand, conceive and promote innovative human-centric design and development methods, education/training practices, informal social learning and citizen-driven policies. The papers are organized mirroring the main conference sessions in six themes, namely (1) the virtue of design and that of technological environments; (2) schools: evaluation and design; (3) toward future technological tools and environments; (4) learning ecosystems and regional development; (5) schools: technologies and contexts; and (6) disabilities and interaction. SLERD 2019 contributes to foster the social innovation sectors, identifying and discussing ICT and economic development and deployment strategies alongside new policies for smarter proactive citizens. The proceedings are relevant to both researchers and policy makers. In summary, SLERD 2019 offered an exciting program that provided an excellent overview of the state of the art in smart learning ecosystems and was an occasion for bringing research forward and creating new networks. We are very proud of the final selection of papers, which would not have been possible without the effort and support of our excellent Conference and Program Committees, including more than 50 international researchers. We would like to thank all the ones who, in different roles, have contributed their time to organize the event with enthusiasm and commitment.

Aalborg, Denmark — Matthias Rehm
Ghent, Belgium — Jelle Saldien
Genoa, Italy — Stefania Manca
April 2019

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About the Editors

Dr. Matthias Rehm received his Diploma and Doctoral degrees (with honors) in 1998 and 2001, respectively, from the Bielefeld University in Germany. In 2008, he successfully completed his habilitation process in Informatics at the University of Augsburg in Germany. He is the Head of the Human–Machine Interaction Group in the Department of Architecture, Design, and Media Technology and will be leading the upcoming cross-departmental Human Centered Robot Interaction Lab at the Technical Faculty of IT and Design at Aalborg University. His research is focused on modeling social, affective, and cultural aspects of everyday behavior for intuitive human–machine interactions. He has over 100 peer-reviewed publications in the area of robotics, HCI, technology-enhanced learning, multimodal interaction, and culture-aware technology. In 2010, he became founding and steering group member of Aalborg University's cross-departmental robotics program Aalborg U Robotics. In 2014, he co-founded an international, Canadian-based startup that is actively pushing the limits in smart learning technologies. In 2015, he was elected vice president for the International Association for Smart Learning Ecosystems and Regional Development.

Dr. Jelle Saldien is an Associate Professor in the Department of Industrial Systems Engineering and Product Design of the Faculty of Engineering and Architecture at Ghent University, Belgium. He received his M.S. degree in Industrial Science ICT at DeNayer Institute (now KULeuven) in 2003 and an additional M.S. degree in Product Development at Artesis (now UAntwerpen) in 2005. In 2009, he received his Ph.D. at the Vrije Universiteit Brussel on the design and development of the social robot Probo. From 2010, he was lecturer in Industrial Design at the Howest University College West Flanders. Since 2013, he is appointed as a Professor of Industrial Design at Ghent University, research coordinator of the UGent Industrial Design Center, and from 2014–2017 steering member of Flanders Make VD4. Jelle Saldien is author of over 60 technical

publications, proceedings, editorials, and books. He is member of the program committee of the ACM SIGCHI International Conference on Tangible, Embedded and Embodied Interaction (TEI). His research looks at the design of interactions between human and product (Interaction Design).

Dr. Stefania Manca is a researcher at the Institute of Educational Technology of the National Research Council of Italy. She has been active in the field of educational technology, technology-based learning, distance education, and e-learning since 1995. She is currently investigating the value of social media and social networking sites for formal and informal learning purposes and in teachers' and faculty staff's professional development. She is also involved in the analysis of participatory practices in formal contexts of learning according to the Student Voice approach, and in the use of social network site use by persons with disabilities. Among her research interests, there are also MOOCs, pedagogical approaches to learning analytics and big data. She has published numerous articles on these topics and given presentations in conferences. She is member of several journal scientific committees, editorial boards, and co-director of the Italian Journal of Educational Technology, one of the most highly ranked Italian journals in this area.

Part I
Invited Contribution

Chapter 1
Educating the Next Generation of Social Innovators. *Lessons Learnt from a Series of Experimental Service Design Studios at the School of Design—Politecnico di Milano*

Daniela Selloni

Abstract This contribution is about the connection between design research and education in the field of social innovation. In the last years, as researchers within the POLIMI DESIS Lab, we organised the service design studios held within the Master Degree in Product-Service System Design as a part of our research projects. These studios, in which we mainly teach service design and co-design methods and tools, were characterised by a strong connection with the local context, including activities such as citizen engagement and involvement of important stakeholders, such as the Municipality of Milan. Named 'City Service Hubs' and 'A resilient city', these studios represented an opportunity to experiment with students' alternative ways of organising the daily life in the city of Milan, simulating within the protected environment of education new possible modalities in which social innovation can start.

1.1 Social Innovation and Design

The idea of social innovation has become highly popular in recent years, raising the interest of numerous diverse actors, from policymakers to economic leaders, researchers and academics.

Today, social innovation is considered a possible solution to tackle the most pressing challenges of our era, but this popularity also caused a stress of the notion, stretching social innovation in so many directions that it is at breaking point [6]. Additionally, the rapid spread of the idea of social innovation has generated multiple conceptualisations, extending its semantic field and enlarging its definition, which is open to a variety of interpretations.

In this introductory paragraph, we consider a comprehensive definition of social innovation outlined within the TEPSIE research in 2012: 'social innovations are new

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solutions (products, services, models, markets, processes etc.) that simultaneously meet a social need (more effectively than existing solutions) and lead to new or improved capabilities and relationships and better use of assets and resources. In other words, social innovations are both good for society and enhance society's capacity to act' [3, p. 18].

More specifically, in this introduction, we intend to draw attention to the connections between social innovation and the design discipline: among the methods and tools applied in the field of social innovation, those related specifically to design bring a relevant contribution. In his speech at the 'Social Innovation Exchange Conference' held in 2009, Geoff Mulgan, identified possible strengths and weaknesses in applying design to social innovation. He highlighted some positive elements such as the adoption of systemic thinking and of a user-centred approach, the ability in using visualisation and rapid prototyping techniques and the capacity of bringing new perspectives and clarifying concepts. Among the negative aspects, he identified an insufficient understanding about economic and organisational issues and lack of skills in the implementation phase.

Another pioneering contribution in applying design to social innovation comes from the British Design Council's RED: since 2004, they highlighted the importance of tackling social and economic issues by using design-led innovation.

In the USA, Tim Brown and Jocelyn Wyatt (both from IDEO, the well-known global innovation and design firm) in their article 'Design thinking for social innovation' focused attention on the ability of design thinking to work on what we may call the edges, the places where 'extreme people live differently, think differently, and consume differently' [2, p. 32]. In other words, they conceive design as a powerful means to support social innovation, in order to answer systemic problems with systemic solutions.

In Italy, one of the earliest examples of design for social innovation is the work done by the author's research group POLIMI DESIS Lab at Politecnico di Milano, where Ezio Manzini founded the network DESIS several years ago. This is an international network of design researchers and design schools interested in design for social innovation and sustainability. In his article 'Making Things Happen: Social Innovation and Design' (2014), Manzini provides a definition of design for social innovation as a new field for design activities. He states that designers must use their skills to support promising cases of social innovation and make them more visible by designing their products, services and communication programmes, and therefore support their growing. Manzini identifies a set of new approaches, methods and tools that are transversal and range from product to service design, from communication to interior design, and from interaction to strategic design. More specifically, he points out that service design and strategic design are central when dealing with social innovation, because they focus on the quality of interactions and on the creation of promising partnerships. In addition, Manzini gives particular emphasis to the connection between social innovation and participatory design (as conceived by the Scandinavian school of Ehn and his colleagues at Malmö University), as they are both pluralistic processes adopting consensus-building methodologies and

running complex co-design activities based on the use of design artefacts (prototypes, mock-ups, design games, etc.).

Therefore, design for social innovation is not a new discipline, but it is 'a constellation of design initiatives geared to making social innovation more probable, effective, long-lasting and apt to spread' [10, p. 60].

Since the first experimentation in this field, many things have changed: in 2015, Manzini wrote the book, 'Design, when everybody designs', an actual introduction to design for social innovation in which he distinguishes two forms of design [9]. One is 'diffused design' performed by everybody, and the other is 'expert design', performed by those who have been trained as designers: he points out that these two forms of design should interact and that design experts should support relevant social changes, identifying a promising field of application for design experts in the coming years.

1.2 Social Innovation Process as a Part of a Design Educational Path

In this paragraph, we describe the social innovation process as a possible part of a design educational path.

We will start briefly summarising the well-known social innovation process in six stages conceived by researchers from The Young Foundation in 'The Open Book of Social Innovation' [15].

These six steps are:

1. Prompts—which highlight the need for social innovation;
2. Proposals—where ideas are developed;
3. Prototyping—where ideas get tested in practice;
4. Sustaining—when the idea becomes everyday practice;
5. Scaling—growing and spreading social innovations;
6. Systemic change—involves redesigning and introducing entire systems and will usually involve all sectors over time.

These phases are not strictly chronological, rather iterative and often overlap, as social innovation processes are not linear, but filled with inferences. In addition, they hardly reach the last stage of systemic change (Fig. 1.1).

Besides the well-known social innovation process developed by The Young Foundation, there are other conceptualisations, such as the so-called Social Innovation Journey outlined by Meroni et al. [11, 12]: a methodological path elaborated for the incubation of social innovation, envisaged to offer a simple and customisable professional tool to practitioners. The various phases are intended as steps of the development of social innovation, indicating the degree of evolution and implementation of the idea.

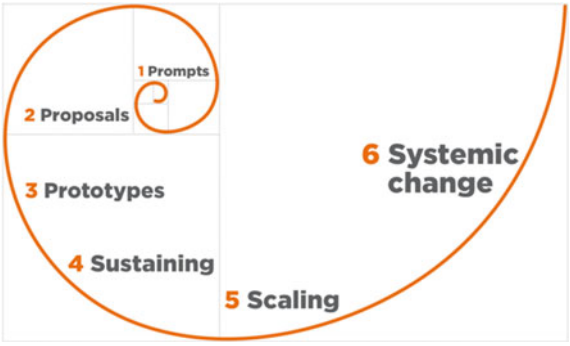

Fig. 1.1 Six stages of the social innovation process from the 'The Open Book of Social Innovation' [15]

In its first draft developed in 2013, the Social Innovation Journey was presented as a sort of action format of design for social innovation, a progressive path to engage a community and support it in developing and prototyping a possible social innovation.

The sequence of nonlinear stages was the following:

1. Raise awareness—a phase of engagement and activation of potential social innovators at a local scale, in which they raise awareness about the possibility of developing their ideas through the design approach.
2. Identify a topic for action—a stage in which a specific object of interest is identified, it can emerge directly from the community or as a stimulation on the part of designers and/or other local actors.
3. Involve proactive people and experts—a step to identify the most proactive agents of the community framing a promising scenario to build consensus and to become attractive for potential stakeholders.
4. Generate and select ideas—in this stage a set of concepts are elaborated in the form of opportunities to be further developed with a broader community of stakeholders. It is a first co-design step.
5. Define timing, roles and exit strategy—this phase is essential to draft an action plan for the possible solution, meaning to roughly identify resources, actors, expertise, time span and possible exit strategy of designers.
6. Co-design with broader communities—a stage in which multiple co-design sessions are organised with a variety of stakeholders and citizens in order to ignite a 'social conversation' about the ideas and get inputs back.
7. Develop the solution: roles and rules—after the co-design phase, the action plan is validated and/or modified and the main elements of the solutions are designed, both hardware (i.e. spaces and objects) and software (i.e. tools, platforms and rules to be followed).
8. Produce an event-like prototype—in this step, the local community is involved in testing the solution, creating both functional and emotional engagement of a broader audience.
9. Take it to an incubator—this is not a mandatory phase, but it is needed when the solution has business potential and the group of innovators is keen to move in this

direction. The venture might then take the form of a social enterprise (Figs. 1.2 and 1.3).

The Social Innovation Journey described by Meroni et al. [11, 12] presents other further steps that are related to typical incubation processes (re-engine the solution, model the business, start up the enterprise and replicate the solution), and it has also been reshaped within the framework of the EU project Transition ('Transnational Network for Social Innovation Incubation', a project to support the scaling-up of social innovations across Europe by developing a network of incubators).

For the purposes of this article, we mainly consider the first draft of the Social Innovation Journey in which the stress is on the initial stages, conceived as a part of an action format that adopts design methods and tools.

In the same way, we focus our attention in the first three stages of the social innovation process developed by The Young Foundation and previously summarised, which mainly deal with identifying problems and framing questions, generating ideas and prototyping solutions, leaving aside the other steps related to the implementation of social innovation.

There are some common features in the initial stages of both paths, which may be clustered into three main macrophases:

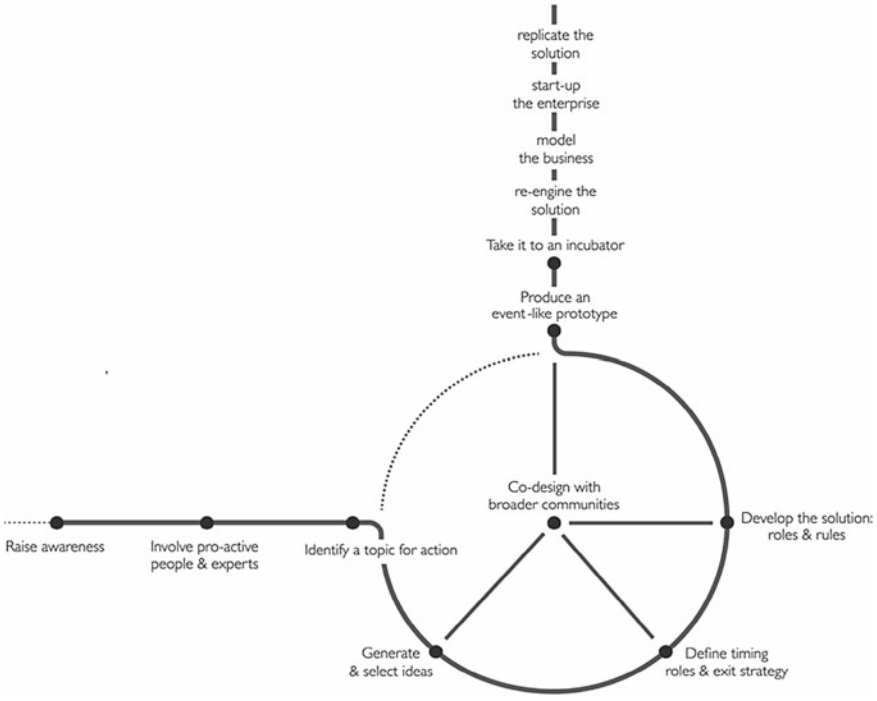

Fig. 1.2 First version of the Social Innovation Journey conceived by Meroni et al. [12]

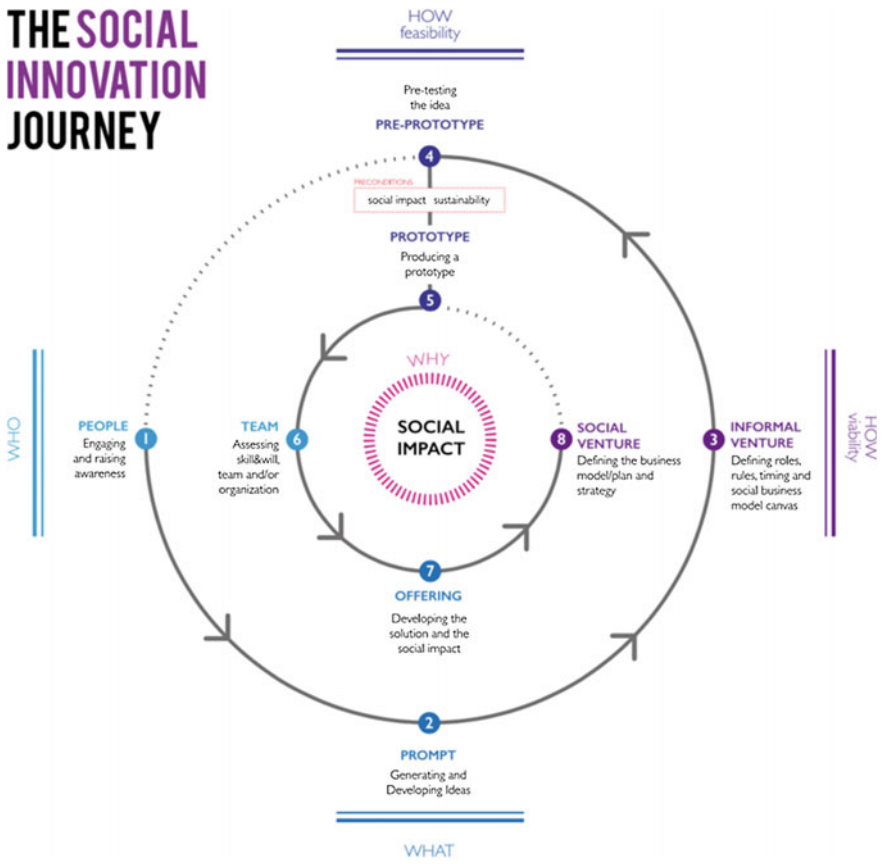

Fig. 1.3 Final version of the Social Innovation Journey retrieved from the website of the EU project transition (transitionproject.eu)

1. Understanding the topic and framing the opportunity—which mainly corresponds to prepare the ground, analyse a context, raise awareness, identify relevant actors, connect with a community and focus on a specific issue.
2. Generating ideas and co-design with diverse actors—which means to use design methods and tools to generate shared meanings and activate creative social conversations with a wide range of stakeholders, experts and citizens.
3. Developing and prototyping solutions—which coincides with designing the main elements of the solution (both hardware and software) and to test them in an event-like prototype or other types of participatory prototypes to reach a broader audience.

These three macrophases may be viewed as the beginning of a possible social innovation (as they exclude the implementation stage) and, at the same time, they represent an action design format that can guide further initiatives, in which design

research and education may be combined, activating the students' creativity in exploring new areas and/or generating ideas that enrich a specific research field.

At POLIMI DESIS Lab, we usually integrate research and education activities: each year we teach in a service design studio within the Master Degree in Product-Service System Design (PSSD) of the School of Design at Politecnico di Milano, and we decided to structure our teaching activities according to this action design format.

We consider this teaching activity as an opportunity to share our researches with students: the studio itself, which lasts one month and it is very intensive, may be intended as frontier experiment within a broader social innovation experimentation. Students are involved in something highly visionary, in which they have the possibility to think about future being connected to a specific research environment and being rooted in a local context.

In the next paragraph, we will describe how this action design format has been applied to two different service design studios held in 2017 and 2018.

1.3 Case Studies Description

Since 2016, the author is adjunct professor in the service design studio within the Master Degree in PSSD mainly as expert in co-design, together with Anna Meroni and Stefana Broadbent, experts in service design and social sciences.

One of the main characteristics of these studios is the link with Milan and its neighbourhoods: the city is intended as the 'natural' recipient of students' projects, and, above all, is considered as a space for experimentation, an actual environment to carry out research activities.

This connection with the city is made explicit in two ways:

- with the participation of the Municipality of Milan mainly as an actual 'client' of the studio asking for specific projects or as a simple stakeholder;
- with the involvement of a local community for accomplishing ethnographic research and co-design activities.

More specifically, we hereby consider two studios: one is named 'City Service Hubs' (held in the A.Y. 2016/17), the other is entitled 'A Resilient City' (held in the A.Y. 2017/18). In both studios, we experimented the application of the action design format previously described: they were structured into three main stages, defined as 'assignments', the first one devoted to understanding the topic and framing the opportunity, the second to generate ideas and co-design with multiple diverse actors and finally, the third assignment was dedicated to develop and prototype the solution.

1.3.1 City Service Hubs

In the service design studio run in 2017, we asked to our students to imagine new spaces dedicated to citizen involvement in Milan, we named these places 'City Service Hubs'.

In contemporary cities, people are offered a growing number of public and private services to support them in their daily lives. Numerous services remain virtually unknown, and one of the issues is to make them available, visible and accessible so that users can choose them and assess them. Therefore, the studio aimed at conceiving new ways to close the gap between citizens and services.

In addition, the studio built upon the consideration that today we are witnessing to a shift in the way services are being designed and delivered: services are becoming more open and collaborative, and citizens are being involved in the phases of design and delivery through techniques of co-design and co-production [7, 13, 16]. Public and private services alike are increasingly being planned and designed with a systematic participation of users. These approaches, however, require innovative processes and new spaces dedicated to citizen involvement: in Europe, there are a numerous examples, such as Living Labs, Community Hubs, Neighbourhood Centres and One Stop Shops. Cities and local authorities are experimenting with different formats to encourage communities to aggregate and collaborate in creating services targeted to their needs, but also to support the regeneration and renewal of disadvantaged urban areas and neighbourhoods. Often these experimental spaces have a hybrid nature as joint public and private initiatives, which encourage the creation of sustainable collective value promoting local economies. Most of the existing spaces are digital as well as physical, and exist as online platforms that enable or enhance the physical experiences.

We asked to our students to design these new hubs which should offer an innovative mix of public and private services and focus on twelve specific areas of need: food, health, family/ageing, housing, environment work/entrepreneurship, production/craft, tourism, transportation/energy, culture, sport and education. Students were divided into twelve groups, in order to work each on a specific area of need.

The studio was organised with the support of the Municipality of Milan, more precisely with the Council for Labour Policies, Production Activities, Trade and Human Resources which had already carried out a set of initiatives close to the idea of the City Service Hubs.

Building upon the action design format previously described, the studio was organised into three main assignments:

1. Framing the opportunity—in which students conducted both desk and field research to answer these questions: how may a City Service Hub look like? What examples, consistent with the general idea of the hub, can be considered? How do people behave today in order to fulfil their needs in certain areas? What places and situations are inspirational for our purpose? Hence, this investigation was about finding relevant case studies (both at international and local level) and exploring the behaviours of people looking for solutions in certain areas

of need, in order to understand their characteristics, issues, challenges, specific requests, aspirations, frustrations and orientations. The aim was to identify the distinctive traits of the observed behaviours and to extract the activity models of the observed places. As we intended to explore both present and future needs, students interviewed both citizens and specialists/experts.

2. Generating ideas, co-designing with stakeholders and users—in which students had to draft a service concept to answer the area of need previously explored and improve such idea through a series of co-designing activities. One co-design session with citizens-users was organised in a collective way: it was an actual 'co-design day' held in an existing 'City Service Hub' of Milan, known as 'Mare Culturale Urbano'. Students set up a sort of exhibition in which they used diverse boundary objects (in the sense used by Star [17]) to attract people passing by and involve them in short co-design interactions. This event was intended as a sort of engagement activity for citizens, an event for the local community to get in touch with the idea of the City Service Hub and its related initiatives. Additionally, students were free to organise other co-design sessions with stakeholders (experts, entrepreneurs, public officials, etc.) according to their scheduling needs.
3. Developing the service and organising an event-like prototype—in which students reshaped their initial idea into an actual City Service Hub and defined its activity model. They also built a physical prototype of the space, shown in an exhibition held at Base, a sort of 'community hub' in Milan which represents an example of urban regeneration. Here we also organised a public event to present the projects to the Municipality of Milan and to the community of citizens and stakeholders who took part to the co-design activities.

Students[1] designed a great variety of City Service Hubs, for example, 'Mario' is an innovative concierge service, a sort of container to bring together and organise all the services provided by the neighbours and build a stronger community. It works as hub for the Social Streets[2] of the district, giving support to each group by providing specific tools and knowledge to their managers, thanks to the collaboration with many local shops and companies.

Another example is 'Baohub', a City Service Hub where to get in touch with services, knowledge and practices related to clean energy. It works as a sort of help desk providing general information and house management tips, more specifically it provides tailored support both for domestic management and for open development of new projects and solutions about clean energy.

'SkillED' is City Service Hub to promote, educate and spread a soft skill culture. It is an educational centre that proposes an open cultural agenda to popularise soft skills, creating a connected community of enthusiastic learners and establishing

[1]The students mentioned are: Todaro, C., Alba, F., Kuleshova, A., Jinliqin (Mario); Kurt, M.; Ma, Y., Macrì, L.; Stiernspetz Fälth, A. (Baohub); Guerrini, L., Piallini, L., Falsina, R., Chen, S. (SkillED); Xin, G., Kettl, L., Son, M., Reina, V. (Socks + Sandals).

[2]The Social Street, originated in Italy in 2013, is a form of neighbourhood community, whose purpose is to promote socialization between neighbours in the same street in order to build relationships, to interchange needs, to share expertise and knowledge.

partnerships with motivated enterprises. Among the activities offered by this hub, there are classes of team skills, social skills and communication skills, all of them characterised by the adoption of a theatre approach.

Another interesting example is 'Socks + Sandals', a place that promotes alternative and authentic tourism. It connects practical needs of tourists and locals with personalised information. Acting as a city shelter both for tourists and for locals, its primary function is to offer a space to rest and to organise the stay. The complementary online platform connects these practical needs with the need for authentic travel experiences: it promotes activities around the city (both proposed by small tour operators or locals) that show unexpected spots and experiences around Milan.

It is important to highlight that all the City Service Hubs designed by students have both a physical and a digital dimension; therefore, they are composed of a real place and an online platform.

For the Council for Labour Policies, Production Activities, Trade and Human Resources, these projects represented an opportunity to imagine a new type of urban localities, both unique and scalable, different from traditional curbside retailers, something in between new 'shops', service factories and community hubs.

Students learnt to apply competences coming from both spatial and service design, defining a space and its related services within a specific context and benefitting from the collaboration of citizens and experts/specialists. As researchers of POLIMI DESIS Lab, the studio allowed us to imagine these hubs as places in which possible social innovations may originate, something close to community engagement spaces and social innovation incubators (Fig. 1.4).

1.3.2 A Resilient City

The main topic of the service design studio run in 2018 was urban resilience, intended as 'the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience' [18].

The choice of this topic was due to two main reasons: the first one was related to the urgency of the issue. In the coming decades, climate change, demographic transformations and the growth of cities will put major stress on urban areas. Cities are therefore starting to prepare with projects and programmes to make citizen, infrastructures, institutions and urban planning ready for unforeseen events and major transformations. The second one is that Milan is one of the 100 cities in the '100 Resilient Cities' project and is defining a resilience strategy and launching initiatives to face future challenges. Milan has chosen a number of strategic priorities, which match the forecasted transformations of the future of the city. These include addressing issues of increasing heat, congestion, the shortage of affordable housing, security and finding alternative economic models in food system, circular economy and digital manufacturing.

Fig. 1.4 Some pictures of the co-design activities carried out within the service design studio 'City Service Hub'

In addition, the course was organised to work closely with the Department of the Chief Resilience Officer part of the General Directorate of the Municipality of Milan. Multiple encounters with stakeholders within the Municipality were scheduled to help students align their projects with the priorities and context of the city.

The course focused on five of the strategic topics of the project '100 Resilient Cities' for the city of Milan:

1. Cool Milano—about climate change and adaptation of the city to the forecasted changes of temperature and climate events in the near future.
2. Milano Città d'acqua/Milan City of water—about re-opening of the ancient 'Navigli' (the water canals) and potential impact on cooling, congestion and energy production.

3. Milano Circolare/Circular Milan—about supporting the circular economy and distributed/digital manufacturing. Also defining initiatives for renewing food production and distribution systems and food policy to better integrate local sources of food production.
4. Safer Milan—about ensuring cyber security and data protection for citizen's data. Also using the existing resources for managing emergencies to participate in defining long-term prevention of natural catastrophes and accidents.
5. Abitare Milano/Housing in Milan—about integrating and welcoming newcomers to the city (an estimated 30,000 new citizens every year). Addressing and reducing the stress on the housing system in Milan (in particular social and public housing) and the rental market.

The aim of the course was to design services that were relevant for these strategic areas of resilience, and to do so by mobilising new technologies such as machine learning/AI, blockchain, Internet of things, big data, virtual reality and crypto-currencies which will inevitably be a significant component of future solutions. Students had the possibility to explore future and innovative concepts to address these challenges by analysing international best practices, understanding the context of the city, envisioning future scenarios, interacting with experts.

Students were divided into groups and chose one of the five strategic topics, in order to have one/two groups working on one specific area of interest. The studio envisaged three main assignments that applied the action design format previously described:

1. Framing the issue, explain the problem—in which students had to describe the constraints and identify the opportunities, finding case studies in other cities and interviewing experts. This was a deep dive in the selected topic and in the city of Milan, carrying out both desk research (looking for reports, documents, maps, plans) and field research (interviewing experts and communities of users).
2. Generating ideas, co-designing with stakeholders and users—in which students had to elaborate a draft service concept to answer the problem previously identified and enrich and test such concept by organising a set of various co-designing activities. Differently from the City Service Hubs studio, this time students had to conceive a comprehensive plan of co-design sessions, finding and involving stakeholders together and engaging small communities of users in order to refine their ideas under different perspectives.
3. Developing the service and organising an event-like prototype—in which students refined their concepts into actual services, designing the whole system and related touch-points. The service prototypes were presented in one final public event at the Triennale di Milano museum, where the Milan Chief Resilience officer and members of his department were invited as 'final recipients' of the projects, together with the stakeholders and the communities of users involved in the previous assignments of the studio.

Students[3] designed different services to improve urban resiliency, for example, 'Coleottero' is City Service Hub for fab labs and companies that recovers local discarded material and puts it back in circulation, creating a market of materials for digital fabrication workshops and furniture for urban agriculture. Students conceived this service as a part of the existing initiative 'Manifattura Milano', the Municipality of Milan's programme for the promotion of digital manufacturing and new craftsmanship in the city. Another interesting example is 'Open Power', a City Service Hub aimed at facilitating the installation, operation, maintenance and monitoring of renewable energy systems, placed within the city of Milan, owned and used by its citizens, towards the power production and sensible energy consumption. It aims at creating a self sufficient community of people, able to generate, share and consume energy coming from renewable sources within the urban network.

'Threads' is a platform for storing and organising personal healthcare documents, available as both a computer and mobile phone application. On Threads, users can upload all their healthcare documents, be they on paper or digital, and save them in one, safe space. This service was specifically conceived for the Lombardy region and has a specific focus on digital security and data protection.

Another example is 'CoolB' conceived as an open consortium network where individual professionals, small companies, investors and building owners can co-create solutions to green retrofit buildings with a comprehensive approach that involve all the stakeholders. It aims at facilitating the implementation of sustainable retrofit practises, with solutions that mitigate the impact of building emissions on the urban area and that ultimately enhance the liveability of the city.

'TimeXchange' is a system that encourages opportunities for civic contributions by the citizens in exchange for access to desired services within a network of collective communal places, using an alternative trading system 'coinX'. The system works on the neighbourhood level, using the principle of proximity services.

For the Milan Chief Resilience officer, these projects represented a great opportunity to put in practice his resilience strategy which presented a high degree of abstraction and needed more concrete contributions to evolve. Students designed a collection of services originated directly within the context and in collaboration with local stakeholders and communities of users. For us, as researchers, this was a way to simulate the starting of some possible social innovations in the field of urban resilience, benefiting from the protected environment of education (Fig. 1.5).

[3]The students mentioned are: Alvarez, D., De Luca, F., Pirola, E., Zheng, R. (Coleottero); Gargareta, H., Muscianisi, S., Özekici, D., Yunxiu, J. (Open Power); Chang, R., Chen, H., Pacchiarotti, C., Parrino, G. (Threads); Cortese, E., Guerra, C., Rodoplu, B., Yu, X. (CoolBe); Chen, L. M., Gupta, A., Piuri, S., Yao, X. (TimeXChange).

Fig. 1.5 Some pictures of the co-design activities carried out within the service design studio 'A Resilient City'

1.4 Lessons Learnt

The previously mentioned cases illustrate the effort of design researchers and students to create contexts for sharing of experience and practice [5] that enable people to act in more unrestricted and unexpected ways, from which a culture of social innovation might emerge.

The main lesson learnt is about the necessity to create and implement such contexts: as stated, these are protected environments [4], in which it is possible to experiment and overcome some of the traditional barriers to (social) innovation.

The concept of 'protected environments' is close to that of 'safe spaces' developed by Mulgan and Albury [14]: these are spaces in which risks are managed within defined parameters that include activities such as piloting, simulating, testing new ways of doing things and changing approach. Research and educational contexts fall by definition within these types of 'parameters': more specifically, from our

experience, design research and educational contexts appear as spaces in which people are allowed to think radically and out of the box.

Our experience is very close to that of Mangan and Thorpe within the Public Collaboration Lab in UK: they focused on the idea of working in 'de-risked spaces' to overcome risk adverse behaviours and practices that reduce the capacity of innovation [8]. They point out that a de-risked space has three main features: a focus on activities that are nonbusiness critical, a shared negotiation of the outcomes rather than a set of predefined outcomes, and a sense of difference which removes the work from ordinary.

The action design format that we applied in our studios includes these three characteristics:

- we attempted to make synergy between our design learning purposes and municipality strategic and operational purposes without exposing our activity to the 'powers', meaning that we chose intentionally to work on what were considered peripheral areas, such as urban resiliency and community hubs;
- we did not envision a set of predefined outcomes, as the very nature of a collaborative process is to negotiate and discuss the outcomes, sharing the responsibility for results. Our studios were functional to explore an issue rather than develop a specific answer to that issue: they represented an opportunity to approach a problem for the first time in a fast and experimental way, with low risks and low investments;
- the enthusiastic contribution of design students brought precisely that 'sense of difference from the ordinary' described by Mangan and Thorpe [8], meaning that, in their activities with communities, stakeholders and members of the municipality, students brought their original and fresh perspectives, 'contaminating' positively people who were not used to this approach and who, in some cases, were disillusioned towards possible changes in their life.

Another important lesson learnt is about the implementation phase: the action design format we applied in our studio is based on the first stages of both the social innovation process conceived by Murray et al. [15] and the Social Innovation Journey developed by Meroni et al. [11, 12], and we did not envision any plan for implementation. This is probably the most critical aspect of our activities: we were focused on experimenting and in making things happen, without reflecting on the next stages: how to support the municipality of Milan in adopting some of these projects? How to support students in becoming social entrepreneurs? Which kind of 'exit strategy' for the researchers by creating the conditions for the innovators to be autonomous and committed enough to take the initiatives further (both on the part of students or communities of users)?

Since a reflection on the implementation stage overcomes the 'given' boundaries of our educational activities, we did not prepare appropriately that phase, we put all the effort in creating a collaborative environment, in stimulating participation and making things happen in a very strict range of time, but if we wish to educate the next generation of social innovators we have to build a bridge between the first phases of a social innovation and its maturity stage.

For that reason, we think that the design university (in its two main scopes, educational and research) has to start to consider itself as an actual social resource able to activate or contribute to social innovation processes, and thus, to also consider itself as an integral part of a Smart Learning Ecosystem [1], where smart may be intended as transformational, collaborative and inclusive.

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Part II
The Virtue of Design ... and that of Technological Environments

Chapter 2
Teaching Experience Design Using Poems as Cultural Probes

Patrizia Marti and Fabienne van Leiden

Abstract Training user experience (UX) design students to develop interactive products valuing the subjective experience as a catalyst is a challenge. Experience design implies a deep understanding of the values, culture, beliefs and practices of a target user group and also sensitivity to consciously integrate them in products with distinctive qualities. This paper presents a method experimented along three years of the Master's Degree Program in Industrial Design at Eindhoven University of Technology. The method uses poems as cultural probes and as an access door to experience cultural elements and to embed them in the design of meaningful interactions. Beside the presentation of the method, the paper illustrates student projects that exemplify the approach. It concludes with recommendations to experience designers for transforming socio-cultural factors into product features which promote a valuable subjective experience.

2.1 Introduction

UX is a field of study in human–computer interaction that focuses on the human subjective experience in interaction with technological artefacts. While this field of study has reached an increasing popularity and maturity, there is still not consensus on how the concept of UX should be defined, researched and taught.

Various scholars have proposed different definitions of UX. Law and colleagues [1], surveyed 110 researchers and on the basis of their survey, published the User Experience White Paper [2] that was included in the revised ISO standard for human-centred design (ISO 9241-210) in 2010. These documents share two main aspects affecting UX that go beyond the characteristics of the product or service like appearance, functions, and performance: (1) a focus on the values that people recognize in

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a product or service over time [3]; (2) a focus on the subjective experience tied to personal attitudes, expectations and feelings.

Glanznig [4] identifies two major competing strands of research in UX both centred on the study of the subjective experience in interaction with technological artefacts. The first one aims at uncovering the objective in the subjective [5] and is more oriented to identify means to evaluate the UX, the second one takes ambiguity as a distinctive quality of experience which is situated and creative [6]. The first approach is grounded in psychology, and the second one takes an interpretative and qualitative approach towards UX.

Other notable tendencies in the field are that of designing for emotions and affection [7, 8] and for pleasurable and attractive experiences of use.

Assuming a positive attitude of the users to be pleased by using interactive technologies and have fun, Overbeeke et al. [9] stated 'Interfaces should be surprising, seductive, smart, rewarding, tempting, even moody, and thereby exhilarating to use. The experiential is assumed to lead to joy of use' (ibid, p. 2).

Other researchers used similar features of surprise and imagination to provoke people to critically reflect upon the use of an artefact [10] and make sense of complex, contradictory and even ambiguous systems and situations [11].

These perspectives and approaches to experience design raise two main reflections: first of all, designing for experience beyond usability is not a question anymore, but a broadly accepted and explored area within design, with a shift from functionality to experience design.

Secondly, the challenges that technology poses on our contemporary society are of increasing complexity, and this calls for new ways of interacting with digital materials that include 'subtle poetic elements to excite imagination' [12] (ibid, p. 269) and stimulate reflection and sense-making.

2.2 Poems as Cultural Probes

The research described in this paper looks at experience design acknowledging the complexity of human needs and desires when engaging with interactive systems.

We take 'poetic interaction' literally, using poems as cultural probes and sensitizing tool for interactive system design. In this way, we hope to stimulate design students and educators to promote design solutions focusing on subjective reflection and sense-making.

Cultural probes have become a popular method in design research to gather qualitative data based on user self-documentation. This method was first introduced by Gaver et al. [13] to encourage users to look beyond functional needs, into the fuzzier realm of their beliefs, desires and cultural preferences. Cultural probes are a collection of tools, typically maps, a camera, a diary that participants are invited to use to record meaningful accounts of their daily lives. The collected probes are in turn interpreted by the design team in their raw form as inspiration for their work and a means to reflect on the culture of participants.

From the original formulation, the concept of cultural probes has been variously adapted. Crabtree et al. [14] developed technology probes to inspire design by exposing users to new experiences by situating existing technologies in their homes. Peeters et al. [15] used smart sensor agents as experiential probes to gather data on users' behaviour unobtrusively. Other adaptations of cultural probes include experience probes [16] and empathy probes [17] used to move from design inspiration to acquiring information about users and design empathy.

Mainly probes are applied in design to inspire the design team, to inform design with data, to establish a dialogue with users, or as a means for participation [18]. In all cases, they can be regarded as a research vehicle to learn about people's life, culture, needs, choices, behaviour, thoughts, values with various techniques: in real time together with people; or longitudinally and remotely.

In what follows we describe our adaptation of cultural probes which use poems as a vehicle to sensitize the designer to the subtleties of a local culture. Our poetic probes are not designed tools to collect data. They can be generated by the participants or selected from existing ones in various ways (books, digital libraries, online communities). The poetic probes can be regarded as very peculiar representations of users' experiences, feelings, attitudes and values, which are narrated with a rich, sometimes ambiguous language purposefully used to reflect, provoke, disclose and offer a viewpoint, a sentiment or emotion.

In the paper, our probing method is exemplified by actual design cases developed within the course 'Poetry in design' of the Master's Degree Program in Industrial Design at Eindhoven University of Technology, where poems were used for uncovering underlying or implicit cultural differences and similarities as well as for general sensitization towards subjective experience and sense-making of young designers.

The assignment of the course was to redesign a mundane object that reflected the qualities of a selected poem. Whatever culture the poem came from, it was explored taking also the viewpoint of a different culture by translating the poem in different languages and trying to make sense of cultural meaning and context. The student design teams were purposely multicultural to stimulate a debate on the interpretation of the poetic probes.

The students experimented with an incremental design process developing from abstract analysis to concrete experienceable designs [19].

In what follows first we describe two exemplar students' projects and later we illustrate the design process discussing the individual steps and their implications for UX design.

2.3 Students' Projects

2.3.1 Teh Lampu

Teh Lampu is a redesign of the tea-drinking experience which combines some practices of drinking tea of Eastern and Western world.

The product Teh Lampu consists of a matt tea glass and a stirring stick with a top that lights up when it comes in contact with water (Fig. 2.1). The combination of the matt glass, loose tea leaves—which are common in Indonesian tea rituals—and the light, create dynamic shadow plays on the glass. The stirring stick with the light creates an even more dynamic shadow play when fulfilling its function. If the stirring stick is not used, the tea leaves cause a calmer shadow play, because the leaves are slowly sinking to the bottom, indicating the tea is ready to drink.

Drinking tea is a rather mundane activity and often a social one. But when you are drinking, you close yourself off from the conversation, both in communication and in covering yourself with the glass. The light effect on the glass, however, maintains the communication by giving others a beautiful shadow play. The aim of this design is to bring imagination, which in a sense is almost at par with reality in the Indonesian culture, to the Western culture in this more mundane activity. A video describing the design process and the final product is available at: https://www.youtube.com/watch?v=E6MYr7Hg4RI&feature=youtu.be.

The design is based on the Indonesian poem Teh Lampu by Sapardi Djoko Damono (1974), and inspired on the Asian tea culture (Poem 1). An English translation of the poem follows (Poem 2). In Sect. 2.4, we illustrate how the poem was used to probe the design of Teh Lampu.

Fig. 2.1 Teh Lampu

Bola Lampu

Sebuah bola lampu menyala tergantung dalam kamar. Lelaki
itu menyusun jari-jarinya dan bayang-bayangnya
tampak bergerak di dinding; "Itu kijang," katanya.
"Hore!" teriak anak-anaknya, "sekarang harimau!"
"Itu harimau." Hore! "Itu gajah, itu babi hutan, itu
kera . . ."

Sebuah bola lampu ingin memejamkan dirinya. Ia
merasa
berada di tengah hutan. Ia bising mendengar hingar-
bingar kawanan binatang buas itu. Ia tiba-tiba mera-
sa
asing dan tak diperhatikan.

Poem 1 "Bola Lampu" © 1973, Sapardi Djoko Damono Publisher: Puisi Indonesia, Jakarta, 1974

Light bulb

A light bulb hangs shining in the room.
The man entwines his fingers and their shadows
seem to
move on the wall; "A deer," he says. "Hoo-
ray!"
shout his children. "Now a tiger!"
"A tiger." Hooray! "An elephant, a wild boar, a
monkey . . ."

A light bulb wants to close itself off. He feels to
be
in the middle of a jungle. He hears loud noises -
clamour of the group of wild beasts. Suddenly he
feels
estranged and unnoticed.

Poem 2 Translation from "Bola Lampu" by Separdi Djoko Damono (1974). © 2015: G. de Boer, T. Elfferich, F. van Leiden, J. Vlaming

2.3.2 Deer Enclosure

Deer Enclosure is a redesign of an answering machine that keeps messages hidden until they are revealed by the listener (Fig. 2.2).

Incoming messages are abstractly represented by water that pours from the tap into the main cup. Messages are constantly played back, but due to the water, they are muffled away, like 'echoing voices' (Poem 4).

The messages are only revealed when the receiver spins the water forming a vortex which allows the message to come out of the speakers. Since this vortex requires a specific speed, this activity requires a state of seclusion and focus. Now and then, the cup has to be emptied to make space for new messages by pouring the water out in the sink, again revealing the speakers and with this the old messages.

Fig. 2.2 Deer Enclosure

A video describing the final concept is available at: https://vimeo.com/194223510. The process video can be accessed through this link: https://vimeo.com/194223457.

The design integrates inspirational elements from the ancient Chinese poem 'Deer Enclosure' (Chinese translation of Lù Zhaì) by Wang Wei (Poem 3), inspired by the meditation rituals in Asian cultures. The way the poem was used to probe the design process is illustrated in Sect. 2.4.

鹿柴
Lù Zhài
空山不見人
Kōng shān bù jiàn rén
但聞人語響
dàn wén rén yǔ xiǎng
返景入深林
Fǎn jǐng rù shēn lín
復照青苔上
fù zhào qīng tái shàng.

Poem 3 "Lù Zhaì" by Wang Wei (seventh Century)

The Deer Enclosure

No one can be seen in the pathless hills
Only echoing voices remain
Rays of dusk light reach deep into forest
To become moving reflections
revealing bright green moss.

Poem 4 Translation from "Lù Zhaì" by Wang Wei (seventh Century). © 2016: Xihao Hu, Bram Rutten, Xander Meijering

2.4 Design Process

In the following, we present the process underlying the development of the projects described above, and the way in which poems were used as inspirational cultural probes. We first describe the overall picture (Fig. 2.3), and later we detail the different methodological steps exemplified by the material extracted by projects.

The design process was incremental and developed through cycles from abstract to concrete. The waving line in Fig. 2.3 shows the constant switch between abstract reflection and concrete explorations.

The whole process is entirely driven by a deep appreciation of the qualities of a selected poem. This process develops with incremental steps starting with making a bodily experience of the poem by reading, reciting and listening (concrete step) through a deep analysis of contents, language and meaning (abstract step). In this way, the deeper layers of the poems are explored, qualities extracted and translated into design properties and a final prototype.

The entire process aims to design products/systems that incorporate values extracted from poems from different cultures. While developing on many cycles from abstract to concrete, it also focuses on the (re)design of an everyday object or experience. This focus leads the process to a design that can be implemented in everyday life, as is highlighted with the blue converging area in Fig. 2.3. This focus is therefore a good bridge between abstract and concrete exploration.

A main motivation to design through the lens of poetic probes is to get sensitivity to the surrounding world in a subtle and unique way. At the most basic level, poems are

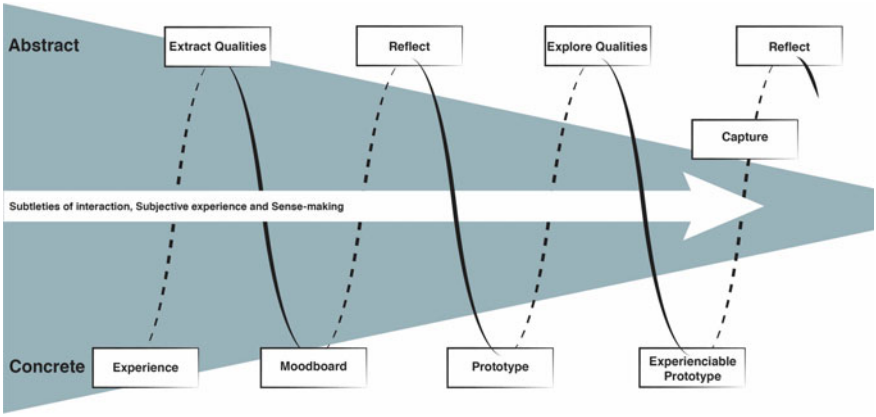

Fig. 2.3 Overall picture of design process. The waving line indicates the constant switch between abstract and concrete explorations. The blue converging area shows the focus on a (re)design for everyday life. Finally, the blocks indicate the steps of the process

important because they make us think, they open us up to wonder to the astonishing different ways to look at the world and express them in language.

Poems reveal areas of our own experience that we might have lost sight of or we might not have been ever aware of. On repeated reading, poems can disclose knowledge and insights. In its subtle yet powerful way of expression, poetic language can be seen as a discipline for re-engaging with a world we take too often for granted by putting feelings and emotions at the forefront.

2.4.1 Methodological Steps

As shown in the model depicted in Fig. 2.3, the design process develops in a number of steps, which are described below and exemplified by the students' projects.

2.4.1.1 Experience (Concrete)

This phase aims to create sensitivity towards the non-literal qualities of the poem. Poems used as probing tools can be collected in different ways. For example, in the course 'Poetry in Design', we invited the famous Dutch poet Jan Glas to kick off the course. He selected for us some of his own poems and recited them in Gronings or Plattdeutsch dialect. This was a lingua franca to all participants that allowed them to appreciate the sounds and rhythm of the poetic language beyond the understanding of the words. In this way, the students could experience the active role of the reader/listener in making sense of the poem. Other poetic probes were selected and listened from Poetry International website,

http://poetryinternationalweb.net/, a literary organization that delivers quality poetry worldwide, often with videos of their recitation. Selection could be based on personal interest in a specific poet, language, culture or topic.

By listening, reciting, reading and discussing the poems, the deeper layers and hidden qualities were extracted.

The students of Teh Lampu show in their video their repetitive recitation exercises. Not only the translation (which was developed by themselves, see next step), but also the Indonesian version of the poem. The Indonesian language was foreign to all students, but they managed to find an Indonesian contact who recited it for them. This created sensitivity towards rhythm, flow and emotion of the poem. This step came back every time the students made a step forward in the design process moving from concrete to abstract exploration.

2.4.1.2 Confrontation/Translate (Towards Abstract)

In this step, the students were asked to translate the poem (Poem 1 and 2). This could be from a foreign language to English or to their other native language. This step enhanced the sensitivity towards the poem and bridged towards the first extraction of qualities. Furthermore, this step allowed to capture and share personal experiences the students had with the poem.

The students of Teh Lampu project managed to capture qualities of the Indonesian language and culture by translating the poem with the support of an Indonesian contact. They compared the literal translation with a professional translation and learned that imagination played a more important role in the Indonesian language than in the English language. For example, Indonesian language translated into 'He feels to be in the middle of the jungle', whereas an English translation mentioned: 'It feels as if he is in the middle of the jungle', see Fig. 2.4.

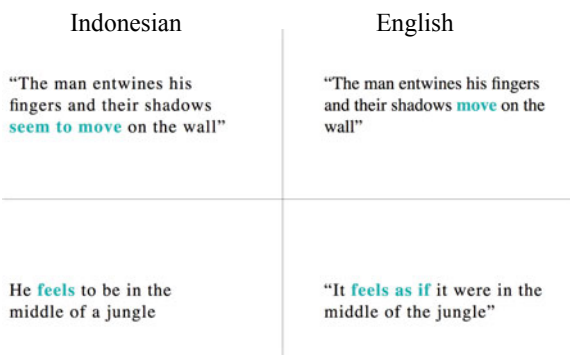

Fig. 2.4 Comparison of the Indonesian and English translation of 'Bola Lampu'

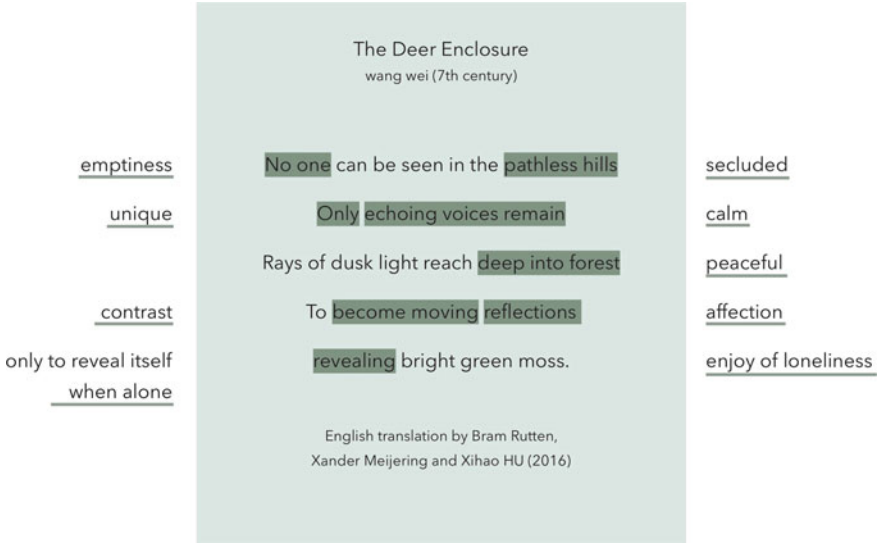

Fig. 2.5 Extract qualities of the poem: The Deer Enclosure

2.4.1.3 Extract Qualities (Abstract)

As a next step, the analysis of the poem was translated into qualities that embodied the non-rational and deeper layers of the poem.

To capture the qualities of their poem, the students working with the poem 'Deer Enclosure' mapped every quality to a section of the poem. Furthermore, they provided an extensive description of every quality defining exactly what they meant. For example, the students extracted the quality 'secluded' from their translation 'pathless hills', see Fig. 2.5. They defined this quality by mentioning the hills do not have paths so not many people visit it.

2.4.1.4 Mood-Board (Concrete)

After having defined the qualities on a more abstract level, these are translated into a first concrete description of an experience. This is captured with a mood-board, which could have several forms, e.g. visual, drawings or video.

Both student groups used a video mood-board in which they explored material, context and human interaction qualities (Fig. 2.6). Because of this activity, the understanding and definition of the qualities were also improved. Both video mood-boards can be found in the process videos of the student projects at https://vimeo.com/194223457 and https://vimeo.com/125128503.

Fig. 2.6 Students exploring the qualities of different material and interaction properties for their 'Teh Lampu'

2.4.1.5 Reflect on Qualities (Abstract)

After focusing on one experience, the students broadened their perspectives again by exploring different materials, forms and interaction qualities that matched the extracted qualities and defined experience (Fig. 2.6).

Different reflective qualities of materials were experimented with to find material properties that matched the qualities that were found in the poem. Sometimes, more literal translations were made, for example, the poem discussed a shadow play made by a light and hands. More abstract translations were explored as well with mirrors and graphical patterns.

2.4.1.6 Prototype (Concrete)

The material explorations were combined with the extracted qualities and defined experience into first concepts and prototypes (Fig. 2.7). The prototypes came closer to a focused redesign and allowed the students to actually experience the envisioned experience. By selecting existing products or experiences, the implementation was done with subtle considerations instead of impacting changes in the design.

2.4.1.7 Reflection (Abstract)

The physical prototype allowed the students to experience the qualities of their design. Furthermore, other people, e.g. fellow students and lecturers could experience and

Fig. 2.7 Students testing a method to create the water vortex required for their design the 'Deer Enclosure'

reflect upon this experience as well. This helped the students to define to what extent the prototype matched the defined qualities and set experience.

The process of prototyping and reflection was iterative and was repeated as long as necessary to define a concept that meets the qualities and experiences of the poem.

2.4.1.8 Experiential Prototype (Concrete)

The iterations on prototype development ended with a final experiential prototype, which according to the designers and people involved in the assessment, captured the experience narrated in the poem (Fig. 2.8). The interaction with the prototypes

Fig. 2.8 Answering machine prototype inspired by 'Deer Enclosure'

was carefully designed to enrich the experience and to make it easier for the user to connect to the intended qualities.

The experiential prototype 'Deer Enclosure' gives a good indication of these aesthetic qualities. The fluency of whirling around the water is an example of the attention paid to the interaction design of the answering machine: the way in which the user spins or pours the water affects the sound and the fluency of the spoken messages, and therefore the experience of the intended qualities of the design.

2.4.1.9 Capture and Reflection (Abstract)

The design process ended with capturing the design and its qualities and experience and reflecting together on the outcomes. This can be done in a written form but also pinpointing the properties of the design and its considerations.

2.5 Reflections

The design process ended with shared reflections about the approach and the obtained outcomes. In what follows we list the main insights that were reflected upon.

Overall, the students reported that the process helped them to create more sensitivity towards cultural aspects. The process taught the students to design using a cultural probe, in this case, a poem that was used to reflect on an experience and inspire a design.

Students mentioned the defined steps as a good motivation to move onwards in the process. They valued the mood-board phase, for example, as an opportunity to move the process from talking and discussing to doing and experiencing. Furthermore, the focus on an everyday object was valued by the students as a way to move from the abstract phase to concrete implementation.

By experiencing, translating and re-experiencing the poem the students realized how much qualities there could be found in one poem. Furthermore, they realized the many experiences one poem could embody. By designing with this insight, the artefact or design also obtained multi-interpretable qualities that supported subjective experiences.

2.6 Conclusions

In this paper, we described an approach to UX design that takes poems as cultural probes to inspire the design process. In doing this, we explored the language of poetry as a means to focus on experiences from a cultural viewpoint. Central to this sensitivity is the language of poetry, a key means by which the uniqueness of the world is poetically brought about. In the language of poetry, the sound of the words,

their flow and imagery are raised to an importance equal to that of their meaning, which remains open to the interpretation of the reader. The language of poetry also seeks to involve the reader in the text, placing importance on reader participation in the construction of meaning.

A poem aims to a subjective and personal experience, and this is the reason why we used poems as cultural probes. In our design process, we constantly considered this by experiencing the poems by reading, listening and translating them. This allowed the designers to gain awareness of how a poem can be interpreted and experienced.

Our approach should be regarded as a way of encoding a design research practice to highlight subtleties and qualities that deserve to be manifested in a concrete design.

One can argue that anything can work as cultural probe in the design process. We believe that poems are a powerful and thought-provoking tool to address the subjective and personal experience. Practicing poems implies an open-minded and focused attention to details of everyday experiences. Poetry is central to culture in its being capable of being a powerful lens through which looking at the inner experience and outer world.

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Chapter 3
The International Summer School for Advanced Studies UniBS: CONTEMPORARY IDENTITIES. Interweaving Spaces and Relations in the Design of Living Services

Angi Barbara, Barbara Badiani, Angelo Luigi Camillo Ciribini and Lavinia Chiara Tagliabue

Abstract The building design is including new features to focus on the users' needs and to be responsive to the boundary conditions, which are nowadays marked by sustainability, energy consciousness, economic requirements, life cycle assessment. The International Summer School for Advanced Studies UniBS: *Contemporary Identities* adopted a multidisciplinary approach to extend the vision and the possibility to deploy the project with design competencies, off-site development of the construction phase, energy assessment and innovative systems, according to urban planning and rules. The goal is to pre-evaluate the design choices to avoid, or minimize, unexpected dissatisfaction factors that could be rise when the project is actually used by people. The *Post-occupancy Evaluation* is predicted, and anticipated, through Virtual Reality and Digital Tools to define the project. This approach strongly helps the designers to review the project and possibly can be used—and it is used in the most innovative and advanced project contexts—to exchange the hypotheses of design interference between different disciplines during the design phase, to explain the projects and understand the spaces for clients and end users. The ISS *Contemporary Identities* explored the possibility to adapt and extend a prefabricated housing unit provided by an Italian company Marlegno for different users and locations, including requirements related to the specific context and stakeholders. The ISS involved the University of Brescia, promoter of the initiative, TU Wien and University of Huddersfield. Students and Ph.D. candidates of the three universities worked together for one week in the resident workshop of the ISS in Brescia, Italy.

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3.1 Introduction

3.1.1 Scientific Framework and International Issues

The ISS answers to the actual trend of digitization of the Architecture, Engineering and Construction industry (AEC) and introduces the *Off Site* topic, which reflects on the impressive growth (a return from the past?) of *Off Site Manufacturing* (OSM) and Industrialization in international markets globally. This process is developing simultaneously with the transition of the Off Site Manufacturing (OSM) concept from the construction and real estate to the environment sector. OSM, as well as DfMA (Design for Manufacturing and Assembly) (and other acronyms), have, in fact, rapidly gained wide popularity in Europe and the United States, also due to policies and strategies that affect the Clean Energy Management and the circular and sustainable economy. The industrial strategies of the British government (Industrial Strategy, Construction Deal, Consultation), the initiative of the German federal government on residential construction (Wohnungsoffensive) or the French law (Loi ELAN), clearly show how modularity, interpreted with versatile and tailor-made production, is now perceived by policy makers as crucial for the development of the sector. The same principles are also beginning to be applied to the infrastructure sector as well as to the construction sector. At the same time, in the USA, some operators are launching important entrepreneurial initiatives, making significant investments (for example, Amazon & Plant Prefab, Autodesk & Project Frog, Airbnb, Alphabet, etc.). All these initiatives imply, first, the ambition of bridging the historical gap existing between the construction and manufacturing sectors, considering the quality of the industrialized product that is claimed to be much higher than that one achieved in the last century. Some industrial digital platforms, able to combine and manage standardised and interoperable components and elements, have recently been proposed, also assuming the use of Artificial Intelligence. Sidewalk Labs, a Google initiative underway in Toronto, for example, has proposed a building configurator, while in other cases common to the sectors of construction and motor vehicles platforms are being imagined. Nevertheless, the affirmation of Building Industrialization implies the presence of high capital requirements and a consistent inelastic demand, against a review of the supply chain (including the shortening of the supply chain). The notions of collaboration and integration, therefore, require the various actors in the process to change, at least in part, their own identity. Thanks to the Fourth Industrial Revolution, instead of leading the construction sector towards the manufacturing sector, it is possible that the former enters the Service Provision and Living Service sector and the Anglo-Saxon firm *WeCompany* [1] appears as the reference par excellence. In other words, Smart Homes and Cognitive Buildings, as defined by IBM [2], Siemens, Google, Amazon, Facebook, Apple, Microsoft, would become vehicles to provide services to the person and, even, to design behaviours. The overall meaning of the ISS focused on the notion of *Design for Manufacturing and Assembly*, since the return of popularity of the *Off Site* as well as of *Modularity*, enabled by digitalization, hides the pitfalls of a

path that has already proved to be unsuccessful. At the same time, the design object is shifting to living services, so that assets must be "as-services".

3.1.2 'Impermanence' of Contemporary Living

The issues debated within the ISS focus on the principle of 'impermanence' of contemporary living. The provisional nature of living is a consolidated topic in Architecture. Today, more than ever, it raises questions about the effects of New Technologies to design and build spaces for living. The continuous evolution of the housing demands, oriented towards spatial solutions with variable layout, solicits a design approach oriented to the experimentation of easily convertible prefabricated building systems [3]. In this field, the construction cannot develop stable and permanent building systems. The design process must prefer solutions that are continually, and constantly, reconfigurable. Therefore, the provisional dimension and the impermanence are essential elements of the architectural project, reconciling the time of technology with the human life. The participants, during the ISS, explored the building potential of low cost, energy self-sufficient and flexible houses that can be built and quickly dismantled. Through the preparation of a highly flexible wooden building system, the housing solutions developed by the students could establish changing relationships with the places where, for short periods, the house can be assembled. The design of the structure must be defined in strict relationship with the location and the environment. This aspect of the design process requires students to think about urban planning rules, in term of limits and opportunities.

3.2 Methodology

The ISS promoted the development of project designed by groups involving PhD candidates and students led by a multidisciplinary team of professors coming from design, urban studies, building production and energy evaluators with international experts, which gave lectures to increase the knowledge and consciousness of the students about the ISS topics. The projects have been developed, in a virtual environment, for different environmental and urban contexts. Students were asked to consider the applicability of the housing prototype in terms of:

- sustainability for energy saving and recovery of building materials once the useful life of the house is over;
- reduction of land consumption, correlating temporality with the natural cycles of ecosystems;
- urban regeneration, to verify the opportunity to introduce activators for the redevelopment processes of underused or disused urban areas [4];

– protection on the territory of vulnerable or sensitive areas in which the temporary nature is a condition for maintaining minimum environmental maintenance activities.

3.2.1 Organization and Teaching Strategy

During the course of the ISS, working groups were composed by students from the University of Brescia, TU Wien: Technische Universitat Wien and University of Huddersfield, architects and experts in the field with a broad disciplinary background able to establish a design process outside the traditional framework. A first phase was dedicated to the study and critical interpretation of the project's contexts. Theoretical lessons have been provided to address from various viewpoints the topics of living in the contemporary disciplinary debate, the issues related to urban feasibility under the regulatory aspect and the integrated design in BIM environments through the validation of design choices in Immersive Virtual Environments (Fig. 3.1).

The intensive program, in addition to the ex-cathedra lectures, included discussions on the projects both in the design phase and in the final evaluation (with an

Fig. 3.1 Organization of the ISS with international lectures and workshops for the design phase

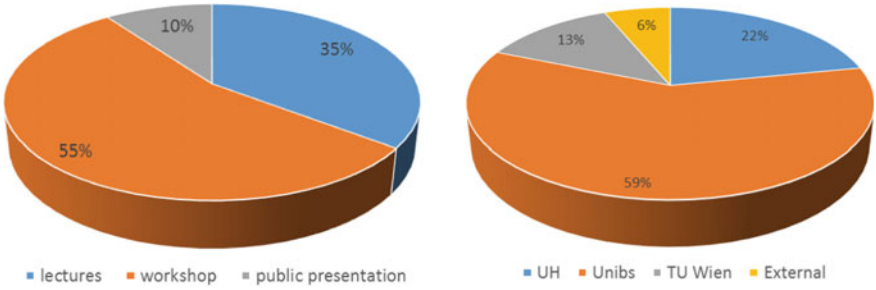

Fig. 3.2 Distribution of the teaching and learning activities and percentage of students from different universities and different backgrounds

external Jury). The teaching methodology has been organized as 35% lectures, 55% workshop and 10% public presentation. The number of students involved in the learning phase has been 31 with 19 students coming from the University of Brescia (Unibs), Combined Bachelor and Master Degree Courses in Architectural Engineering, 4 information engineering from TU Wein (TU Wein) and 7 design students from the University of Huddersfield (UH) and 2 external professionals (External) (Fig. 3.2).

The working groups, supported by academic tutors and qualified experts, have developed their own original proposal, drawn up to the appropriate scales of representation. The activation of the ISS was a structured response to the specific needs expressed both by the professional and construction production sectors. The School also responded to requests of the academic world, to implement a path of improvement in line with advanced training objectives and best practices of the universities operating in the field of integrated architectural and urban design [5].

3.2.2 Training Objectives

The training objectives of the ISS are listed below:

- Development of methodological and operational tools for the design of experimental architectural projects on contemporary living issues and preparation of digital simulations for technical and regulatory checks related to the planning system.
- 'Horizontal' exchange of knowledge among students, favouring methods of learning that do not proceed only vertically (from teacher to student).
- Collective verification of theoretical approaches and reference systems of an interdisciplinary nature in order to expand the field of individual and collective information.

3.2.3 Location and Partners

The International Summer School was held in Brescia at Palazzo Calini from 3 to 8 September 2018, organized by the University of Brescia in collaboration with TU Wien and University of Huddersfield, under the patronages of the Municipality of Brescia and with the support of some industrial partners (Ambiens VR, eFM, Italmesh, Marlegno, Team System). The lectures were held by CCLM, Lombardini 22, Nomisma, Wienerberger, and Giovanni Corbellini (Polytechnic of Turin) enhanced the design review, contributing significantly to the final result of the six groups of Austrian, British and Italian students. The lectures have been included in the professional training credits and attended by engineers and architects (95 professionals) with a total of involved people of 127 units. The ISS promoted the horizontal

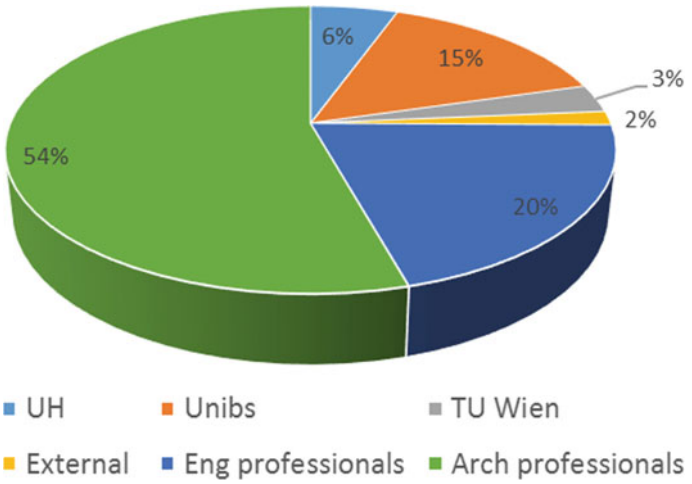

Fig. 3.3 Distribution of involved people in the ISS

learning exchange of knowledge in the 25% of the people and vertical learning in the 74% (Fig. 3.3).

3.2.4 Virtual Reality for Design Review

The challenge behind the initiative was to start from six different and stimulating locations, six different behavioural plots of 'temporary and evolutionary' housing models (related to User Centrism) [6], which represent six different possible combinations of promoters, owners and final users of the temporary building. *Off Site* was the main construction solution to be developed through the combination of 'analogical' approach (the manual sketch) and computational methodologies (BIM Library of the prefabricated components and energy models) [7]. The use of immersive tools [8], allowed 'analogical' and real-time design reviews of student work. This has led to a greater awareness of the project activity carried out with a much controlled and spatially correct results (Fig. 3.4). In Fig. 3.5, an example of design review is shown: the design group is assessing in the virtual reality (VR) the use of the mezzanine in the designed house.

3.3 Case Study: The Housing Unit for Specific Users

The starting point of the analysis and design has been the sustainable housing unit of the Italian company Marlegno, namely *Nidoom*, one prefabricated module which is

Fig. 3.4 Tutors and students engaged in a virtual reality session to verify project choices

Fig. 3.5 Design review for the plot 4 (Table 3.1) with 'analogical' approach and VR visualization

an almost 30 m^2 building, transportable and repositionable for changing scenarios. The unit has a wooden natural and light structure, and it is conceived to have zero environmental impact. The module is designed to minimize the energy consumption [9] through the envelope solutions [10] and the smart systems management. Moreover, the comfort level is guaranteed. Thank to the support of Municipality, a 1:1 scale prototype of house was located in Piazza Rovetta, Brescia. The unit has been installed the first day of the ISS (3 September 2018) and used by the students working inside it during the day, and visited by the citizens that showed a strong curiosity and interest in the new installation in the city centre. For the workshop, the bed has been substituted with a table for team working shifting the bedroom/living room into a meeting room (Fig. 3.6). Six specific users' plots have been delivered to the students' groups to start thinking how to design for an extended user experience (UX) and how to include into a small unit the temporary concepts of new living frameworks and spaces. The plots are conceived starting from real context and assuming possible promoters, owners and users, who could find opportunities in a temporary location. The different situations show possible interactions among needs, features of the context, impacts on the environment and urban planning rules. They sometimes are in

Fig. 3.6 Marlegno housing unit *Nidoom* installed into the city centre of Brescia during the ISS summer school, external view and internal view

Table 3.1 List of plots, sections and subsections

No.	Plots	Sections	Sub sections
1	Soundtrack	Context	
2	The Fugl	Place	
3	Mr. Bresciani	Users profile	
4	Erasmus generation	Context characteristics	
5	Foreigners everywhere	Spatial requirements	Interior spaces
6	The Smiths		Exterior spaces
			Relationship with the ground
		Energy requirements	

contrast, or they sometimes show a lack in urban planning rules. In each one, the students had to take them into an account to face the conflict and solve it.

3.3.1 Main Design Requirements

The design requirements are reported in the following Table 3.1 where the plots' names are listed together with the sections and subsections of information provided to the ISS students. In Table 3.2, the plots design specification for the context and place are summarized while in Table 3.3 the design requirements are explained.

3.4 Results

The main outcome of the International Summer School is a new concept for the national context of multidisciplinary and combined design process, developed with

Table 3.2 List of plots with context and location specifications

No.	Plots	Context	Place
1	Soundtrack	Public square in historical context	Piazza Rovetta (Brescia)
2	The Fugl	Protected area–touristic area	Nature Reserve of Torbiere, Camping
3	Mr. Bresciani	Residential zone with low building density, private green area ruled as a natural network for the community	Sereno Village—Via Tredicesima n. 7, Brescia
4	Erasmus generation	Urban suburbs–public green area–students and teachers' spaces	Spaces owned by the University of Brescia, between via Branze e via Valotti, Brescia
5	Foreigners everywhere	High density residential area–shared spaces between different services, market and houses	Tintoretto tower (social housing building)
6	The Smiths	Agricultural area in mountain, affected by flooding risk	Location Caregno, Trompia valley, Brescia

the support of innovative researches in which the DICATAM Department, University of Brescia, is a leader in the field of technical architecture, building production, architectural design and urban planning. The students focused on provocative topics such as the dynamic and temporary dimension of resilient living from the point of view of urban planning, user centred and interactive design as exceptional element of architectural design process. The adoption of IVE enhanced the students experience and increased the consciousness of the importance of the POE (pre-operation phase evaluation process) and the possibility to adopt the end-user point of view in the assessment of the quality of the living spaces. The temporary spaces are also a hot topic in our changing society.

The smart learning approach has been adopted and exploited to provide the students with innovative systems of investigation and knowledge exchange and to promote a vision of the digital environment which is crucial in the future of design and construction sector (Fig. 3.7).

The cooperative and collaborative immersive virtual environment (IVE) is suitable for reducing the problems in the construction phase through the verification of the possible concerns during the review sessions and it is beneficial for the students' training to enable problem-solving skills and digital environment manipulation (Fig. 3.8).

The students started with the analogical discussion of their ideas with the teachers and tutors and, in the following steps, when the design possibilities have been deeply investigated in the specific details, they could use in the team group the immersive virtual model of their project to test the perception of an end-user into the space. The

Table 3.3 List of plots and design requirements

No.	Plots	Design requirements
1	Soundtrack	Soundtrack is an ensemble of four violoncellists, invited by the Foundation Teatro Grande of Brescia in occasion of the Opera Fest event, for an artist-in-residence program. The month before the event (in September) they have to prepare a specific track to present. During the period in Brescia, Soundtrack sets the unit in a public area, temporarily used by the Foundation Teatro Grande. In the unit, Soundtrack live, study, compose, practice and performance every day for the citizens
2	The Fugl	Mr. and Mrs. Fugl are a couple of retired researchers who have joined an international project that gives chances to study the mutations of aquatic birds in sensible areas of the planet close to touristic areas. The project runs through four years and involves yearly stays in specific Nature reserves in different periods, between one and three months. During the period, the Fugl can place the unit, owned by the WWF that is the project promoter, in an area between a camping and the nature reserve of Torbiere. The owners of the camping collaborate to the project in two ways: he gives for rent the installation space for the unit and he doesn't use the surrounding area in order to refresh the natural ecosystem regenerating the ecological connections. The Fugl stay at Iseo Lake camping area between April and July, during the years between 2019 and 2022, and then they reach the Berguzin Reserve close to the Bajkal Lake in Siberia for a three-month stay
3	Mr. Bresciani	Mr. Bresciani is an 80 years old man with mobility problems and passion for travelling. He is the owner of the unit and he subscribed a programme, promoted by a Touristic agency that proposed a special treatment to all those people that, like him, love travelling autonomously, but at the same time, need specific attentions. The programme allows the unit to be set in different touristic locations, where an integrated inbuilt equipped structure is located to support the units and to guarantee an easy accessibility for all. Mr. Bresciani's unit can also be set in his son's garden in Brescia for a fixed period—from one week until a maximum of 6 months—and it can be attached to the house in order to use all the facilities and the shared spaces. During the travels, the unit can eventually be set up to host a caregiver and two guests (the grandchildren)
4	Erasmus generation	Erasmus Generation is a programme promoted by an association of university hubs, joined by the University of Brescia, in order to help the students exchange during the Erasmus project, and/or among teachers who want to spend a period of time in an associated university for studying, researching and teaching. The associated hubs own a different number of units according to their internationalization goals (the University of Brescia owns 20 units, and it joined a free subscription with the municipal council that allows the temporary occupation of a plot, today used as a parking area, close to the university in Via Branze). On the plot is envisaged a public parking where a fixed structure has to be built to host the units during the exchange period (between October and June). Moreover, the structure hosts public facilities. The units are standardized and must include a living space for a single person and a studying space

(continued)

Table 3.3 (continued)

No.	Plots	Design requirements
5	Foreigners everywhere	The users join the experimental project for the Tintoretto tower retrofitting, promoted by the Brescia's Municipality (landlord of the units) and ALER (owner of the building). The experimental project involves building empty modular spaces into the structure of the tower, which can be temporarily used for different purposes, installing units with specific features. The functions that can be hosted inside the modular spaces are different. They can be: – temporary dwelling for the relatives that are visiting the users or that are helping their 'folks' with any possible issue, for a minimum stay of one month and a maximum of one year – temporary commercial activities such as the weekly market, or the Christmas market (one month maximum) – workshops for little familiar retails that need help during the beginning of the activity and that can become an initial aid for all those new families in the building, for a minimum period of one year until a maximum of five years – medical practices organized in small centres for specialist analyses and visits, that are joining together monthly
6	The Smiths	Mr. and Mr. Smith have joined the Brescia Pre-Alps programme for conservation and protection promoted by the mountain Communities that aims to maintain a hub along all the poor areas affected by flooding risk, where the private landlords cannot afford the maintenance costs. The programme involves the setting of a unit in the private areas (temporary convey to the mountain Communities for free) which mostly need environmental conservative interventions, for the time involved in the development of maintenance activities (lumberjacking, wood cleaning, local vegetation plants, water streams recovering, agricultural productions, etc.). The programme indicates that to keep sustainable the economical effort, the Smiths can develop retail activities, such as touristic-reception structures (within a maximum of 10 guests) and the fabrication and selling of natural products

housing unit boosts the optimization of the space, and the students were stimulated to find solutions in even small spaces considering the idea of temporariness of living conditions changing in the life cycle of the modern era and fluid society (Fig. 3.9).

The results of the project work have clearly confirmed that we are on the eve of a profound paradigm shift, aimed at digitally designing (in the full sense of the term that covers the spectrum between Gamification and Immersiveness), on advanced industrial bases, real estate goods and products. These have a strong intangible connotation related to Behavioural Patterns and Design Service. The Summer School aimed at analysing the possibility of structuring in the most efficient way the Architecture of Living Services for the actual realization of the house, through the definition of Data easing at verify the correct applicability in real contexts also from Urban regulation point of view.

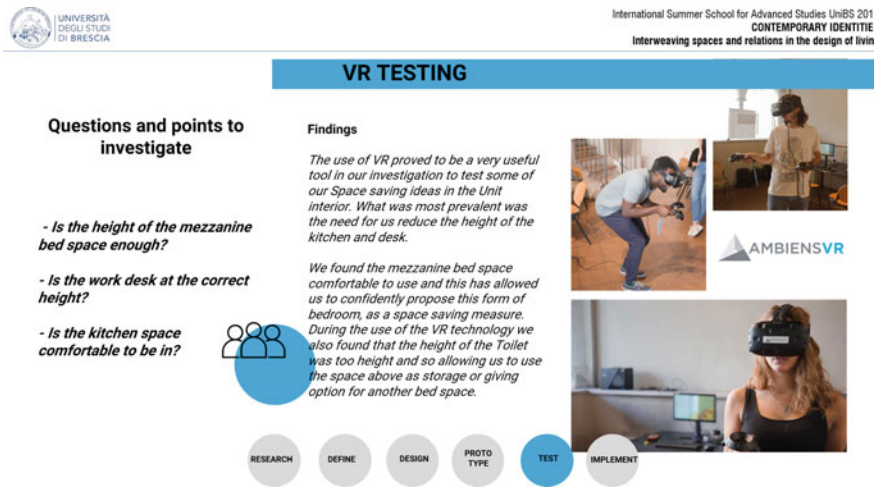

Fig. 3.7 Final presentation: analysis of the project issues with VR testing with Ambiens VR software. Students: Niza Nyimbili, Elena Fasser, Alberto Gaffurini, Matilde Tessari

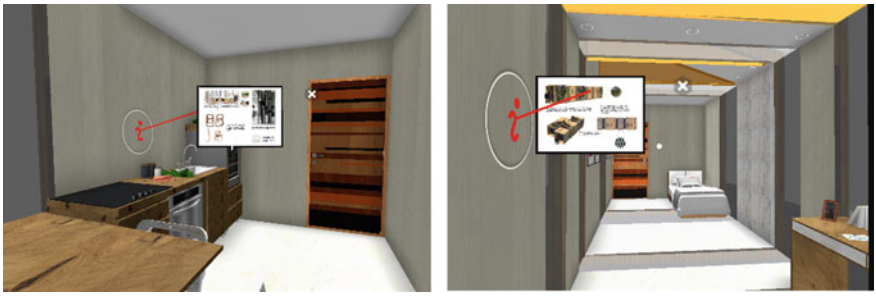

Fig. 3.8 Use of the digital model in the IVE with the technical information data enrichment

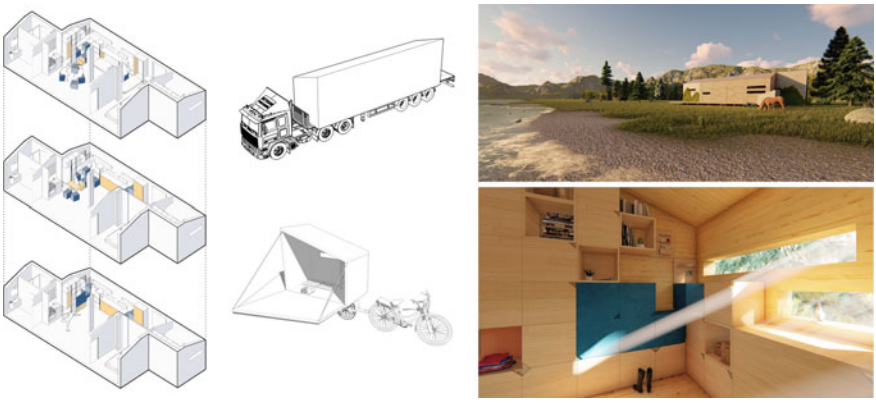

Fig. 3.9 Architectural project for the plot 2: *The Fugl*. Students: Viktoria Dimitrova, Gabriele Uberti, Franco Tomasoni, Aristide Troletti

3.5 Conclusion

The Summer School went beyond the self-referential logic and the infertile academic competitiveness, putting into contact, through the digitalization of the design process, different scientific disciplines with extraordinary local productive effect. For a week Brescia was an 'interdisciplinary and digital social laboratory' for the prototyping of temporary housing. Mobile structures that, in the near future, could temporarily to lean against, not only on the tested local cities or regional territory but also in other urban contexts unhinging, maybe, the current logic of urban development. This is why the final Jury of the ISS, which had the valuable participation of the Chancellor of the Brescia University, included representatives of the Politecnico di Milano (Department of Architecture and Urban Studies and Department of Mechanical Engineering), the University of Bergamo, Guangdong University, the Urban Center of the Municipality of Brescia, eFM, Italmesh and Marlegno, that positively evaluated the ISS results and outcomes considering also the value-adding students' satisfaction. Once again, the University of Brescia is one of the main national competence centres on the for the development of innovative and interdisciplinary learning systems aided by digital methodologies and advanced tools.

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Chapter 4
Towards a DSS: A Toolkit for Processes of Co-designing

Giuseppe Roccasalva

Abstract Urban transformation practices have often involved formative experiences in order to set experimental design approaches which have involved different points of views (expert and non-expert), citizens and public administrations. One of the challenges is to understand how design processes can work to induce or be aware of the opportunities/risks of various cognitive approaches within different case studies and design objectives. The arguments of this essay are based on a series of research and educational experiments of designing public spaces carried out between 2011 and 2015 at Polytechnic of Turin in collaboration with public authorities in the Piedmont area. From these experiences, a "toolkit" was built to combine different critical issues that must be considered to design the process rather than the projects. Smart design solutions can be influenced by the processes which lead to the design solution. The goal of ToolKit is to become a support system in collaborative processes of urban design while tackling the opportunity of using participative methods.

Urban design practices have defined many models [1] and supportive approaches [2] to study and implement project solutions. Each process can lead to different design results depending on what is occurring in each phase of the implementation; practices can have many different specific technical supports, inclusive innovative approaches and a clear definition of goals and their implication. In this regard, it is possible to employ a new tool which can support co-design practices by integrating different dimensions influencing the process development.

Projects of urban transformations are often developed with similar or 'standardized' processes. However, all processes vary according to different conditions as:

- the levels of inclusion we want/need to achieve
- the engagement techniques we are able to perform
- the design objectives we are starting from

This essay propose a matrix which relate the previous three conditions and the way these might occur in a design practice, even if we are conscious there is no explicit

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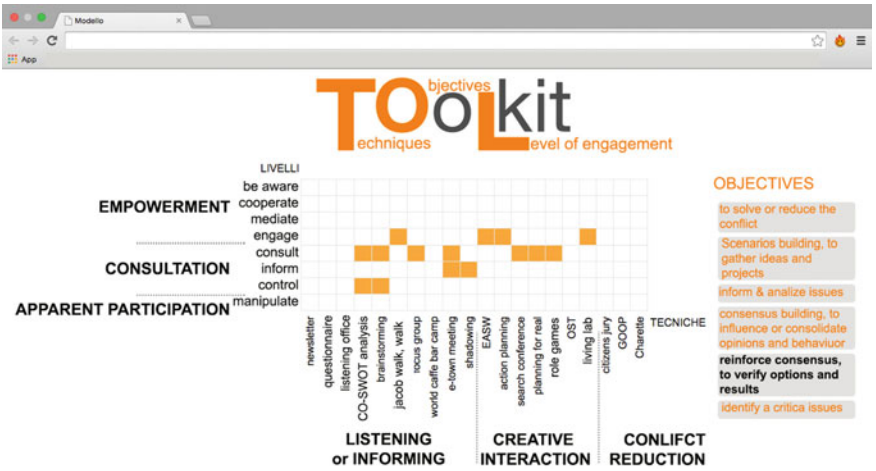

Fig. 4.1 Example from the Toolkit dynamic html page. The image shows in a synoptic view all the three different conditions influencing design process. More specific, the image shows the "techniques" and "level of engagement" which are possible to achieve if the "objective" selected is "reinforce consensus by verifying options and results of a given project"

dependency between the process we develop and the related design solutions (see Fig. 4.1).

On the vertical axis of the Toolkit matrix are listed different modes of engagement which goes from empowerment to manipulation depending on the type of people inclusion:

– which is possible to build (time or space or other reasons can reduce the capacity to build an engagement process on the design issue)
– which is deserved to be implemented (not all the persons are interested in the design process; it is important to "map" stakeholders in order to have an efficient process)
– which is requested form stakeholder (client, users or practitioners are often the generator of a co-design process; it is important to select the level of inclusion in accordance to active people).

Toolkit was designed from a serious of definition of engagement methods which are available in literature [3]. The matrix depict levels of inclusion that are commonly used in professional practices and that were frequently debated during the formative and research experiences carried on at Politecnico di Torino in collaboration with several public administrations of Piedmont. The levels include approaches which have the aim to manipulate/control/inform/share/consult/involve/mediate/coop/empower stakeholders in a co-design process. Toolkit gather all the levels of inclusion in three groups where co-design approaches are distinguished in:

- really inclusive
- partially inclusive

- apparently inclusive

On the horizontal axis of Toolkit matrix are listed the engagement techniques. Most of them are generally defined in community planning practices. Some of the engagement techniques are keen in using technology to share or collect data and opinion (from newsletter to OST) while other focuses on the method to include and organize people's opinion and choices (from Charrette to EASW). There are some techniques which are more focusing on dynamic and real-time analyses (shadowing, urban walking) and other which are more direct and non-time-consuming techniques (citizen Jury, focus group). Toolkit tried to make again a clustering of the horizontal category without thinking to make a specific order or evaluation. It came out that it is possible to distinguish engagement techniques among that:

- are used for listening or informing stakeholders
- are providing creative environment for making stakeholders interact
- are used for avoiding or reducing conflict in the engagement process

Out of the Toolkit matrix, there is a third category, design objectives, which is tightly connected with the horizontal and vertical conditions. Toolkit has listed some of the most frequent reasons from which a design process start. Either you are a Public Administration, a Company or citizen association, it is often needed to redeem some divergent opinion on a development, to collect ideas, to choose among different options or to build consensus among a project proposal. In accordance with your design objective, Toolkit shows the possible relation with the other two categories in order to support your design process with the suitable level of inclusion and a set of participatory techniques. All the categories are generally listed in the matrix, and they are not considered in a hierarchic terms, so it means that Toolkit do not consider a better versus worst approach, but it gives the possibility to the user to learn and decide which are the suitable processes for the selected conditions.

4.1 Toolkit's Aims and General Output

The relations of the Toolkit matrix were made on an ontological basis and then they were optimized in a more visible and understandable platform. In a relation which can be queryable, it was used a html dynamic grid which connect all the categories and subelements, and let the user be free to move from a detail to the whole matrix. The Toolkit grid allow to start from the category which is mostly interesting for the process we are about to design and see in advance consequences, opportunities and critical points.

It took more than two years of research to make a preliminary order among the different options of the three categories. All the relations among the categories were built upon a literature review [2, 3] and were matched against five co-design experiences carried on at Polytechnic of Turin [4] which have gathered more than 25,000 inhabitants between analogical and digital engagement techniques. The general purpose was to assist decision-making processes with a more integrated tool, support

experts and non-experts in choosing adequate processes that can enhance inclusive experiences in design practices while tackling the problem of using participative methods.

We are often witnessed of improvised urban co-design processes where there is no specific target, people are casually involved and techniques are poor of data and scope. The Toolkit promote the idea that thinking about the processes can help community to focus on 'how' to reach the design solution rather than 'what' might be the best design idea.

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Chapter 5
The Impact of a Research-Based Institutional Strategy for Opening up Educational Practices: The Case of the MOOC-Maker Project

Pedro Cabral, João Paz and António Teixeira

Abstract The MOOC-Maker project aimed to research on initiatives related to the development of management capacities in massive open online courses (MOOC). This paper presents the main experiences of the partner institutions in the MOOC-Maker project and describes the improvements achieved by the partner institutions in what concerns the design, development, and implementation of MOOC as a result of the research-based approach used in the project. In terms of methodology, we used content analysis of the different deliverables produced in the framework of the MOOC-Maker project and of the data retrieved from a dedicated survey sent to all partners. The paper elaborates on the definition, evolution, and major trends of MOOC, and open education, with particular emphasis on Latin America, characterizes the partner institutions, presents the main outcomes of the project, and finally, states a series of recommendations for quality improvement regarding the different phases of the MOOC production cycle: institutional planning, learning design, quality assurance, and certification procedures.

5.1 Introduction

The project MOOC-Maker, funded by the European Commission Erasmus+ , had a main purpose to conduct research on initiatives related to the development of management capacities in massive open online courses (MOOC). Supported by a research-based approach, the creation of an intercontinental network between higher

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education institutions (HEIs) from Europe and Latin America with this aim addressed the development of competencies and knowledge to fulfill the needs of current learners.

5.1.1 Open Learning and Massive Open Online Courses

The philosophy of the open learning movement which is materialized in the MOOC gathers three basic principles of our network society: freedom, scalability, and ubiquity. As proposed by de Waard et al. [1], these courses are by definition open and online in order to allow as many participants as possible with the option of free and open enrollment, have a publicly shared curriculum and accessible resources, and are facilitated by leading professionals in the field of study.

An alternative definition, by the OpenupEd initiative, describes a MOOC as "an online course designed for large number of participants that can be accessed by anyone anywhere, as long as they have an internet connection, is open to everyone without entry qualifications and offers a full/complete course experience online for free" [2, p. 1]. This definition has been validated among European institutions [3]. Another definition can be found in the ECO sMOOC pedagogical model, which defines MOOC as full/complete courses which should not only include educational content but also facilitate interaction among peers (including some but limited interaction with academic staff), provide authentic activities and tests, including feedback (with well-designed rubrics for peer assessment and AI engines for the integration of massive qualitative assessment), have some kind of (nonformal) recognition options, and provide a study guide or syllabus [2].

MOOC started as a demonstration of the new connectivist educational theory principles. The connectivist-inspired approach highlighted the disruptive and networked nature of the learning experience [4]. These courses are known as cMOOC for connectivist-oriented. According to the connectivist principles of learning, which are based on a participatory pedagogy and on networked learning, there is not a fixed body of content to be learned, "professors" teaching "students" or a single location where the course took place. Content results from the production of artifacts by participants, following their interaction with, and their reflection upon, a given set of resources (and other resources shared by them or by others), as well as the dialogue among participants around these artifacts. The organizers act mainly as facilitators and providers of some necessary structure, the "teaching" role being assigned to the learning community itself. And, although there is a course site, with the relevant information (weekly topics, list of suggested resources, synchronous session schedule, etc.) and forums where people can interact, the conversation is distributed by the participants' own spaces (mostly individual blogs) and several social network spaces [5].

However, the international wide impact of the MOOC phenomena is mostly linked with the initiatives led by the most prestigious universities in the USA, which focused on the potential of open online courses for massive scale distribution of high-quality

scientific content and for popularizing star professors and top institutions. This traditional learning approach is known as xMOOC. However, the phenomenon of MOOC is a rather complex one as it results from different kinds of approaches. This fact has important consequences in the diversity of formats used and features as well as the true nature and purpose of the educational experience they provide. In fact, although the above-mentioned cMOOC and xMOOC approaches seem to be dominant, other alternative formats have been emerging. Clark (2013) identified eight types of MOOC.

These courses have the potential to educate several learners who have not had the opportunity to get a degree in the conventional university system [6]. The emergence of innovation in MOOC reflects therefore the convergence of interests of developing social, economic, and technological progress in education in a global context. The potential exists for open education to play an important role in access education and to address issues and challenges of an ever-changing environment that needs new forms of access and offer. The path to an open education opens up opportunities for sharing ideas and collaboration between institutions, teachers, and learners, both locally and internationally, that makes the involvement in the teaching learning process more significant [7].

But are MOOC really open? In a certain way, yes. In reality, and if comparing with the type of opening of OERs and OCWs, the degree of openness of MOOC is limited [8]. Usually, the platforms that deliver the MOOC refer to themselves as repositories, leaving the question of open licenses for universities. However, it is difficult to add this type of licenses when the platform is not designed for that purpose [9].

The advent of MOOC forced an overview journey of the OER movement in what concerns their guidelines in the scenario of modern education. In fact, OERs are an important part of MOOC but do not define them [6]. According to Havemann and Athens [8], the process of opening up MOOC's resources does not only add value to the resources in achieving a wider community, but also promotes the authors and institutions that offer the MOOC. However, perhaps the aspect more important for institutions of higher education would be the possibility to demonstrate its commitment to openness and a better access to education for all.

Regarding the different institutional approaches to MOOC development in Europe and Latin America, in 2016 the WPD 1 (Status Report on the Adoption of MOOCs in Higher Education in Latin America and Europe) of the MOOC-Maker project observed the following major trends:

- The entrance of Latin America into the MOOC movement took place over a very short period and with greater intensity than Europe saw in its early days. Up to March 1, 2016, 418 MOOC were recorded in Latin America and 1,705 in Europe. Despite the difference in the total number of MOOC, the growth in terms of production in the Latin America region has been much faster.
- The production of MOOC is concentrated in a few Latin American universities, leaving the great majority of the region's university system out of the MOOC phenomenon. This seems to respond to the same pattern observed in Europe, where few universities account for the greatest production of MOOC.

- The subject areas with the highest representation in MOOC in Latin America are those that teach professional skills and applied sciences. The same phenomenon exists in Europe: Regarding course topics, those most represented fall under the field of professional skills and applied sciences in both regions. However, compared to Latin America, there has been an effort in Europe to produce MOOC in the areas of social science.
- Coursera, edX and MiríadaX are the platforms that host the greatest number of MOOC. However, more than 50% of MOOC courses are deployed via platforms specific to institutions (developed or maintained by the institution itself), a trend that could grow given the exclusivity policies of these proprietary platforms. Platforms with the greatest use in Latin America are Coursera, edX, and MiríadaX. However, the high number of institution-owned initiatives developed in this region is surprising, as approximately 50% of MOOC have been delivered via specific institution platforms.

5.2 Methodology

The present paper aims to synthesize the main experiences of the partner institutions in the MOOC-Maker project, and also to describe the improvements achieved by the partner institutions in what concerns the design, development, and implementation of MOOCs as a result of the research-based approach used in the project.

In order to fulfill the purpose of this paper, we did a content analysis of the different deliverables produced in the framework of the MOOC-Maker project (http://www.mooc-maker.org/?page_id=869) and of the data retrieved from a dedicated survey sent to all partners.

The survey had the following open questions:

- What was the impact of the MOOC-Maker project in your institution?
- As a result of this impact, which best practices in MOOC design and delivery have emerged (e.g., learning design, technological development and infrastructure, participants/student support, learning resources, learning analytics, assessment and certification, business model, and economical sustainability)?
- What are the most interesting success stories in the development of MOOCs in your institution, and how do they relate to the impact of the project?
- From your perspective, which steps does your institution still need to take in order to improve the quality of MOOC provision?
- Based on your experience in the MOOC-Maker project, please suggest a number of recommendations for institutions to improve the quality of MOOC design, development, and delivery.

5.2.1 Characterization of the Participant Institutions

The project had nine partners involved (three from Europe and six from Latin America):

- Universidad Carlos III de Madrid (Spain)
- Universidad Galileo (Guatemala)
- Graz University of Technology (Austria)
- Universidade Aberta (Portugal)
- Católica del Norte Fundación Universitaria (Colombia)
- Universidad del Cauca (Colombia)
- Pontificia Universidad Católica de Chile (Chile)
- Universidad de Chile (Chile)
- Universidad Panamericana (Guatemala)

At the start of the MOOC-Maker project, its member institutions were at different stages concerning the development of MOOC:

- Two had never developed MOOC.
- Four had developed more than six MOOC.
- Three had more than 10,000 enrollments.
- One had less than 1,000 enrollments.
- All had developed MOOC with a range of weeks between four and eight.
- All had different management processes, but it was more common to have a proposal and an entity which approved the development of the MOOC.
- The member institutions had different approaches to develop a MOOC: While some had low or no support from an e-Learning team (course design, video production, Web design, development of activities, implementation in the LMS, and course moderation), others had mid- or high support. Moreover, in some institutions, they had a coordinator of the project or a coordinator for the different stages of development; others had a quality check process; one institution had a "Bootcamp" module at the beginning of the course. What was common in all institutions was the existence of a scientific expert to define the content.

5.3 Results

Most institutions involved referred the critical relevance of their participation in the project as it allowed them to improve their quality standards and criteria, but also their course design, course delivery, and course materials produced.

5.3.1 Learning Design

In WPD 1.02 (Report about requirements on MOOC management and infrastructures in partner HEIs), it was identified that a MOOC should have learning resources (such as videos), formative and summative learning activities (which can combine automatic exercises, self-assessment and peer assessment, and forums). Moreover, the course should have duration between four to six weeks.

In WPD 1.03 (Report on management, administration and designing of MOOC), topics were addressed regarding the planning of the learning design. The first one is related to the teaching and learning model. As we stated earlier, different learning design models can be applied or combined. Therefore, we should have them in consideration. A second important point is related to the definition of learning objectives and the identification of previous knowledge required. The learning objectives should be aligned with the learning path and the assessment, which brings us to the third and fourth points. The learning path is divided into modules, and each module has a combination of instructions, content, and activities. Usually, this path starts with the module's introduction or/and presentation, followed by in-depth materials related to the topic's module, and a closure. The assessment depends on the pedagogical model, but needs to be aligned with the objectives and the learning path; therefore, we should have ways to assess if learners are reaching the learning goals. When it comes to assessment, we can develop exercises with automatic feedback, peer assessment, or self-assessment. The last two ones need to have rubrics to help participants.

Regarding the development of a learning design, WPD 2.5 (Package with materials for teacher training) and 2.6 (Package with materials for technical training) have tools which can help teams for that task. In WPD 1.9 (Report on technologies and infrastructures to manage MOOCs), the results argue the relevance of having a multidisciplinary team which can support the development of the learning design, and, at the same time, builds capacity in the teachers.

One of the results observed in WPD 1.9 (Report on technologies and infrastructures to manage MOOCs) was the need to have a multidisciplinary team for the course design, which can be able to deliver high-quality learning materials and activities. This team is also important in the professional development of teachers, since, by working directly with them, these professionals can train teachers to be more effective and efficient in the integration of ICT in their teaching methods. WPD 3.8 (Intermediate project evaluation) identifies that all training objectives were achieved for teacher, academic staff, and people who did not belong to any of the partner HEI.

In the survey, one of the institutions mentioned that the use of a MOOC Model Canvas was crucial for the analysis and design of their MOOC. Its use was instrumental to change the previous structure (which was based on video quiz approach).

5.3.2 Technological Development and Infrastructure

Besides the pedagogical concerns, the infrastructure and the available technology can limit the development of a MOOC. In WPD 1.2 (Report about requirements on MOOC management and infrastructures in partner HEIs), it is identified that is important to have a team capable of developing educational resources. Particularly in what refers to videos, it is important to use a studio (fixed or flexible) with video cameras, microphone, lightning, chroma key, and an audio console. Regarding the video's postproduction, it is necessary to have the appropriate software (WPD 1.9 identifies specifically Adobe Studio, Camtasia, or Captivate) and a computer with a Pentium i7 processor and 16 MB of RAM. Both WPD 1.2 and 1.3 mention the importance of deciding if MOOC should be developed in an existing LMS provider or if the HEI should create their own. Those decisions should be analyzed with the IT team. Specifically, WPD 1.3 (Report on management, administration, and designing of MOOC) refers some points to be considered during this decision:

- Management, maintenance, and delivery of content components which support students' learning
- Access to data of students' behavior in the platform
- Predicted model to support students' learning process
- Server to produce reports about the predicted model
- Adaptable motor.

WPD 1.5 (Report on promotion, visibility, and image of MOOC-related HEIs) identifies the necessity of having present in these decisions the usability and aesthetics of the platform, which should be accessible to anyone, no matter what disability the person might have.

In WPD 1.10 (The Application of Cloud-Based Tools in MOOCs: Experiences and Findings), different tools are identified to support MOOC's development and management:

- Authoring tools to create more attractive and interactive content and exercises
- Collaboration tools which aim for different activities' purposes
- Social bookmarking tools
- Content sharing and development tools
- Content creation tools
- Software development and programming tools
- Gamification tools
- Assessment tools
- LMS.

However, one of the major outcomes enabled by the project, which is identified in WPD 2.4 (Report on the improvement of technological infrastructure in the partner HEIs for the production and delivery of MOOCs, according to the implementation plan), is the technologic infrastructure improvement, specifically for ICT and Recording. In the first stage of the project, 18 recording equipment and 37 complementary accessories, plus 58 ICT equipment and 36 complementary accessories

were bought. For the final stage, more equipment and accessories were expected to reinforce the current technological infrastructure. Besides the hardware, two institutions have bought software. In fact, one of the institutions participating in the survey referred that the equipment allowed them to improve their course production, and another mentioned that they are now using different styles of videos (not just lecture style, but also interviews, tutorials, and other styles).

5.3.3 Participants/Student Support

As mentioned before, to support a big group of learners is necessary to create activities with automatic feedback or rely on peer feedback and self-assessment. Nevertheless, it is important that teachers show their presence in a MOOC. That presence can be observable in the announcements they make, their forum participation, or by giving a general feedback to the learning experience observed during each module. WPD 1.3 (Report on management, administration, and designing of MOOC) refers two roles assumed by the course team:

- Instructors—Specialists on the MOOC's topic and its development. From time to time, they might interact with the MOOC's participants.
- Facilitators—They coordinate their actions with the instructors and are more active during the course run.

Based on the information collected in the survey, at least one institution hired a group of tutors who support the different MOOC on a daily basis. This has led to an increased satisfaction of participants with their courses.

5.3.4 Learning Resources and Activities

Both learning resources and activities are a core element inside a course and should be aligned with the learning objectives and assessment.

In WPD 1.4 (Report on MOOC content production and pedagogical strategies), it is referred that content is traditionally organized in a vertical hierarchy (list of references to study). Nevertheless, in MOOC, they should be organized in a horizontal perspective, where you can find a direct connection between a content and the discussed theme. Furthermore, augmented reality, adaptive learning, gamification, or algorithms, which are able to predict learners' needs, may improve the ways to create resources. Content can be more formal (video, text, audio, and presentation) or more informal (blog, tweet, and social network). In the development of resources, WPD 1.5 (Report on promotion, visibility and image of MOOC-related HEIs) and WP 1.13 (Report on MOOC accessibility) mention that both usability and accessibility should be taken into consideration. It also identified the importance of having a balance in the number of different resources and activities. Regarding the activities,

WPD 1.4 (Report on MOOC content production and pedagogical strategies) identifies three types of activities that can be used in a MOOC and are interconnected: tasks, projects, and evaluation.

Concerning this topic, WPD 1.12 (Report on open educational resources (OERs) and massive open online courses (MOOCs)), stresses the importance of MOOC promoting open educational practices; thus, all resources and activities created in the course should be able to allow, at least, participants to retain, reuse, revise, remix, and redistribute.

5.3.5 Learning Analytics

WPD 1.3 (Report on management, administration, and designing of MOOC) identifies that learning analytics is the process of collecting, measuring, analyzing, and reporting data about learners and their learning contexts. Thus, it allows understanding and optimizing the learning process. With MOOC, this has a special impact, since it is possible to track all activities conducted by the learner. Thus, institutions have access to big data due to the very high number of participants.

Regarding the survey results, one institution refers that it is using the course data for research purposes on the learning experience in order to be able to improve it in the near future. Not directly related with the learning analytics, but with research, another institution is using the MOOC for research projects, development projects, and innovation projects.

5.3.6 Assessment and Certification

As referred previously, assessment can be divided into exercises with automatic feedback, peer assessment, or self-assessment. Regarding the exercises with automatic feedback, WPD 1.4 (Report on MOOC content production and pedagogical strategies) identifies that each person should have access to randomized questions. When we have exercises where we cannot use automatic systems, the best solution is to use either peer review or self-assessment. In both cases, it is necessary to build good rubrics. The weight of self-assessment in the final grade should be lower when compared with the other two types of assessment. In the future, it is expected that artificial intelligence will assume an important role in assessment.

WPD 1.8 (Report on MOOC's credits recognition between HEIs in Europe and Latin America) analyzes the certification process in MOOC. Typically, three types of MOOC certificates are offered:

- Participation—usually free; to obtain it, a learner needs to complete at least 60% of the activities.

- Completion—usually implies paying a fee and reaching specific completion requisites.
- Accreditation—usually implies paying a fee and learners need to submit to an identity control process. Some institutions require an examination (face-to-face or in a proctoring system).

5.3.7 Perceived Impact

This subsection draws from additional contribution from the American Latin partners. Only one of the partners has not answered the survey, but we may assume that the results are similar.

When we analyze the impact of this project in the different institutions, we can see similar results, but also some differences, probably due to institutions having different experience in this field and different expectations about the impact of the project. Table 5.1 resumes the impact in each institution.

Table 5.1 Perceived impact of MOOC-Maker project in the institutions

	PUC Chile	Univ. Chile	Univ. Panamericana	Univ. Cauca	Univ. Galileo
Training (teachers and staff)	X		X	X	X
Studio and equipment	X		X		X
Institutional policies	X	X			
Course development			X	X	
Publications and dissemination			X		X
Increase in the number of online learners				X	
Ph.D. projects in the area				X	
Installation of an OpenEdX platform				X	
Institutional exchanges					X
World visibility					X

Most of the success stories were identified in students' testimonials, where they refer the impact MOOC had in their life (mainly professional). However, there are also success stories related to the institutions such as

- The increase of online courses inside the institution (not just MOOC).
- The recognition of teachers' qualities, which has led to invitation as keynote speaker in different academic events.
- The reuse of MOOC materials on campus and the changes in the face-to-face teaching methods.
- The use of different activities to assess learners (e.g., digital portfolio and peer review).
- Giving access to knowledge to learners who, otherwise, would not have possibilities to access the university.
- The increase of learners (in some cases, 10 times more than the numbers they used to have on their campus) with no big change in the number of workers.
- Train other institutions on the digital learning area.

All the different project partners have expressed their strong commitment to improving the quality of their courses in the near future. In order to achieve higher quality standards, a number of recommendations were identified in the survey:
Institutional level

- Define clear and efficient procedures.
- Design and implement policies based on recognition and rewards for those teachers involved in the production of MOOC.
- Integrate the MOOC production in traditional practices through the idea of blended learning as a way of innovation so that teachers do not see MOOC as something completely new and disaggregated from their practices.
- Improve the institutional policies for online learning.
- Establish an institutional guideline for the MOOC design aligned with the communication team of your university to generate a "brand."
- Create other online initiatives.
- Involve all universities and democratize MOOC production.
- Set up a support team specialized in online learning.
- Expand the research group.

Learning Design

- Produce a reference tool (e.g., book) with best practices.
- Create new courses based on learners needs.
- Improve the learning activities with new tools.
- Implement training activities using cloud-based tools.
- Train teachers about video recording.
- Design scripts to record videos.
- Improve video editing and explore technologies, which allow interaction inside a video.
- Improve the quiz questions.

- Have a clear course structure (time, modules, different types of creative commons resources, identify formative and summative assessment).
- Incorporate gamification techniques to increase learners' participation.

Quality Assurance

- Have standardized surveys to check MOOC quality.
- Assure monitoring of all courses.
- Have beta testers to review each course.
- Certification.
- Expand the number of institutions that recognize credits by doing a MOOC.

5.4 Conclusions

The MOOC-Maker project aimed to build or improve the capacities of Latin American universities to plan, design, and deliver MOOC and other open educational resources. Its main purpose was to foster access to high education opportunities and to have a significant social impact by leading to higher employability. The results from the project activities demonstrated the achievement of those broad objectives.

More particularly, results show how the project has contributed to increase the capability of partner institutions to produce quality MOOC. Both in terms of the required equipment and facilities, and most importantly, in what relates to the pedagogical design and delivery methodologies used. This resulted from the fact that all institutions have demonstrated a strong commitment to the MOOC-Maker initiative and have dedicated efforts and resources to carrying it on. Several of the universities involved in the partnership have started almost from scratch to achieve success and high satisfaction rates from participant learners. They have accumulated a strong experience in the process.

In this report, we have described the most relevant practices used by the partner institutions on MOOC management and presented the most significant good practices identified. A number of recommendations for quality improvement regarding the different phases of the MOOC production cycle (institutional planning, learning design, quality assurance, and certification procedures) were also presented. We believe these can contribute to enhance the quality and impact of MOOC production as well as the open learning experience provided by Latin American universities.

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Chapter 6
Engagement in a Blended University Course

Rosa Di Maso and Maria Beatrice Ligorio

Abstract The paper presents an exploratory study on the involvement of students within a blended university course that implements a series of collaborative activities aimed at developing both specific e-learning and transversal skills (social, cognitive, and metacognitive). The aim is twofold: (i) to observe the evolution of students' involvement during an informal discussion, occurring in an online forum; (ii) to analyze the role played by the tutors who monitored the course. A data set consisting of 978 messages produced by 42 students and two tutors, produced during 9 weeks of the course, was analyzed. The messages have been coded through a purposely created category system. Furthermore, the data has been collapsed into three time periods, each lasting three weeks. The results highlight how the role of the tutor is very important at the outset of the course to sustain students' involvement, whose commitment grows along the course. The high level of involvement explains students' feeling of missing the online interaction in the periods when the platform is less used or when the conclusion of the course is approaching. Finally, also negative aspects related to an initial skepticism for the new approach or to the stress of the deadlines have been faced by the students with reciprocal encouragement.

6.1 Introduction

The term "engagement" refers to a series of behaviors implemented by students who claim to be more involved in their learning environment compared to their less involved peers [5]. In the case of university students, engagement refers to the time, energy, and resources that students dedicate to learning activities [6]. Astin [2] argues that students learn when they are involved. The involvement, therefore, contributes positively to achieve good results, to persist in work and to feel satisfied [7, 11, 4].

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The university institution should understand and satisfy the needs of students coming from different backgrounds. The challenge is to propose stimulating activities that give a sense of cultural and professional growth and avoid boredom and lack of interest that causes dropout and deactivation. New technologies represent a useful tool, with different potentialities, for instance by proposing models of e-learning and blended learning, but often the problem arises of how to maintain active involvement of students online. One of the possible ways to support involvement and engagement is to introduce the figure of the tutor identified in a more advanced peer, which acts as a mediator between the teacher and the students in order to deal with the conflicts and problems that may emerge especially, at the beginning of the course. Although engagement implies student autonomy and empowerment, the tutor can support students in living fully the relationships and activities within the digital environment.

Barab et al. [3] argue that the authenticity of online activities is not in the students, in the tasks or in the environment, but in the dynamic interactions between these various components, not taken in isolation, but as a single flow. Students need to be immersed in something familiar to them. The tutor can support exactly this process.

6.2 Objective

The objective of the study is to observe how engagement evolves during an informal discussion, embedded into an online forum monitored by purposely trained tutors.

6.3 Context and Participants

The research was carried out in an online forum, specifically dedicated to informal discussion, embedded into a course about psychology of education and e-learning, taking place at University of Bari (IT). The course is held in blended mode and implements a series of collaborative activities aimed at developing both specific e-learning skills and transversal skills of a social, cognitive, and metacognitive nature.

The structure of the course is rather complex, and the set of activities are composing a model called Collaborative and Constructive Participation (CCP). This model has been developed through more than 10 years of consecutive application [7–8]. First of all, the course is divided into two modules. They have similar structure but different stakeholders and aims. Module 1 is aimed at providing theoretical information about online learning strategies and e-learning. Students are required to build educational objects working either in groups and individually (more details about the activities will be given later). This module works as a modeling for the subsequent module. Module 2 offers to students the opportunity to put the knowledge acquired in practice. During this module, they work with and for external partners (e-learning

companies) and they are required to build "real" professional objects. The proposed activities can be classified as follows:

6.3.1 Independent Individual Activities

Two activities are included into this category: (a) compilation and maintenance of an individual e-portfolio which includes personal information and material such as photographs, reflections, links to Facebook pages or blogs. Furthermore, at the end of each module, students are required to insert into their e-portfolio what they think are their best products and to list what they think they have learned and what they intend to learn in the next module; (b) compilation of a self-assessment grid. The grid is composed by questions aimed at favoring the development of critical self-assessment and recognition of the skills learned.

6.3.2 Individual Interdependent Activities

These activities are meant to support individual responsibility in a social context and to offer a structure shaping students participation. The activities included in this cluster are: (a) writing a review. To each student is assigned a specific learning material (a chapter, a scientific article, a Web site, etc.), and they are required to write individually a critical review which summarizes the salient contents. Each review is an individual but interdependent because, once the reviews are completed and posted online, groups are formed with the task of reading all of them, comparing them and building a collaborative product (a collective text, a map) and synthesizing and integrating all the reviews.

Role Taking. This technique allows members of a group to take on a function explicitly defined within the educational context, which involves specific tasks and responsibilities, aimed at supporting individual participation toward the achievement of shared objectives. Examples of roles implemented within the course and assigned in turn to students in both modules are:

- E-tutor: The student covering this role coordinates the group discussion, manages times and spaces, and monitors the development of the other roles. The student who performs it must have clear objectives of the discussions and of the connected tasks. The tutor becomes the temporary leader of the group.
- Synthesizer: The task of who takes up this task is to summarize the group discussion. It is a role of a metacognitive nature, as it promotes the competence to analyze and describe the dynamics and methods of discussion independently on the contents. In particular, he/she looks at how the discussion progresses, from facts and data to ideas and knowledge building.

– Product Manager: This role is aimed at managing and monitoring the process of building collaborative products (see small group activities). Taking this role stimulates coordination skills and the ability to supervise group work finalized to the construction of a collaborative product.

6.3.3 Small Group Activities

These activities are organized so that they can be performed only within a group. In module 1, the product is the result of the reviews' comparison; in module 2, the product is built under the guidance of the e-learning companies involved.

Data analysis was performed on a corpus of 978 messages produced by 42 students and two tutors during 9 weeks. To analyze these messages, a qualitative methodology was used, which involved three expert coders and three reading rounds. In the first round, two coders read the whole corpus to become familiar with the material. They selected parts deemed relevant to the goals of the research and performed a first coding independently. The two coders compared their results and consulted an experienced researcher to discuss controversial categorizations and doubtful cases. A second round of reading on larger pieces of data with a new comparison with the third researcher followed. Finally, during the third reading round, it was possible to define a category system and the whole corpus of data was coded. The categories obtained are:

- Scaffolding Tutor: These are the messages written by the tutors in order to support the students from the technical point of view, for doubts related to the use of the platform, and to support students.
- Troubleshooting: In reference to all the doubts, perplexities, and difficulties students reported.
- Off-line references: Relating to events and activities related to the part of the course taking place in the classroom or in any case not online.
- Collaboration: Related to all collaborative activities undertaken online.
- Controversies: Whenever reference was made to different points of view and various disputes related to the course but also to experiences in courses.
- Engagement: Referring to the degree to which students feel involved in the course and in the platform.
- Detachment: Referring to the feeling of missing the course and the peers known therein.

Below is a table reporting the categories described, accompanied by the explanation of how are they connected to engagement and an exemplary extract (Table 6.1).

In order to trace a change in the interaction, the corpus of data was divided into three periods: Period 1 (the first three weeks), Period 2 (from week 4 to week 6), and Period 3 (the final three weeks).

Table 6.1 Categories' table

Categories	Exemplary extracts
Scaffolding Tutor	"Tell us in detail what is the problem you encountered in login in. I will be happy to help you. Meanwhile, here you could talk a little bit about yourself just to get to know each other informally before we start!"
Troubleshooting	"Hello everyone, unfortunately I can not find the questionnaire to fill out and I can not access forum community from the phone. Does any one can help me?"
Off-line references	"I hope this course will give me all the practical and practical skills that can actually be used in the workplace"
Collaboration	"I figure that working together to build a product will allow us to achieve better results than if we had done it individually"
Controversies	"I graduated in February, in Education Sciences while most of you graduated in psychology. Perhaps we have different ways of seeing things. I'm beginning to wonder if I made the right choice by enrolling in this course"
Commitment	"This platform really starts to be useful! We are a nice group!"
Detachment	"It will be hard not to be together again online in the next semester"

6.4 Results

A category has been associated with each message and, subsequently, the percentage of messages assigned to each category has been calculated. Below is the graph that compares the frequency of the three periods (Fig. 6.1).

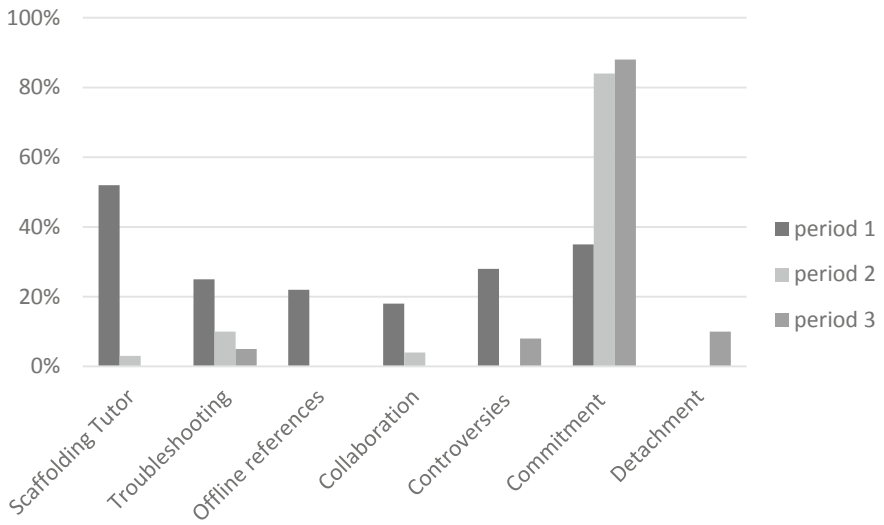

Fig. 6.1 Comparison of the frequencies in the three periods of the course

The graph shows that:

The "Scaffolding Tutor" category records a high frequency in Period 1, decreases dramatically in the Period 2, and totally disappears in Period 3. This shows that in Period 1 the tutors deeply deployed their actions offering a sort of reception to the students. Gradually, students become independent and the tutor's intervention was no longer needed.
The "Troubleshooting" category displays a steady decrease over the three periods. Probably, the students become familiar with the platform and therefore feel progressively more comfortable with it.
The "Off-line references" category is only present in Period 1. One possible explanation of this result is that students—from Period 2 on—feel totally immersed in the virtual environment and they no longer quote what it is happening off-line.
The "Collaboration" category, again, appears only in Period 1, in particular in terms of expectations and hypotheses of what actually implies. We reckon that in the two following periods this dimension was discussed during the various online activities, carried out in other sections of the platform.
The category "Controversies" appears during Periods 1 and 3. During Period 1, students refer mainly to their different educational backgrounds. In Period 3, these differences are described in terms of complementarity and integration of the different points of view emerged during the discussion.
The "Commitment" category is the only one that increases progressively across the three periods. From the data examined, we noticed that students use the platform more frequently and with increasing enthusiasm.
The "Detachment" category is only present in Period 3; it includes farewell and greeting messages.

6.5 Conclusion

The objective of this study was to examine the engagement in a blended university course and to understand the role played by the tutors. From the results obtained, we understood that the tutors seem to have played an important role in particular at the outset of the course, and then, it faded away. The "Commitment" was the category that has grown most and continuously across the three periods. The involvement was such as to feel the gap in the periods when the platform was less used or at the final moment of the course. The informal discussions, therefore, have helped to create an atmosphere of involvement that, probably, has allowed the qualitative change observed within the category "Controversies." Initially perceived in a negative way, the differences in terms of attitude or believes in Period 3 were appreciated and considered as supporting the learning process. The initial skepticism of some students on the new approach with which they were about to tackle turned into enthusiasm in the project, despite the fatigue during some stressful moments during the semester.

Even the negative aspects, such as the stress at the time of the internal deadlines, have been addressed together by the students, encouraging each other. At the end of the course, the students said they felt involved and satisfied with the results obtained.

The study presented here certainly has many limitations. For instance, the corpus of data is limited and referred to only one course. In fact, this is an exploratory study, but, nevertheless, the results gathered encourage us to further explore the function that tutors can play in supporting engagement in online courses, where students are required to work together often without knowing each other and without previous experiences either in digital environments or in collaborative activities.

A future direction could be to investigate the relationship between the engagement and students' academic achievements. We have already collected students' testimonies describing the course as highly educational, in terms of both learning outcomes and possibility of finding an employment [1]. Nevertheless, it would be interesting to explore what they remember about the content of the course, if this experience actually changed their learning strategies and how much the informal online environments supported also self-regulation and collaborative learning.

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Chapter 7
Empowering Engagement in a Technology-Enhanced Learning Environment

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Abstract Engagement is one of the most powerful driving forces that moves learners forward in a learning experience. The effects of engagement are related to satisfaction, learning results, and reduction of drop-out rates. School engagement can be positively influenced by problem solving and technology-enhanced learning activities. This paper discusses how online interactive activities can promote engagement in Mathematics at school level. After discussing a theoretical framework for defining and measuring engagement, the potentialities of activities with automatic formative assessment used in a blended environment are illustrated. The activities have been experimented with 299 students of grade 8 in Italy; their effects on student engagement are evaluated through questionnaires administered before and at the end of the project. The activities resulted particularly effective with regard to the increase of the engagement level of students who showed a low interest in Mathematics at the beginning of the project.

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7.1 Introduction and Theoretical Framework

Engagement is one of the most powerful driving forces that move learners forward in a learning experience. It can be defined as "students' dynamic participation and co-participation in recognition of opportunity and purpose in completing a specific learning task" [1]. It is a multidimensional construct, whose main dimensions, recognized by most scholars, are behavioral, emotional, and cognitive [2]. When students are engaged in a task, they tend to keep focused, to enact deep learning strategies, to achieve good results, and even to get satisfaction out of their activity; on the other hand, disengaged students often have difficulties in achieving success [1]. Students in low socioeconomic status might find it harder to be engaged in learning activities than students coming from medium–high social classes, due to the greater difference they may perceive between their school and home environments; this might be a root cause for dropouts [3]. Educational technologies as interactive learning environments can facilitate the development of engagement, as they enhance the possibilities to activate learning-by-doing strategies, increase the chances of interactions, and can facilitate self-regulation and adaptive learning through formative assessment [4]. In this paper, we present and discuss an experimentation where interactive technologies were used in order to improve students' engagement in mathematics at grade 8.

7.2 Methodology

This research is aimed at understanding if technology-enhanced didactic interventions based on problem solving and automatic formative assessment can affect engagement in students of 8th grade in mathematics. In order to investigate this issue, a didactic experimentation has been designed and realized in the city of Turin (Italy) in the 2017/2018 school year by the University of Turin in collaboration with the National Research Council. The project involved 299 8th grade students attending six different schools. About half of the students belonged to lower socioeconomic classes, while the other half to middle–high social class. For the whole school year, all students with their teachers had access to an online platform populated with interactive worksheets with real-life mathematical problems coupled with automatically assessed quizzes [5]. Problem-solving tasks actively involved the students in the exploration of data, in the paths toward the solution, and in the abstraction of the mathematical models used in solving the problem. The quizzes were algorithm-based, so that at every attempt values, formulas and graphs changed; they admitted open answers evaluated for their mathematical correctness, and they provided students with immediate and interactive feedback, which actively involved them in a correct solving process [6]. All the students filled in an initial and a final questionnaire before and after the project, which aimed at investigating their level of engagement toward school and, more specifically, toward mathematics.

7.3 Data Analysis and Results

Answers to the questionnaires were treated through factor analysis in order to individuate the three components of engagement; six standardized variables were created, representing the initial and final levels of emotional, behavioral, and cognitive engagement. Through cut scores, the sample was split into three groups, corresponding to the low, medium, and high level of initial engagement. The increase of each engagement's component was examined; in particular, its dependence from the initial level of engagement and from the socioeconomic status was tested through ANOVA. According to the results, engagement increased more in students who were initially little engaged in mathematics than in those who were initially highly engaged. Moreover, engagement increased more in students from lower social classes than in those with high sociocultural background. We believe that engagement was elicited by the nature of interaction enabled by the interactive files and by the automatic assessment, which supported the exploration and the understanding of complex concepts, facilitated teachers' explanations in the classroom, and allowed students to self-correct and understand mistakes.

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Part III
Schools: Evaluation and Design

Chapter 8
The ASLERD Pyramid of Smartness: A Study on the Stability of Indices and Indicators in Schools

Carlo Giovannella

Abstract In this paper, we present the outcomes of a participatory evaluation of the smartness of a sample of Rome's schools conducted over two years. The analysis of the results allowed:

(a) to follow the evolution of the schools on the smartness plane; i.e., the plane identified by the two principal components extracted from a PCA analysis applied to the indices derived from the multidimensional evaluation of the schools' smartness;
(b) to study the stability of indices and indicators and identify possible strategies aimed at shortening the questionnaires and make its use more agile for future runs.

8.1 Introduction

In 2015, the 17 Sustainable Development Goals of the 2030 Agenda for Sustainable Development have been adopted by the United Nation summit, and since that decision, all countries are expected to mobilize resources and make all needed efforts to achieve them and, thus, promote prosperity while protecting the planet. Among the SDGs that can be considered at the foundation of the people's life improvement and of a sustainable development, there is the "quality of education" (SDG 4).

What is expected to be a "quality education" in the UNESCO vision? According to the targets that have been defined for SDG4, quality means free ad equal access to pre-primary, primary, and secondary education for all boys and girls (gender equality and inclusion), and in particular to technical/vocational high school; to support the development of skills (both transversal and hard skills) for employment, decent jobs and entrepreneurship, sustainable development, and global citizenship, while

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assuring that a substantial proportion of adults, both men and women, could achieve, at least, a reasonable level of literacy and numeracy [1].

Of course, such commendable goals can be achieved only if learning ecosystems will be capable to offer adequate conditions for operational sustainability. In the UNESCO vision, it would be important to have:

- adequate physical infrastructures, i.e. safe, inclusive environments that nurture learning for all, regardless of background or disability status;
- a large number of scholarships (in particular available to developing countries and least developed countries), also to develop vocational training and information and communications technology, technical, engineering, and scientific programmes;
- the qualification of teachers (in particular available to developing countries and least developed countries).

Although these are three key aspects for the achievement of the 2030 agenda for Sustainable Development, they denote also a limited understanding of:

(a) operational conditions and daily problems that nowadays characterize schools of, even, developed countries (partially due to the changes induced by the technological revolution driven by Internet);
(b) the complexity of the learning ecosystems and, thus, of all components that contribute to determine their level of smartness [2];
(c) the role that can be and it is already played by ICT, together with their sustainability [3].

The development of an adequate set of competences [4]—like the transversal [5] or the sectorial hard ones, that go well beyond literacy and numeracy—implies a sort of revolution in learning design and didactics: from contents and goals oriented to experience-oriented learning processes. Even leaving out the impact of ICT on learning (technology-enhanced learning), such pedagogical and strategic revolution requires, anyway, a generation of teachers trained to design and manage competence-oriented learning processes [5–7]. Actually, the ability to design and actuate such learning processes is a rare teachers' skill, even in the developed countries. In this latter, moreover, from the students' point of views, the main problem is not represented by the access to education (with the exception of some highly critical and degraded areas) but, rather, by the lack of attractiveness of the learning processes. They are much more captivated by the offer of what now we have to consider the fourth educational and socialization agency: the Web. In addition, one can observe also a strong hard skill mismatch: among those that can be developed into the schools (i.e., technical and vocational schools) and those that are actually required by the market [8].

These are only some of the elements, although already very relevant ones, that may prevent to achieve SDG4.

Since schools are very complex learning ecosystems, one has to go beyond the UNESCO vision and consider a lot of aspects that are relevant to realize a high-quality *place* (rather than a *physical space*) for learning, where high-quality educational processes can be realized to implement high-quality learning. To this respect, a

useful framework of reference to determine the "quality" of learning ecosystems, like the schools, is the one that we have proposed recently and that is based on the multidimensional index called *learning ecosystem's smartness* [2].

A learning ecosystem is "smart" not when own up-to-date ICT facilities. This is only a causal positive condition that by itself is not capable to assure quality. Instead *a learning ecosystem is smart when it is capable to assure an adequate level of well-being (driven by the learning ecosystem's smartness) to all actors that take part in the learning process*: students, teachers, families, territorial stakeholders, etc.

It is trivial to state that the functioning of complex organisms like schools could be deeply influenced by ICT on many respects and thus, of course, their smartness. Administrative processes, communication interaction, and didactics can take advantage by the *e-maturity* [9, 10] of the school that implies, at least: (a) the mastery of an adequate e-literacy by all actors that contribute to the educational process; (b) the access to reasonable ICT facilities (network, hardware, and software) and their meaningful use; (c) a vision and adequate policies to manage the technological evolution. In the following, however, we shall not deal with the *e-maturity* of the learning ecosystems that would require separate investigations. Nevertheless, we want to launch a warning on an aspect that too often is not considered and that needs a careful investigation: the sustainability of the ICT facilities [3] of learning ecosystems.

Here we prefer to concentrate on the *smartness* of learning ecosystems, that in the recent past, we have operationalized with the aim to measure it. In the next paragraph we first introduce the framework of reference, i.e. the ASLERD [11] pyramid of the smartness of the learning ecosystems that integrates Maslow's pyramid of needs [12] and the Csikszentmihalyi's concept of flow [13]; and then we describe the measuring/monitoring tool—the ASLERD questionnaire—that can be flexibly adapted to various categories of learning ecosystems: e.g., universities [14] and schools [15].

In the school case, the ASLERD questionnaire has been developed first for the case of Italian schools, and this has required a careful consideration for the expectations of the local Ministry of Education (MIUR) on schools' evaluation [16]. Accordingly, the ASLERD questionnaire had to include quite a large number of indicators and, of course, questions. The questionnaire has been specialized for each category of actors and has been used in 12 schools to detect their level of smartness. The outcomes produced by the questionnaires have been largely appreciated but those that took part in the survey found the questionnaires too long. The complaint is fully understandable if one considers that, due to the large number of indicators that one had to work out, the questionnaires were composed by 75 (for parents and students) and 96 (for teachers) open and closed questions.

In order to explore possible strategies to reduce the number of questions (that unavoidably should be related to the stability of indices and indicators) in five of the schools that participated in a first survey, after one year, we have administered the questionnaire again and performed a comparative analysis between the outcomes of the two runs and among schools. In the following, thus, after the description of the structure of the questionnaires that have been designed to map the ASLERD pyramid of the smartness, we present and discuss the outcomes of the surveys in

terms of evolution of school smartness, and, finally, we present a comparative study on the stability of indices and indicators derived from the ASLERD questionnaires.

8.2 The ASLERD Pyramid of Smartness and the Questionnaires to Measure the Schools' Smartness

Figure 8.1 shows the ten levels of the ASLERD pyramid that have been obtained by integrating the Maslow pyramid of needs [12] and the dimensions involved in the definition of the Csikszentmihalyi's concept of flow [13]. Table 8.1 shows how these dimensions have been mapped on learning ecosystems. It is worthwhile to stress that, in the case of schools, the basic needs include all conditions that are deemed relevant to run the educational process smoothly and to avoid stressing conditions

Fig. 8.1 ASLERD pyramid: the ten dimensions that define the smartness of learning ecosystems

Table 8.1 Mapping among: (a) the dimensions of the ASLERD pyramid (middle column); (b) the levels of Maslow's pyramid and the flow dimensions (left column); and (c) the Eurostat indices of well-being (right column)

Levels of Maslow's pyramid (MP) integrated to the dimensions relevant to determine the flow state (FS)	Dimensions of the ASLERD pyramid of learning ecosystems' smartness	"Quality of life" indices defined by Eurostat to measure the level of well-being
MPI: basic physiological needs	• Resources • Info/admin services (to include process governance) • Environment • Mobility • Food	• Material living conditions • Governance and basic rights (i.e., public services) • Natural and living environments
MPII: safety needs	Safety (physical)	• *Economic* and physical safety • *Health*
MPIII–IV: psycho-social needs (i.e., belongingness, estimation, and prestige)	Social interaction	• Social interactions *and leisure* • *Governance and basic rights (i.e., equal opportunities and active citizenship)*
MPV: self-actualization (achieving one's full potential) also part of FS	Self-realization	Overall experience of life education
FS: satisfaction (also related to MPV)	Satisfaction (working well-being)	*Productive or main activity*
FS: challenges	Challenges	

for the individuals. Table 8.1 shows also a comparison between the dimensions of the ASLERD pyramid and those identified by Eurostat as indicators of the quality of life and well-being [17]. They map quite well each other, and this leads us to state that the *smartness* of the learning ecosystems can be considered also a measure of the *well-being* of the actors that take part in and animate the educational processes. The main differences reside in the economical safety and in the health services that are not so relevant in the case of school ecosystems.

Table 8.2 shows the list of the corresponding indices and indicators that have been identified as relevant for school ecosystems. It is worthwhile to stress that: (a) the index *mobility* (although it has been measured) has not been included because it has been deemed not so relevant for schools like for spatially extended campuses; (b) the social level has originated two separate indicators, *social interaction* that reflects the internal climate and *social capital* that reflect the relevance of the school for the community and the territory of reference; and (c) all the dimension relevant in the generation of a flow state at the individual level have been integrated to produce a unique index: *flow* index.

Table 8.2 Indices derived from the dimension of the ASLERD pyramid adapted to schools (left column) and corresponding indicators (right column)

Index	Indicators
Resources	Infrastructures; equipment; and professional competences
Process	Info/admin services, design, actions, and governance
Environment	Internal
Food	Internal and external services and facilities
Safety (physical)	Inside and outside the school
Social interaction (internal)	Social climate (*general climate and harmony among peers*) Support to socialization (*inclusion/integration, valorization of diversity and support to social interaction*)
Social capital	School–families interaction; families involvement; school–territory interaction; and students' social competences
Flow	Working well-being (*appreciation competences and results, opinion consideration*) Self-development and realization (*including continuous training*) Opportunities and challenges (included SWA schemes)

8.3 A Comparative Analysis of Schools' Smartness Over Two Years

As already described in previous work [15], after their validation, the questionnaires have been proposed online to the members of the three main categories of actors of the educational processes—students, teachers, parents—to realize a participatory evaluation in 12 high schools. In five cases, the evaluation has been repeated in two subsequent school years and allowed for a comparative analysis of the evolution of the learning ecosystems. The collection period varied from school to school, on average about one month. The number of filled questionnaires varied also from school to school. Considering only the five high schools where we have run twice the participatory evaluation, we have collected 3295/4118 (first run/second run) student forms, 261/222 teacher forms, and 277/236 parents form. These figures testify a generalized difficulty to involve parents whose participation in the evaluation process was quite low (less than 10% in almost all schools).

After having extracted the values of the eight indices listed in Table 8.2 for each school, we have used them to perform, as usual, a principal component analysis (PCA) [18, 19] to compare the level of smartness of the schools and, as well, to detect the evolution of the smartness level that occurred in slightly more than one-year time. Figure 8.2 shows the position of all schools in the plane represented by the two principal components, Y1 and Y2. The value of Y1 is determined in an almost equivalent manner by all indices with the exception of the *food* one. The value of Y2, on the other hand, is determined mainly by a large negative contribution of *food* index and by a less relevant and equivalent contributions of the index *safety* (negative) and indices *social capital* and *flow* (positive).

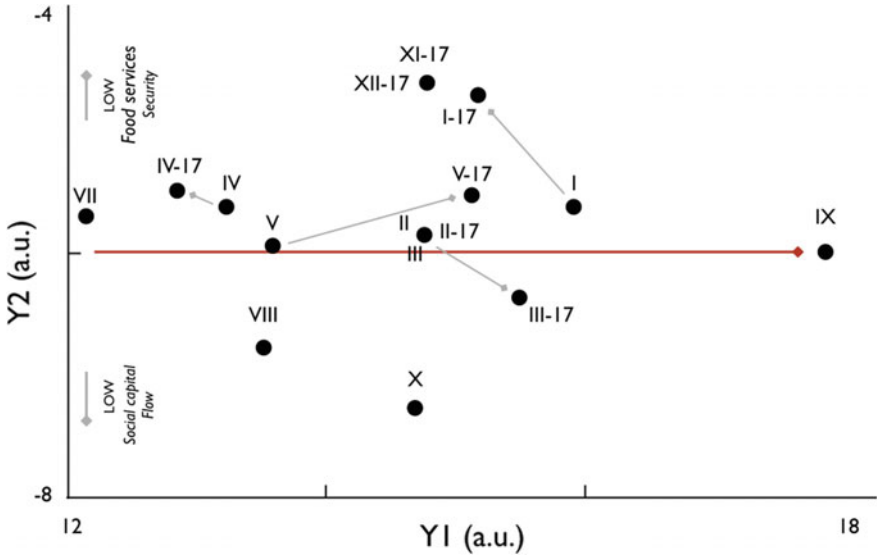

Fig. 8.2 Positioning of the schools on the plane identified by the two principal components, Y1 and Y2 derived from the PCA. The red line indicates the direction of increasing "smartness." The gray arrows highlight the displacement of the school position in the Y1–Y2 plane occurred between the first and the second run of participatory evaluation

We have detected a meaningful displacement of the position for four of the five schools where we have performed the second run of participatory evaluation of the school's smartness. In the case of school V, we have observed the largest displacement, and, by inspection, we realized that it was determined by a more or less relevant increase of the values of all indices listed in Table 8.2. School III is characterized by an overall rightward displacement that appears to be determined by a less relevant improvement of the value of all indices, being the larger ones those of the *resources* and of the *food* (that determines the downward displacement). The small displacement of school IV is determined mainly by the decrease *of the environment* index and by a less relevant decrease of the *food* one. Finally, the large displacement of school I is determined mainly by the decrease of the value of the indices *environment*, *social capital*, *process*, and *food* being the latter the most relevant one.

It may be worthwhile noting that school IX is a private school, the only one considered in this comparative study.

Since Fig. 8.2 offers an overview on the level of *smartness* of the schools and on how it can vary in one-year time—together with some hints on the dependence of the displacements on the values of the indices—it may serve as a good basis to produce a *social reporting,* based on a quantitative and qualitative (open questions) bottom-up multilevel comparative evaluation of the learning ecosystem. Of course, a social reporting would require a more detailed analysis of the collected data aimed at segmenting the opinion of the various categories of actors involved in the

educational processes and at analyzing the indications that can be extracted by each single indicator and, as well, by the answers to open questions. However, this kind of detailed analysis and the social reporting is beyond the scope of this work and will be dealt with in forthcoming papers.

In the next paragraph, we will concentrate on an overall comparative analysis of the variation of the indices in order to explore available margins to reduce the length of the questionnaires.

8.4 About the Stability of Smartness' Indices and Indicators

Table 8.3 shows the mean value of the indicators (together with their semi-dispersion) that have been worked out considering only the five schools for which we have performed two runs of participatory evaluation. The mean values tend to be quite stable while those of the semi-dispersions tend to increase substantially for *food* and decrease substantially for *social interaction*. It means that in the case of the *food* index the divide in perception has increased while for *social interaction* narrowed substantially. The narrowing of the semi-dispersion, however, is not enough to take a decision about the need to measure the corresponding index each year, since one has also to look to the range of variability of the indices (last column of Table 8.3). Unfortunately, such range of variability is quite important for all indices and also in the most favorable case, that of the *social interaction* where we observed a

Table 8.3 Mean values and standard deviations of the indices worked out from the ASLERD questionnaires (quantitative answers)

Index	Mean semi-dispersion 2016	Mean semi-dispersion 2017	Range of variability
Resources	6.30 ± 0.48	6.48 ± 0.49	−0.29 to 0.87
Process	6.33 ± 0.36	6.31 ± 0.41	−0.36 to 0.54
Environment	5.5 ± 1.0	5.58 ± 0.74	−0.52 to 0.95
Food	6.48 ± 0.35	6.43 ± 0.79	−0.74 to 0.46
Safety	6.30 ± 0.42	6.47 ± 0.50	−0.12 to 0.48
Social interaction	6.62 ± 0.45	6.80 ± 0.12	−0.10 to 0.82
Social capital	6.21 ± 0.35	6.20 ± 0.34	−0.40 to 0.60
Flow	5.90 ± 0.30	6.10 ± 0.28	0.07 to 0.51

substantial stability of the value of the index for four schools over five, the fifth one was characterized by a very relevant positive variation of the index.

The contents of Table 8.3, thus, do not authorize any general reduction of the length of the questionnaire while, on the other hand, allow us to identify increasing divide (e.g., for *food* index) and tendencies toward general improvements (like for *safety*, *social interaction,* and, overall, *flow* indices).

Although we failed in identifying a general strategy to shorten questionnaires, one can take a more local perspective and explore the possibility to operate a contextualized reduction of the length of the questionnaires. To that end, we have taken, as key study, school III and performed a detailed analysis of the outcomes of the participatory evaluation. Here below the summary of our findings:

– almost all indices increased their value as a result of the student opinions;
– a certain number of indices remained stable along the two years for both teachers and parents (*environment, safety, flow*); we consider an index to be stable when the variation of its mean value remains within one standard deviation;
– in addition, we have also found that a certain number of indicators that contribute to determine the values of some indices remained stable for both teachers and parents (e.g., *students' social competences, inclusion/integration, valorization of diversity, info/admin services,* etc.).

Considering all above we can conclude that, in the case of school III, students have to fill again the full questionnaire in order to verify the consolidation of the positive trend described above, while in the case of teachers and parents, we can proceed with a selective reduction of the questionnaire, biennializing data collection of indicators and indices that are more stable. This contextualized strategy of reduction led to shorten questionnaires by more than 30%.

Of course, any proposed reduction of the questionnaires should be validated with the representatives of the school since, in the while, the school principal and/or her/his collaborators may have taken actions to mitigate or solve criticalities that emerged from the previous runs of the participatory evaluation and that may be related to indices/indicators that appear to be stable.

8.5 Conclusions and Future Work

The achievement of quality education (SDG 4) is strongly dependent on several factors (preconditions) that can be summarized in two main properties of the learning ecosystems:

– its level of *multidimensional people-centered smartness*
– its level of *e-maturity* together with the *sustainability of the digital facilities*.

In order to achieve the preconditions for SDG 4, one needs to work hard on the improvement of learning ecosystems to assure equal conditions for all. This implies also the availability of open tools and procedures, derived from a solid and shared

framework of reference, capable to stimulate participatory approaches and support monitoring, comparative evaluation, and co-design.

In this paper, we have first shown how the ASLERD questionnaires, derived from the ASLERD pyramid, can be adapted to participatory evaluate the smartness of the schools. Then we have shown how it can be used to follow the progresses of the schools over the years and to compare learning ecosystems, also with the aim to identify actions needed to assure equal opportunities (and this allowed us to point out the consistent gap existing between public and private high schools, at least in Rome).

Of course, the outcomes of the questionnaires (in particular the qualitative ones) are also very useful as a basis to co-design actions to increase the smartness of the learning ecosystems, but this aspect is well beyond the goals of this paper and has been already partially investigated in other works.

Finally, by comparing the outcomes of two subsequent participatory evaluation runs, we have investigated possible strategies to reduce the length of the questionnaires, i.e., the efforts to take part in the evaluation process. Unfortunately, it turned out that it is not possible to adopt a global strategy for all schools involved in the participatory evaluation, despite their belonging to the same confined portion of the territory (southeast area of Rome). A result that demonstrated how each learning ecosystem has its own characteristics and needs to follow its own path toward the achievement of an adequate level of smartness to implement SDG4.

In order to explore the possibility to adopt a more contextualized strategy to reduce the questionnaires' length, we have performed a detailed comparative analysis of questionnaires' outcomes in the case of school III. It turned out that the length of some of the questionnaires (those for teachers and parents) could be shortened by more than 30%.

The impossibility to adopt a global strategy to reduce the length of the questionnaires tends to increase the work for the investigators, but the viability of a contextualized strategy decreases the effort for the stakeholders to contribute to the participatory evaluation process and satisfies their request and expectation for future evaluation runs.

This work, thus, represents a step forward an optimized adoption and use of the ASLERD questionnaires as a tool to monitor learning ecosystems' smartness and guide them toward the achieving of the basic conditions needed to host high-quality educational processes.

For the future, one needs to integrate the ASLERD questionnaires with equivalent questionnaires aimed at the participatory evaluation of the level of *people-centered e-maturity* of the learning ecosystems; i.e., the capability of the learning ecosystems to technology enhance their smartness and, thus, to host technology-enhanced high quality and sustainable education for all.

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Chapter 9
Smartness Comparison Among Different Age Group Students in an Integrated School: The Potential for Design and Management

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Abstract The empirical research documented in this paper took place in a school ecosystem and considered 7th–9th-grade students and 10th–12th-grade students in a bottom-up approach to nurture the knowledge needed to understand the relation that is established between the educational community and school. The reported work contextualizes and explains the smart learning ecosystem strategy and describes the research method used to involve and gather stakeholders' motivations and sense of optimal experience in the school ecosystem. This particular paper tests the capability of having qualitative comparison smartness studies among different school stakeholders in the same (place and institution) school ecosystem. The qualitative research procedure, smart school questionnaires, data gathering, and analysis will be shared in the context of the study that took place May/June 2018 in the José Estêvão Aveiro School (Portugal), namely with the younger students (7th–9th grade), $n_1 = 157$ and older students 10th–12th grade, $n_2 = 108$. The comparative analysis exercise leads to the potential for technology-mediated solutions driven by co-design initiatives and suggests some smart school management issues.

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9.1 Introduction

The work reported in this paper is contextualized in several strategic concepts that emerge fundamentally from postmodern ideologies [1] were the singularity of the individual, Lipovetsky [2], plays an important role in socioeconomic innovation and territorial development. The "smartness" concept, as explained in SLERD2019 site[1] and several other ASLERD contexts and publications,[2] is not a technology-driven adjective, and it is fundamentally a "people-centered", Norman [3], driven adjective capable of identifying their wishes, needs, and expectations [4] even if in technology-mediated contexts. Considering that smartness is a human motivation-driven concept, Maslow's [5] and Mihaly's [6] classical theories define the ASLERD smart school questionnaires' main study dimensions, benchmarked with other models by [7]: (i) basic needs, (ii) security, (iii) socialization; (iv) social capital, (v) self-fulfillment, and (vi) Mihaly's flow/satisfaction. Other personal drivers/theories have been used in similar human-centric studies, [4, 8] but all report back to these universal references on human motivation. The traditional ".com" industry at San Francisco's bay area (*aka* Silicon Valley) was also highly influenced by Maslow's human motivation theories, as highlighted by Rolf Faste's [9] contributions on how to "perceive user/client needs" i.e., *observations are made about how the need-finding activity might be structured within the corporate arena.* Faste's human-centered design approach at the time influenced IDEO[3] co-founder David Kelley (his colleague at Stanford University), which still is today, an "interaction design" reference company to the worldwide new media industry, strategically interested in incorporating in its production funnel "human needs and experience" within co-design thinking techniques. Maslow's [5] positive theory of human-centered motivation continues to be an ultimate formulation of the goals that lead to motivation arranged in hierarchies of pre-potency. Inherent to the theory are prepositions that state its formulation as integrating the whole of the human organism and the absolute relevance of culture and situational context in which motivation is being studied. Mihaly [6, pp. 232], on the other hand, defines the conditions that foster optimal experience or experience of flow (cognitive immersion/total engagement in action): *perceiving challenges or opportunities for action, existing skills, sense that one is engaging challenges at a level appropriate to one's capacities; Clear proximal goals and immediate feedback on progress made.*

Former work has been done with ASLERD smart school questionnaires [10, 11], but this paper contributes with a different perspective based on a qualitative comparison analysis between different age group stakeholders/students. Smartness benchmarking has been used with the ASLERD smart campus questionnaires [12–14] but without a coupled hybrid relation of quantitative–qualitative data, namely between quantitative valuation (statistical summary) and participants' qualitative (subjective) clustered opinions. This hybrid quantitative–qualitative data analysis

[1] SLERD2019—http://slerd2019.uniroma2.it/.

[2] Journal IxD&A—http://ixdea.uniroma2.it/inevent/events/idea2010.

[3] IDEO—https://www.ideo.com.

procedure enriches the usual holistic analysis and augments with complexity (detail) and certainty in the evidence of need, reported in the results.

The school ecosystem is heavily studied worldwide by different actors and in different perspectives. In Portugal and considering the ASLERD "smartness" concept, most of the studies are top-down oriented [15] based on the student performance analytics and other data. In these top-down studies, only a small part of the qualitative data gathered, usually specific interviews with a sample of the school members, are added to the final contributions. The method proposed in this research framework is fundamentally bottom-up [1] and complements the results of these traditional approaches.

The goal of this study is to test the questionnaires' capability of performing a "smartness comparison" exercise with two different stakeholders and two different (cohorts) age group students of the same school (institution and place). This study also includes the iterative goal of improving the ASLERD smart questionnaires as a "smartness" assessment instrument.

9.2 Methodological Approach

This paper reports on a comparison study that uses a survey methodology supported by the ASLERD smart school questionnaires [10, 11] with closed and open-ended questions applied to two different stakeholder cohorts, out of six possible types of educational community stakeholders, the 7th–9th-grade students and the 10th–12th-grade (secondary) students of José Estêvão School Cluster at Aveiro (AEJE), Portugal. This study fundamentally integrates a postmodern epistemological approach, as announced by Lipovetsky [2] in the early ages of the Internet. In fact, Lipovetsky believes nowadays that postmodern movements are giving place to the hype individualism with the possibility of designing services and products specifically personalized and adapted to individuals' needs and expectations, with their participation and even direct customization intervention.

The 7th–9th grade cohort has $n = 157$ participants, 29.30% 7th grade students, 38.85% 8th grade and 31.85% form 9th grade, 60.5% female and 39.5% male participants. The 10th–12th grade cohort has $n = 108$ participants, 37.04% from 10th grade, 34.26% 11th grade and 28.7% from 12th grade with 70.4% female and 30.6% male subjects. The data used in this study was gathered in May/June 2018, and both samples represent students that go to the same school, i.e., share the same place and institution during their daily classes.

The study received ethical clearance from the Ministry of Education of the Portuguese Republic (N.º 0576100001) that included the validation of the study's procedures and was also authorized by the Director of AEJE school cluster. All participants under 18 years of age, had parent authorization and all, over and under 18 participants, signed a consent form. Smart school questionnaires were administered to eligible students (w/parental authorization and consent form) during "citizenship"

classes with a short contextualization regarding the pertinence and contribution of this study.

This study selected 15 closed (1–10 point Likert scale) and open questions/comments from the ASLERD smart school questionnaires for qualitative comparison purposes. The approach complements on former research developed by ASLERD members [10, 11, 16] and inquires eight main dimensions: infrastructure/equipment (closed question 1 and CQ2); environment (CQ3); food services (CQ4); security (CQ5, CQ6); people and space (CQ7, CQ8, CQ9, CQ10); interaction with family (CQ11); social and territorial interaction (CQ12, CQ13); and self-fulfillment (CQ14, CQ15).

Table 9.1 summarizes the relation of both reference "theories" Maslow, 1943 [5] and Csíkszentmihályi, 1990 [6] with the main smartness "dimensions" used for comparison purposes in this work and the underlying 15 questions used to gather quantitative (closed questions, CQ) and qualitative (open-ended questions, OQ) data.

9.3 Data Analysis

The comparative qualitative data analysis is organized in eight dimensions, collected from 15 open-ended questions and comments directly coupled to closed questions with a 10-point Likert scale (Min. 1–Max. 10). The radar in Fig. 9.1 represents an integrated view of the average score (μ), lower and higher quarters given by the 7th–9th grade participants in each closed question. The radar axis number identifies the closed question and the caption establishes the question—study dimension relation.

Figure 9.2 associated with the older students' sample depicting the average for each closed question and the corresponding lower and higher quarter of this data. The border value of the low and higher quarters, contrasted in both the radar representations (Fig. 9.1 and Fig. 9.2), pinpoint quartile 1 ($Q1$) and 3 ($Q3$), information that is important to understand the coherence of the sample's "judgment" represented by its average.

This descriptive statistics information is of utmost importance in this qualitative comparison study to evaluate the opinion clustered in the corresponding open-ended questions. A quantitative–qualitative information relation technique clearly assumed as an important asset to understand and validate the pertinence of clustered subjective opinions obtained with the ASLERD smart school questionnaires.

The first holistic observation and result of this study is that the authors did not find any evidence of need, in these stakeholders' data, to improve the questionnaire, namely due to confusing questions, a need to remove questions or add any new questions (or "smart dimensions"), during this study process.

The analysis and qualitative comparison of the open-ended questions for both samples follow the organization of the eight main smart dimensions and their relationship with the corresponding open-ended questions (OQ) and closed questions

Table 9.1 Relation of reference theories, smartness dimensions, OQ, and related CQ

1. Basic Needs/Infrastructure, Equipment
CQ1. Score the quality of your school infrastructures (classrooms, laboratories, auditoriums, sports facilities, WC, public areas, etc.). **OQ1**. What problems should be pointed out?
OQ2. What infrastructure do you propose to make your school more suited to your education/training?
CQ2. To what extent do you consider the school equipment (didactic material, computers, WI-FI access, etc.) suited to your school requirements? **OQ4**. What problems do you think should be highlighted?
OQ3. Indicate what additional equipment and resources could make the school more suited to your needs and requirements?
2. Basic Needs || *Environment*
CQ3. Indicate to what extent the environment is cared for in your school (gardens, recycling, environmental education, etc.)?
OQ4. If you have encountered problems that you consider relevant, please describe them?
3. Basic Needs || *Food Services*
CQ4. Indicate the extent to which the following services—access to drinking water, canteen, vending machines, bar service, etc.,—are of quality and fit your needs? **OQ5.** If you have found problems that you consider relevant, please describe them?
4. Security
CQ5. To what extent do you feel safe in your school?
CQ6. To what extent do you consider the surrounding area of the school safe?
OQ6. What are the problems you consider important to point out?
5. Socialization || *People and Space*
CQ7. What is your level of satisfaction with the environment in the classroom and in general with that of the school? (w/comments)
CQ8. To what extent do you feel affinity and attuned to the people who attend school? (w/comments)
CQ9. To what extent do you consider the relationship with teachers positive? (w/comments)
CQ10. How much do you feel appreciated by your peers in school? (w/comments)
6. Socialization || *Interaction with Family*
CQ11. To what extent do you think the school involves families in school activities?
OQ7. Do you feel the need for other initiatives?
7. Social and Territorial Interaction
CQ12. To what extent do you consider that the school encourages interaction (also social) with the territory (e.g., associations, public initiatives, cultural and sports events of public interest, with neighboring spaces, on the Web, etc.)?
OQ8. What initiatives could be promoted to facilitate the acquisition of your social and/or civic competences?

(continued)

Table 9.1 (continued)

CQ13. To what extent do you consider the development of a virtual territorial educational community to be useful? (w/comments)
8. Self-fulfillment || *Educational Process*
CQ14. Indicate to what extent you consider that your education has been able to develop your potential? (w/comments)
OQ9. What other initiatives and actions could be promoted?
CQ15. How satisfied are you with the initiatives taken by the school to support students in difficulty? **OQ10**. Please indicate the initiatives that you believe may be taken to improve assistance to students in difficulty?

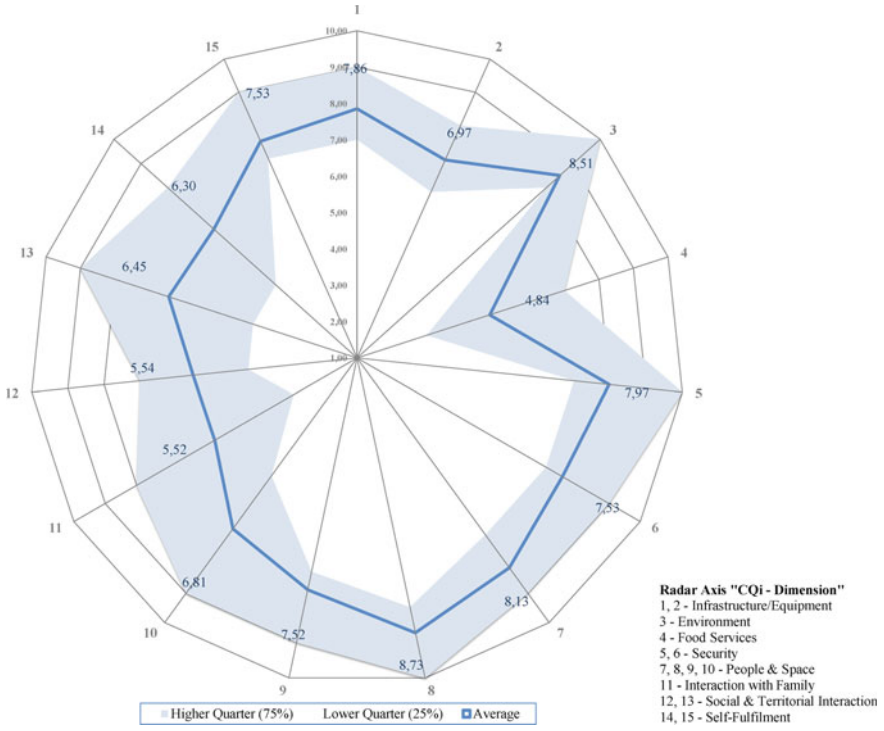

Fig. 9.1 Average, first quarter (inner white) and third quarter (light blue) of each closed question related to open-ended questions/comments from 7th to 9th grade students

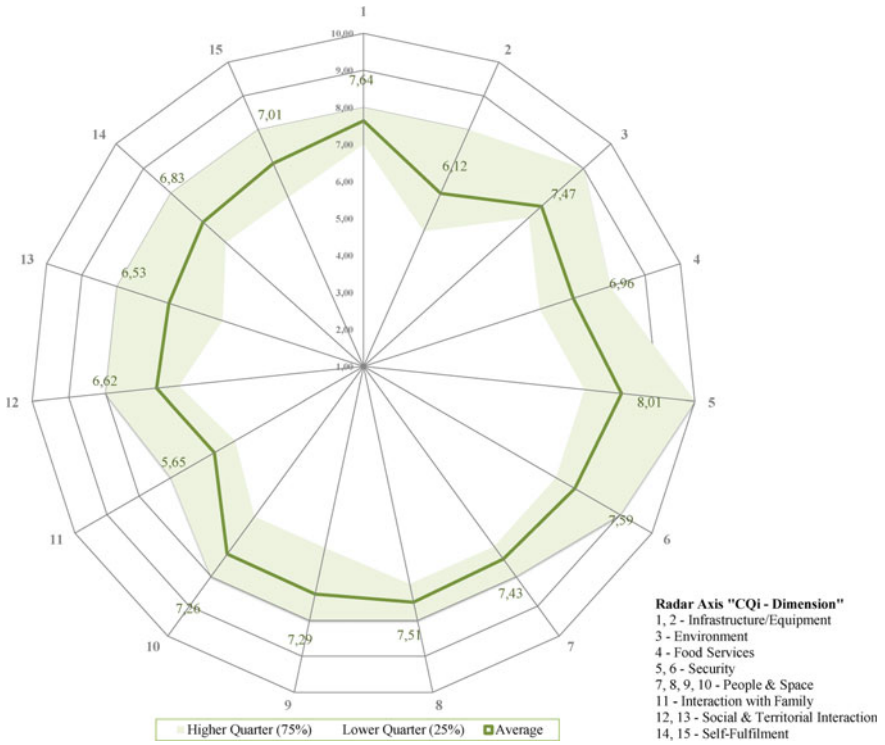

Fig. 9.2 Average, first quarter (inner white) and third quarter (light green) of each closed question related to open-ended questions/comments from 10th to 12th grade students

(CQ) as systematized previously in Table 9.1. The results reveal a holistic evidence that, although questions (Table 9.1) had different phrasing to cope with the different age group interpretation and understanding, data delivered by both age groups revealed what we wanted to know (without any thematic or misunderstanding deviation) and a qualitative comparison was possible.

9.3.1 Infrastructure and Equipment

The first open-ended question received from both age groups a very similar amount of interest, 66.24% (104/157) of the younger students shared their judgment of the school's infrastructure valuated with $\mu = 7.86$ (SD = 1.35) with first and third quartile depicting $Q1 = 7$, $Q3 = 9$ for CQ1 and $\mu = 6.97$ (SD = 1.69) for equipment in CQ2. Older students contributed in a similar proportion 72.22% (78/108) and valuated infrastructure with $\mu = 7.64$ (SD = 1.34) and concerning equipment $\mu = 6.12$ (SD = 2.00 $Q1 = 5$, $Q3 = 8$). It is interesting to notice that younger students had the need

to mention (43.3%, 45/104) that they really think their school infrastructure is very good, some even mention they love their school, even so, they described what is still missing or needing improvement. With this sense of opinion, only 18.6% (11/59) of the older students mention everything's ok with their school and that they don't have any improvements to declare 6.4% (5/78).

Figure 9.3 represents an integrated comparison with the percentage of opinions, younger, and older students had to share on this dimension's improvements.

Open-ended questions mentioning improvements received 86.62% (136/157) opinions from 7th to 9th grade students versus 54.63% (59/108) of the older students. The main issue of both groups of students is related to the classroom comfort (cold/hot) and lack of equipment or its maintenance with younger students slightly more concerned with this. The sports facilities maintenance problems (Alavarium gym, by older students) mainly with rain and lack of some equipment are mentioned by both groups. Shelter from the rain is also common to both age groups, and the younger students really concerned with this and all of them mentioning this should be corrected. The younger students exclusively mention they would really appreciate improvements and more specific spaces, namely for socialization activities but also for other purposes, such as cinema, dance, ping-pong, and entertainment. Curiously, food service received less attention, with both groups requesting improvement in the cooking process, more tables, chairs, and microwave equipment. The need for more and better Wi-Fi is an exclusive major demand of the older students. The need for more and better computers, software/hardware, in most of the classrooms is a request of both groups. One of the equipment recommendations fosters a change of paradigm, the 7th–9th-grade students would like to have tablets instead of books and notebooks to study and do their individual/group work. A request that is directly related with children's complaints of back problems due to the immense weight of

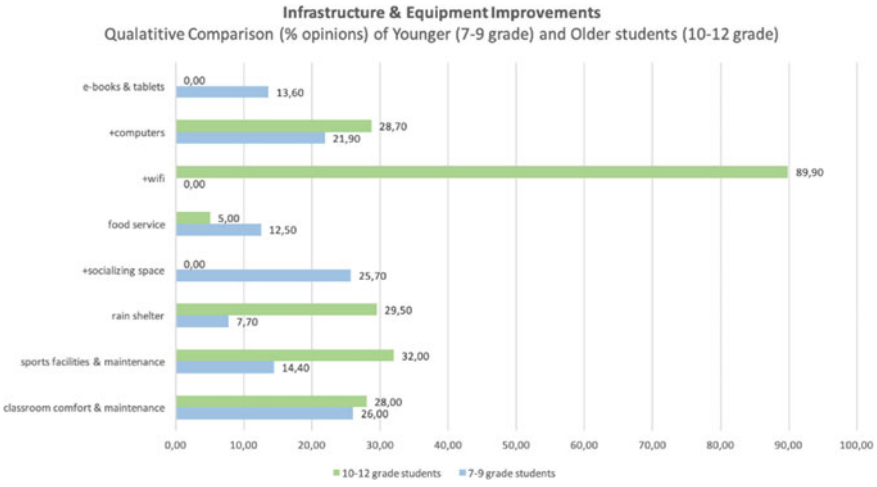

Fig. 9.3 Opinion comparison of both cohorts on infrastructure and equipment improvements

their backpacks, a very old issue in diverse international contexts (the backpack KÅNKEN[4] by Fjällräven occurred due to this in Sweden, in 1978).

9.3.2 *Environment*

This dimension was scored by the older students in CQ3 with average $\mu = 7.47$ (SD $= 1.80$ $Q1 = 7$, $Q3 = 9$), and the younger students registered $\mu = 8.51$ (SD $= 1.56$ $Q1 = 8$, $Q3 = 10$). Despite this higher average, younger students seem to be much more concerned in revealing their opinion on their school environment (89.81%, 141/157) than the older students (33.33%, 36/108). Figure 9.4 shows a summary of the relative amount of opinions of both groups.

Although both student groups reveal to be concerned with indoor/outdoor litter/garbage on the floor, the younger students are much more concerned in reporting the problems and the older students mentioning some solutions. The following excerpt is an excellent example of the younger student's discourse *We find most of the times litter/garbage on the floor. It is not that the cleaning staff doesn't keep the floor clean or remind us to keep it tidy, it is just because the students aren't careful at all.*

Younger students still add in their concerns the civic awareness for garden care.

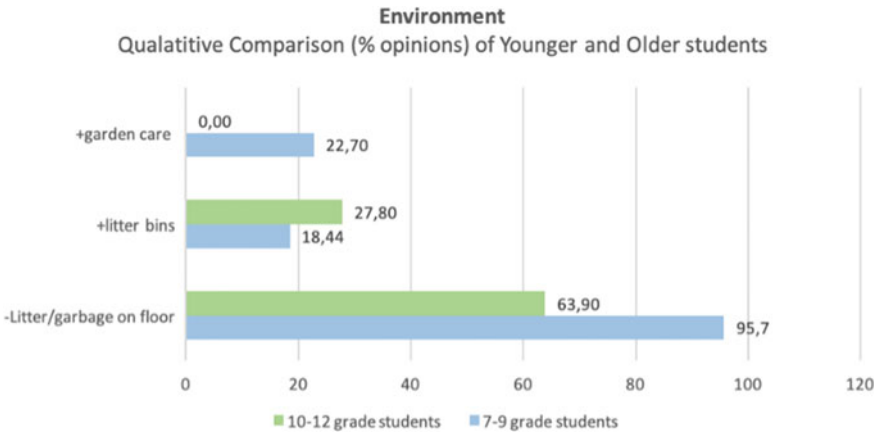

Fig. 9.4 Opinions of both student groups on environmental improvements

[4]KÅNKEN by Fjällräven—www.fjallraven.com.

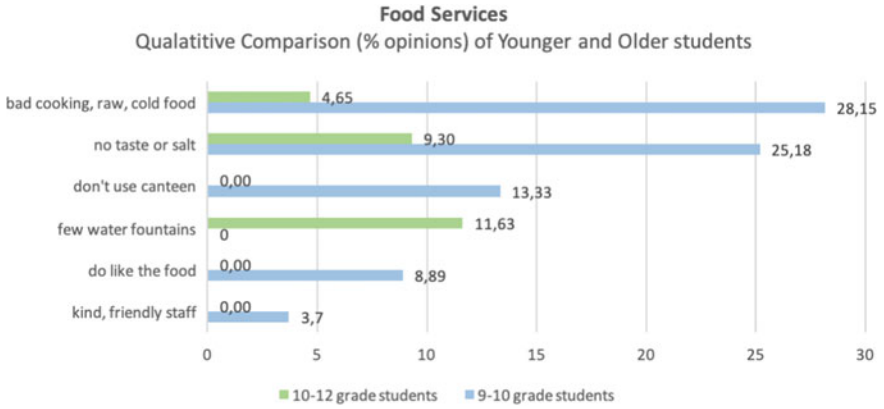

Fig. 9.5 Food services opinions of both student cohorts

9.3.3 Food Services

There is a big difference in the number of students that left their opinion concerning the food services, with (135/157) 85.99% of the younger students contributing with their comments versus (43/108) 39.81% of the 10th–12th graders. Both age groups valuated their opinions in CQ4 differently, with the older students depicting an average $\mu = 6.96$ (SD $= 1.93$ $Q1 = 6$, $Q3 = 8$) and the 7th–9th graders $\mu = 4.84$ (SD $= 2.54$ $Q1 = 3$, $Q3 = 7$). The details of each cohort are systematized in Fig. 9.5.

9.3.4 Security

Students of both age groups have identical opinions on school security with a slightly higher concern for the younger students with 92.36% (145/157) of the participants leaving individual comments compared with 48.15% (52/108) of the 10th–12th graders. Both groups have some students saying their school is secure, or they don't have any security issue to report, 26.9% of the 7th–9th-grade students and 25.0% of the older students, curiously an identical proportion of students revealing the same security sensation. Another common issue is that both groups are very worried about the lack of control or video surveillance cameras in the schools' main gates/entrance. This is manifested by 57.69% of older students and 51.72% by the younger ones, once again very similar proportions sharing this opinion. The average of the closed questions CQ5 and CQ6 in Figs. 9.1 and 9.2 confirms the similarity of opinions already mentioned, interesting, considering the age difference between samples.

9.3.5 People and Space

For the purpose of comparison between both age groups, four common closed and open-ended questions will be analyzed in this section. Younger students were much more interested in sharing their opinions (77.1%, 121/157) than the older students (25.0%, 27/108), something that was already clear in the "environment" dimension. The younger students say they like their school (67.77%), because they have friends (16.53%) to socialize, and very good teachers (14.05%), colleagues (13.22%), and school staff (11.57%). The younger students valuated the corresponding closed question (CQ7 in Fig. 9.1) slightly higher than older students. Besides this judgment, some older students (25%) felt the need to write that teachers could have a more friendly attitude, namely during class.

9.3.6 Interaction with Family

Both cohorts valuated their family's participation in school activities (CQ11 in Figs. 9.1 and 9.2) with similar scores. Older students with 73.47% (36/49) opinions going very strongly into non-participation suggestions and only 16.33% mention they would like to have their parents directly involved in school or classroom activities. Younger students have more equitable opinions and go into more details. These students (39.52%, 49/124) mention that their tutors/parents should have no relation whatsoever with the school. The another 44.35% cluster mentions that their families should participate in study visits or projects, games or sports, parent association, classroom, assessment, and lunch.

9.3.7 Social and Territorial Interaction

An 89.17% (140/157) cluster of the younger cohort left comments on this issue and a majority want field trips (56.43%). These students judged the relation school—city (CQ12 in Fig. 9.1) with an average $\mu = 5.54$ (SD $= 2.67$) a clear sign that more must be done. Their suggestions mention solidarity walks, city visits/activities, outdoor classes, and sports tournaments. The 10th–12th-grade students had a smaller participation in this open question (42.59%, 46/108) and of these, 21.74% suggest more talks/workshops or field trips/activities, within the city to improve their citizenship/social skills. Inquired on what organizations should have a relation with school, these older students, concerned with their future work mention the need for more internships (28.89%) and professional qualification information (24.44%). This group of students valuated this topic (CQ12 in Fig. 9.2) with $\mu = 6.62$ (SD $= 1.88$) which reveals they do think the school fosters and organizes school–city activities

but apparently not many of these students suggest school improvements concerning this topic (30.43%).

9.3.8 *Self-fulfillment | Personal Development and Educational Process*

Inquiry on personal development to the older students produced two types of comments from 44.44% (48/108) of the sample, nothing to add (22.92%) and another group of opinions that require activities supported by real-life needs, and soft skills (50.0%), namely citizenship workshops, problem solving, and future trends. These students graded the CQ15 (Fig. 9.2) with average $\mu = 6.83$ (SD = 1.88, $Q1 = 6$, $Q3 = 8$) that can be understood as an overall positive acceptance of the school's contribution to self-fulfillment. The 7th–9th-grade students valuated this dimension (CQ15 in Fig. 9.1) with $\mu = 6.30$ (SD = 2.52, $Q1 = 4$, $Q3 = 8$) and 76.43% (120/157) of these younger participants require outdoor classes/activities, interchange programs, and social activities with other schools and more field trips/activities, namely related with real-life situations (elderly care org.) and industry. An excerpt of a participant suggests *that the school should announce more student contests like the recent 'student reading contest'*.

9.3.9 *Satisfaction*

A great majority of the students from both age groups were keen on answering these open-ended questions related to global satisfaction at school, highlighting positive and negative aspects of daily life. Younger students more active in reporting "positive aspects" with an expressive percentage of 97.45% (153/157) and the 10th–12th-grade students with 80.56% (87/108). Negative issues received a little less but very similar involvement of students with a participation of 96.82% of younger students and 74.07% of older students. The younger students highlight the excellent human environment, mentioning all community members are very friendly, namely colleagues (18.95%), teachers (20.74%), and staff (7.19%). The school's infrastructure and space are mentioned again as an outstanding characteristic of the José Estêvão School. The older students mention that they really appreciate their teachers and colleagues. The school infrastructure, classes, and library are also pinpointed as very good. The diversity of programs, namely visual arts is a distinctive issue in the comments.

9.4 Potentiating Co-design and Management

Food services can gain from a technology-mediated quality assurance service that could also support canteen access and queue management.

Civic issues are pointed out by both groups and needing some intervention to correct student behavior indoors and outdoors, namely in the schools surrounding gardens and related to litter on the floor.

The need to have more extracurricular activities and related with real-life situations is a self-fulfillment recommendation of both groups and can be related with a reinforcement and strategic realignment of protocols school–city, surrounding organizations, stakeholders of the Aveiro educational community. Inter-generational activities, namely between the students and the city's elderly care organizations, are a possibility to be considered. Other recommendations can still be extracted from the smart comparative analysis produced in this paper and further developed in an extended publication format.

9.5 Conclusions

The work reported in this paper shows evidence that neither of the student groups disapproved any of the smart dimensions selected for this qualitative comparison that organizes the several open-ended and closed questions of the ASLERD smart school questionnaires. No remark was detected mentioning the need to add or correct questions or dimensions. It is reasonable to state that both cohorts considered these questionnaires as viable to produce a smartness assessment of the school ecosystem.

The comparative data analysis also validated the potential of opportunities, inherent to the smart questionnaires, to confront different stakeholder's opinions even in different age groups (between 7th–9th- and 10th–12th-grade students) were the phrasing of questions and interpretation considering age difference could be problematic.

The next step will have to establish a compromise with the school cluster's (AEJE) management board and define social innovation co-design initiatives to foster design literacies and project dynamics. A possibility is to engage the community's stakeholders (namely students, teachers, and parents) in design thinking [17] methods to start a learning process capable of contributing for change in management and converge for a better school ecosystem. Such a process was recently tested in the 2017 AEJE pilot study reported by [18, 11].

Concerning the method used in this paper, the quantitative–qualitative data relation established in this qualitative analysis research also proved to be pertinent to augment qualitative results with valuated information. The descriptive statistics summary, namely average (μ), standard deviation (SD), lower and upper quarter and first ($Q1$) and second quartile ($Q2$), is used to better understand the valuated "meaning" of average considering its dispersion in each of the study's smart dimensions. The

concrete contributions of this study to potentiate co-design initiatives or to foster management improvements in José Estêvão School cluster at Aveiro, are clear-cut in the opinions of the participants of this study and aligned with ASLERD's "people-centered" approach to assess, design, and improve ecosystem smartness.

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Chapter 10
A Multidimensional Space Approach to Innovative Learning Environments

Lara Sardinha, Ana Margarida Pisco Almeida and Neuza Pedro

Abstract Technological-enhanced physical environments, as well as learner-centred educational methodologies, are increasing their presence within learning spaces. The spread of physical learning environments grounded on the pedagogy-technology-space and innovative learning environments led to an increase of studies and researches on this field. We argue that physical learning environments and innovative learning environments can be approached through a multidimensional space perspective, which includes social, cultural, technological/digital and architectural dimensions. In our research, we intend to create an interior design strategy for an inclusive physical learning environments. This article presents our multidimensional space approach to innovative learning environments and physical learning environments followed by some results from in-depth interviews applied to key agents involved in Portuguese innovative learning environments. The results reveal the Euclidean space as an important factor perceived by interviewees, but the space social dimension presents a significant role for the participants, followed by the space technological/digital dimension.

10.1 Introduction

This article is part of an ongoing research which addresses the physical learning environment (PhLE) through a multidimensional space approach [1]. Nowadays, learner-centred educational methodologies, as well as technological-enhanced physical learning environments (TEPhLEs), are influencing PhLE and many of these follow educational models grounded on the pedagogy-technology-space concept

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[2, 3]. To this triad, we add a fourth concept: inclusion, as this research aims at creating an interior design strategy for an inclusive PhLE, considering in particular youngsters that are not in education, employment or training (NEET) and migrants. A multidimensional approach to space is, therefore, in our perspective, a more complete approach as it enfolds different space dimensions, namely, the social, cultural, technological/digital and architectural ones.

This article explores these different space dimensions as well as some results found during in-depth interviews applied to key agents of Portuguese innovative learning environments (ILEs), a national project that aims at promoting the development of reconfigurable and technology-enriched classrooms in public elementary and secondary schools. These results, together with some already analysed [1] and other data currently being analysed,[1] will be the core for the interior design strategy to be created in the end of the research. The presented results are followed by a discussion and some considerations bearing in mind the previously referred space dimensions.

10.2 Space Dimensions

10.2.1 A Multidimensional Space Approach to ILEs

Innovative learning environments [4], its physical space [5, 6] and learning physical space in general [7] have been discussed in several studies. These studies approach different space dimensions interacting as an all. PhLEs are complex systems [8, 9], even more now with TEPhLEs spreading side by side with learner-centred educational methodologies, as collaborative and project-based learning, among others (Table 10.1).

Table 10.1 Approaches, theories and space dimensions

	Social dim.	Cultural dim.	Technological/digital dim.	Architectural dim.
Classroom orchestration	x		x	x
Enabling spaces	x	x	x	x
Human-Building interaction	x		x	x
Lefebvre "space production"	x	x		x

[1]Creative workshops/interviews with NEET and Migrants in order to understand their perception and conception regarding PhLE as well as video analysis of classes in ILE's context enabling the understanding of how students and teachers occupy these spaces.

Different approaches and studies regarding space [10–12] and learning environments [4, 13] stress the importance of a social dimension. Peschl and Fundneider, when referring to knowledge creation in collaborative settings, state that this necessarily occurs in "a 'social container', a (social) atmosphere, in which these processes can develop their own dynamics" [9]. According to Lefebvre [10], space is not only influenced by those who conceive and construct it, but is also produced by those who occupy and experience it. For Lefebvre [10], space is social and is a social product, which implies, according to Benade, "that every society has its own identifiable space and spatial practice " [14]. This social dimension should not be detached from the cultural one as these reflect in space organization [15], since each culture has its own way of experiencing it [15].[2] Also Peschl and Fundneider mention a cultural dimension however through an institutional/organizational perspective [9].

Considering TEPhLEs, it is important to take into account the different space dimensions stressed by Peschl and Fundneider [9], namely the social, cultural, architectural and technological ones, among others, which must be "orchestrated in an integrated way" [9] and classroom orchestration, as proposed by Dillenbourg et al. [8]. According to Dillenbourg, this stems from the ability to manage an environment with a strong technological presence [8]. In his perspective, classroom orchestration aims at providing a better environment (physical, technological, social, among others) to students, in order to reinforce and facilitate knowledge acquisition [8]. From the intersection between smart technology and active pedagogical approaches "as collaborative learning, project-based learning, (…) students' autonomy, educational co-responsibility, etc." [16] and "classroom's architectural design and its ergonomy" [16], Bautista and Borges state that the concept of smart classroom arises as an intersection which also relies on the actors' learning processes. Space technological/digital dimension is also one of the bases for Human-Building Interaction (HBI), which consists in the study and design of interactive opportunities for users to shape the physical, spatial and social product of their built environments [17]. Space architectural dimension is related to the built space. This latter is often approached through an Euclidean perspective, meaning, as the architectural space [9] or the constructed space [18] and based, in part, on static and dynamic resources [18]. Nevertheless, HBI approaches built space through Hillier's perspective [17] in which physical and spatial forms are connected to a social–cultural function [19], as buildings are not only the construction that creates and protects a space but also its social value.

[2]Nevertheless, social and cultural dimension were analysed separately, in order to better understand each one.

10.3 In-Depth Interviews

10.3.1 Methodology

This research is eminently exploratory and relies both on grounded theory [20] and development research [21], resorting to mixed methods of data collection [22]. Through a qualitative and exploratory methodology, in-depth semi-structured interviews were applied. With these interviews, we intended to listen the key agents involved in Portuguese ILEs. These are the part of the ITEC project developed between 2010 and 2014. In 2012, the "Future Classroom Lab" (FCL) was created in order to translate ITEC concepts into a space. From the different countries associated to this project, Portugal is the country with the highest number of ILEs. Specifically, the study involved: two architects/designers (AD); three decision-makers who are also teachers (DMT); two teachers (T) and two students (S). All participants are from different ILEs and are or were using these spaces. When the interviews were applied, there were in Portugal 24 ILEs corresponding the nine selected ones to 37.5%. A random selection process was applied using an online random selector (https://www.randomizer.org/) for each type of key agent.

Interview script was grounded on the results found on an European web survey applied to the European Schoolnet FCL members, already described in previously published works [1]. The script was divided into two main parts, a workshop, consisting of three activities, and an interview. The workshop aimed at: (1) understanding participants' perception of what constitutes a classroom layout, its reconfiguration and their conception for an ideal classroom layout; (2) identifying participants' perception of classroom paths and dynamics. Interviews aimed at: (1) understanding participants' perception for a classroom layout (existing one, reconfigured and ideal) and its use; (2) identifying space dimensions' characteristics present in the participants' solutions. Nevertheless, the focus for this article is to characterize the ILE physical space, its use, space dimensions and space constraints. During the interviews, a broad definition of the space dimensions in use in our research was given: (1) social dimension—comprises the social space, the interactions' space and in which relationships of trust can be built; (2) cultural dimension—includes not only the cultural space of the institution, its organizational structure, as well as the environment culture in where it is; (3) technological/digital dimension—covers the technological/digital space, both interactions it provides plus those with the devices itself; (4) architectural dimension—comprises the built space, furniture and, consequently, the resulting paths by these created. Nearly 10.5 h of audio were recorded and collected by skype (from July 2016 to February 2017), transcript and coded.

10.3.2 Results

Five categories were defined for data analysis: (1) New media (NM)—references concerning technological devices, digital resources, its influence in teaching and learning and its infrastructure; (2) Architecture and design (AD)—references to the Euclidean space, layout and furniture; (3) Teaching and learning (TL)—references regarding its ecosystem, population, teaching, learning, activities and learning zones; (4) Space dimensions (SpDim)—references concerning space as a social, cultural, architectural and technological/digital construct; (5) Improvements (*I*)—references regarding the need (or absence) of improving any of the previous categories. Its relative frequencies were, from the highest to the lowest: NM (30.6%), TL (30.3%), AD (22.7%), SpDim (14.7%) and *I* (1.7%). Each of these is divided into sub-categories (some grounded on the web survey results and others emerging from the interviews' qualitative data analysis). Table 10.2 presents the categories and sub-categories that have been defined and their relative frequencies:

It is interesting to notice that Euclidean space sub-category is the one with the highest frequency (fr = 611;17.8%). However, when focusing on SpDims' sub-categories, architectural dimension (fr = 123) presents a lower frequency comparing to the social (fr = 185) and technological/digital space dimension (fr = 162). As an example, the following excerpt translates this idea: "we consider that social dimension is the capacity for interaction, to create relationships, to know how to communicate, all this is evident in the way our spaces were designed, as we thought the spaces with specific things to communicate, to collaborate. So, the social dimension, in our spaces, is present" (DMT1). So, looking deeper to SpDims' category (Table 10.3), we may observe that ILE space, from the participants' perspective, increases interactions between those using these spaces gathering 20.8% of SpDims' category relative frequencies (fr = 105). Nevertheless, participants also acknowledge that interaction with technological devices (fr = 100), a sub-sub-category of a technological/digital sub-category, are equally important summing 19.8% of the category relative frequencies.

Furthermore, built space (fr = 61) and architectural dimension, as a balanced ecosystem (fr = 56) sub-sub-categories, may also be highlighted in these results, namely corresponding to 12.1 and 11.1% to the space dimensions' category relative frequencies. These sub-categories can be represented by the following excerpt: "design, technology subjacent to education, spaces that make people feel more relaxed and behaving in a completely different way" (DMT1). These results also show that cultural dimension sub-category is not strongly considered by interviewees, gathering only 6.7% of the social dimension category's relative frequencies, the lowest score found.

Table 10.2 Interview's categories and sub-categories

	fr	% partial	% total
New Media (NM)			
Technological devices	242	23.0	7.0
Apps/platforms/programs/on-line resources	206	19.6	6.0
Influence in teaching and learning	422	40.1	12.3
Infrastructure	183	17.4	5.3
	1053	100.0	30.6
Architecture and Design (AD)			
Euclidean space	611	78.2	17.8
Furniture	170	21.8	4.9
	781	100.0	22.7
Teaching and Learning (TL)			
Ecosystem	196	18.8	5.7
Population	370	35.5	10.8
Teaching	106	10.2	3.1
Learning	219	21.0	6.4
Activities	84	8.1	2.4
Learning zones	66	6.3	1.9
	1041	100.0	30.3
Space Dimensions (SpDim)			
Social	185	36.7	5.4
Cultural	34	6.7	1.0
Technological/digital	162	32.1	4.7
Architectural	123	24.4	3.6
	504	100.0	14.7
Improvements (I)			
Suggestions	55	96.5	1.6
No need of improvement	2	3.5	0.1
	57	100.0	1.7
Total	3436		100.0

10.4 Discussion

From the presented results, we may state that interviewees perceive ILEs' space as multidimensional. Being ILEs the spaces in analysis, it is not surprising that NM and TL are the two categories with the highest relative frequencies. Having in mind that these spaces are grounded on pedagogy-technology-space triad [2, 3], our results are aligned with it, as ILEs are TEPhLEs and thought to allow active pedagogical approaches to be employed. Even though AD category summed almost 8% less of

Table 10.3 Space Dimensions category, sub-categories and sub-sub-categories

Space dimensions	fr	% sub-cat	% cat
Social dimension			
Establishment of relationships	32	17.3	6.3
Increasing interaction between students/students	41	22.2	8.1
Increasing interaction between students/teacher	58	31.4	11.5
Increasing interaction between teacher/teacher	6	3.2	1.2
Increasing interaction between institution/community	6	3.2	1.2
Increasing motivation for learning	30	16.2	6.0
Increasing motivation for being in school	12	6.5	2.4
	185	100.0	36.7
Cultural dimension			
institution culture	18	52.9	3.6
surrounding environment culture	6	17.6	1.2
establishment of a communication with the surrounding environment	10	29.4	2.0
	34	100.0	6.7
Technological/digital dimension			
Interactions enabled by technology	50	30.9	9.9
Interaction with the technological devices	100	61.7	19.8
Strong technological presence in the space	12	7.4	2.4
	162	100.0	32.1
Architectural dimension			
built space	61	49.6	12.1
furniture	4	3.3	0.8
paths	2	1.6	0.4
as a balanced ecosystem	56	45.5	11.1
	123	100.0	24.4
Total	*504*		*100*

the relative frequencies than NM, it is important to underline that Euclidean space sub-category was the one gathering the highest relative frequency. From this result, we may infer that there is an awareness of the physical space importance from interviewees' perceptions towards ILEs, specifically its equipment (technology) and instruction-related practices. These results, in our perspective, reinforce the need of a deeper study and reflection concerning built space. Nevertheless, social space sub-category (within space dimensions' category) is the space dimension that interviewees enhance the most. We may state that "Euclidean learning space" works, in part, as a "social container" aligned with Peschl and Fundneider [9] proposal of discussing knowledge creation in collaborative settings. Our results are also in line with Lefebvre [10] humans' interaction and behaviour idea that space is a social

product: ILEs' increase interactions between its users, summing more than 50% of relative frequency in social dimension sub-category. Relationships establishment (sub-sub-category from social dimension sub-category) is also highlighted by interviewees. ILEs ability to provide an increase of motivation both for learning and for being in school was also emphasized. Having in mind the research goal, the social dimension must be definitely present, not only because we are working on learning environments, but also due to the fact of aiming at inclusive PhLEs.

Since ILEs were the focus of analysis in these interviews, results show that technological/digital sub-category (within space dimensions' category) is also strongly highlighted by interviewees being aligned with the interviews context. When creating our interior design strategy for an inclusive PhLE, these results will lead us to consider the most suitable technological/digital environment in order to improve classroom orchestration through both Dillenbourg's [8] and Peschl and Fundneider [9] perspectives of it. In addition, we consider also HBI [17] as a concept aligned with the smart classroom one [16], so that better provide a richer learning environment to students and teachers.

Space architectural dimension may be commonly related to an Euclidean perspective, as the architectural space [9] or the constructed space [18] as mentioned above. Despite this, interviewees' perception of it also stresses its importance as a balanced ecosystem, in which not only the architecture itself is essential, but also its furniture, layout and paths and dynamics resulting from these.

The presented results were quite surprising in what regards to space cultural dimension sub-category. We tend more and more to a heterogeneous society, and progressively more cultures are sharing the same spaces, perceiving and experiencing it in its own way [15]. Probably there could be an increase of this fact awareness if space cultural dimension is scaffold within PhLEs. The obtained results, for us, reinforce this study importance as it approaches PhLE space as a multidimensional one. As our aim is to create an interior design strategy for an inclusive PhLE, making an approach to PhLE as a complex system, in which different space dimensions' work as an all, even though with different weights, will, probably, result in a more balanced PhLE. This is due to a better understanding on: (1) how social dimension can scaffold PhLEs, in particular by providing an improvement of opportunities for interactions and establishment of relations between PhLE users; (2) how technological/digital dimension can improve built environment physical, spatial and social impacts, by providing interactive opportunities interactions either with technological devices and interactions enabled by these; (3) how architectural dimension, especially Euclidean space itself and as a balanced ecosystem, may provide a better learning environment; (4) how cultural dimension, either through institutional/organizational culture and user's culture, can influence PhLE.

Collected data analysis is being finalized in order to support the proposal of a structured interior design strategy for an inclusive PhLE. Constraints related to the design process, as budget and time, will be considered when creating this proposal.

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Part IV
Toward Future Technological Tools and Environments

Chapter 11
Concept Integration to Develop Next Generation of Technology-Enhanced Learning Systems

Antonella Carbonaro

Abstract This paper offers an overview on the personalization of learning process components to different learners' characteristics using ontology-based frameworks. Diversification of ontology knowledge sources is a promising solution to support interoperability between the components, achieve effective personalization, improve learning process and support of a precise and richer e-learning system structure. Ontological components can use open data, published ontologies and domain knowledge to construct a domain ontology consisting of common constructs, concepts and instances. The paper describes a set of requirements that context modelling and reasoning techniques in education area should meet and highlight how the currently most prominent approach to context modelling and reasoning is rooted in ontology-based frameworks.

11.1 Introduction

The intrinsic potential of the available online educational data and datasets can be exploited using sophisticated data analysis techniques such as automatic reasoning to find patterns and extract information and knowledge in order to enhance decision-making and deliver better learning resources to the users. Moreover, education information sharing and analysis in conjunction with non-traditional data sources (e.g. social media, Web contents and Linked Data) can provide an important component to facilitate the development of the next generation of technology-enhanced learning services, in particular, personalization and inference reasoning. However, due to the high heterogeneity of data representation and serialization formats, and a lack of common accepted standards, the education landscape is characterized by a ubiquitous presence of data silos which prevent domain experts from obtaining a consistent representation of the whole knowledge. Without a shared data model for such concepts' integration, it is impossible to actuate automatic data analysis processes like inference reasoning, especially within interdomain or mobile contexts [1, 2].

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Semantic Web (SW) technologies are a promising solution for the integration and exploitation of data about students, resources, courses, syllabus and institutions. SW describes a new way to make resources content more meaningful to machines, whereas the meaning of data is provided by the use of ontologies [3–5]. Ontologies, as a source of formally defined terms, play an important role within knowledge-intensive domains overcoming the problem of interpreting homonyms and synonyms in different sources. Ontologies can also be reused, shared and integrated across applications. They provide a common agreed understanding of the domain by specifying a formal representation of the entities and relationships involved in concepts and the associated background knowledge.

Therefore, the use of SW technologies as concept representation formalism enables the creation of a common model thus interconnecting a variety of heterogeneous data sources. In the context of technology-enhanced learning, such a concept model could be employed to analyse information from multiple data sources, like generic or domain-specific datasets, and unify them in an interlinked data processing area. This scenario could promote interoperable communication among various information technology systems and can be used for automatic reasoning processes.

Although SW approaches are already well known in the scientific literature, only few studies have analysed its application to personalize learning process according to student's learning styles. In their systematic review on recommendation systems using Linked Data, Figueroa et al. [6] state that one of the most promising directions for future work is personalization of recommendations. The main advantages of this framework are analysis of interlinks between students' learning needs, e.g. learning styles and suitable learning components based on using pedagogically sound vocabularies of learning components to evaluate suitability of learning components to particular learners' needs, and application of intelligent technologies.

Smart ontology-based systems for e-learning will likely rely on diverse sources of ontology knowledge both implicitly and explicitly [7]. There is a wealthy of ontology knowledge available on the Web that may be relevant to the learner and learning resources. Extraction of ontology knowledge both implicitly and explicitly from diverse sources can improve the quality of ontology knowledge and by extension the quality of technology-enhanced learning systems.

When automated reasoning is required, the Web Ontology Language (OWL) is the output format adopted [8]; in fact, it is oriented to knowledge representation and its description logic level permits to use reasoning over the knowledge base. Indeed, on the basis of the asserted knowledge, it is possible to automatically derive new knowledge about the current context and detect possible inconsistencies among the asserted information.

This paper analyses how ontology-based frameworks can offer powerful benefits in education addressing personalization of all learning process components to different learners' characteristics. Diversification of ontology knowledge sources makes it easier to support interoperability between the components, improve learning process and support of a precise and richer e-learning system structure. Reuse and sharing of domain ontologies should be considered to reduce the cost of gathering, evaluating, and maintaining context information. The paper describes a set of requirements that

context modelling and reasoning techniques in education area should meet and highlight how the currently most prominent approach to context modelling and reasoning is rooted in ontology-based frameworks.

11.2 Concept Integration Using Linked Data and Semantic Web Technologies

The term Linked Data (LD) refers to a set of best practises for sharing and interlinking structured data and knowledge on the Internet by using standard Web technologies [9]. The primary goal of the LD initiative is to make the Web not only useful for publishing documents, but also for sharing and interlinking single piece of data. The movement is driven by the idea that the SW technologies facilitating the data sharing, integration and analysis on a global scale could revolutionize the way we manage knowledge just like the Web revolutionized information sharing and communication over the last two decades.

Technologically, the core idea of LD is to use the Internationalized Resource Identifiers (IRIs) [10] for univocally identifying arbitrary entities and concepts. Information about entities referred by IRIs can be simply retrieved by dereferencing the IRI over the HTTP.

Data about entities and concepts are then represented through the Resource Description Framework (RDF) [11] language. RDF is a standardized data model which uses graphs to represent information and facts by means of triples in the form subject, predicate and object.

Whenever a Web client resolves an IRIs associated with a triple's subject of a resource, the corresponding Web server provides an RDF description of the identified entity; these descriptions can contain links to other RDF graphs in the triple's object. Whenever an application resolves a predicate IRI, the corresponding server responds with a RDF Schema (RDFS) [12] or Web Ontology Language (OWL) [13] definition of the link type, that is a vocabulary or an ontology. Ontologies are a key aspect of the SW since they enable interoperability among different systems by providing an agreed-upon terminology such as the basic terms and relations in a domain of interest, and as well as rules how to combine these terms.

Because the Web of Data is based on standards for the identification, retrieval, and representation of information and knowledge, and scattered entities are interconnected by links, it is possible to crawl the entire data space, fuse data from different sources and provide expressive query capabilities over aggregated data, similarly to how a local database is queried today.

For this purpose, the Simple Protocol and RDF Query Language (SPARQL) [14] is the standard language for querying, combining and consuming structured data in a similar way SQL does this by accessing tables in relational databases.

Since LD is exclusively based on open Web standards, data consumers and domain experts can use generic tools to access, analyse, and visualize data. Moreover, LD

makes use of ontologies to formally define the meaning of entities and resource so that they do not limit the ability of machines to process data automatically.

Semantic Web (SW) describes a new way to make Web content more meaningful to machines. The SW architecture is based on a layered approach, and each layer provides a set of specific functionalities. Semantic layers, on the top of the stack, include ontology languages, rule languages, query languages, logic, reasoning mechanisms, and trust. Ontologies, as a source of formally defined terms, play an important role within knowledge-intensive contexts such as the one described in this article. Ontologies can be reused, shared, and integrated across applications, and aim at capturing domain knowledge in a generic fashion and provide a common agreed understanding of the domain. Ontologies constitute the backbone of the SW expressing concepts and relationships of a given domain, and specify complex constraints on the types of resources and their properties.

Rule languages allow writing inference rules in a standard way which can be used for automatic reasoning. Among several standards of rule languages, there are RuleML and SWRL [15]. The latter combines RuleML and OWL, and includes a high-level abstract syntax for Horn-like rules. SW technologies are a promising way for the integration and exploitation of food, nutrition, activity and personal data. In this context, ontologies enable the formal representation of the entities and their relationships and the associated background knowledge. On the highest layers, there are logic and reasoning; logic provides the theoretical underpinning required for reasoning and deduction. First-order logic and description logic (DL) [16] are frequently used to support the reasoning system which can make inferences and extract new insights based on the resource content rely on one or more ontologies.

The conceptual architecture of such a system comprises four components, namely data retrieving layer, data processing layer, service layer and presentation layer. Data retrieving layer collects educational datasets from users or automatically from remote servers. Data processing layer transforms input data in semi-structured formats into an RDF graph; datasets are thus semantically annotated according to reference ontologies and stored within a triple-store server. Service layer controls data access and bridges the clients to the system via service protocols. Presentation layer allows users to interact with the system using either the Web-based access or the SPARQL endpoint.

11.3 Concept Modelling in Technology-Enhanced Learning Systems

The main requirements that need to be taken into account when modelling concept in education area are:

- Heterogeneity: Context information models have to deal with a large variety of context information sources that differ in their update rate and their semantic level. A context model should be able to express different types of context information,

and the context management system should provide management of the information depending on its type. For example, information provided by the user (like user profiles), in general does not need additional interpretation. Context data obtained from dataset or digital libraries (such as the British Museum, which has made their collection available as LD, representing more than 100 million triples, or the Bibliothèque Nationale de France, which made available information about 30,000 books and 10,000 authors in RDF, representing around 2 million triples) is often static. While some context information derived from sensors provide rather raw data (e.g. Linked Sensor Data (http://wiki.knoesis.org/index.php/SSW_Datasets) have been introduced as an application of the LD principles to observation data) that has to be interpreted before being usable by applications [17, 18].

- Relationships and dependencies: One of the most important characteristics of context modelling systems is relationships between context information entities. For example, we want to express logical constraints and detailed relationships such as disjoint, inverse, part-of, and so on. All the work involved in relationship and dependencies representation can directly benefit learners by helping them to visualize and comprehend the relationships between concepts in their domain, as understood by more experienced practitioners. This can trigger associative ways of processing, reflecting and analysing information.
- Imperfection: Due to its dynamic and heterogeneous nature, educational context information may be of variable quality. For example, the context information may be incomplete or conflicting with other context information. Thus, a good context modelling approach must include modelling of context information quality to support reasoning about context. Reasoning can also be used for automatically detecting inconsistency of the knowledge base.
- Reasoning: It is important that the context modelling techniques are able to support both consistency verification of the model and context reasoning techniques. The later can be used to derive new context facts from existing context facts and/or reason about high-level context abstractions that model real-world situations. The intrinsic potential of context representation can be exploited using sophisticated data analysis techniques such as automatic reasoning to find patterns and extract information and knowledge in order to enhance decision-making and deliver better educational resources and feedback to users.

LD, ontologies and reasoning approaches to concept modelling can be considered a natural extension of the first context modelling approaches to use RDF and to include constraints and relationships between context types to satisfy the requirements of heterogeneity, relationship, imperfection and reasoning.

There is a wide variety of technologies available to represent, sharing and reusing educational Web data, but according to a number of publications, LD-based approaches started realizing the vision of highly accessible and Web-wide reusable learning resources by providing the standards, tools and Web infrastructure to expose and interlink educational data at Web scale [19].

Dietze et al. [20] propose using LD as the de facto standard for sharing data; necessity to furnish interoperability derives from the fragmented landscape of metadata

schemas, such as IEEE LOM or ADL SCORM (e.g. large use XML and relational databases, often consisting of poorly structured text lacking formal semantics) and interface mechanisms, such as Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH), Simple Query Interface (SQI) and RESTful services.

The project "mEducator" (http://www.meducator.net) demonstrates how the LD principles can be applied to model and expose metadata of both educational resources and services/APIs. The metadata of educational resources, retrieved from different services, are transformed from their native formats into RDF and are made accessible via Uniform Resource Identifiers (URIs). The mEducator metadata schema covers the most frequently used aspects of educational resources from basic ones such as title and descriptions to more sophisticated ones such as learning outcomes and licensing models. The results of the experimental evaluation demonstrated improved interoperability and retrievability of the resource descriptions, presented as part of an interlinked resource graph.

Vega-Gorgojo et al. [21] have performed a systematic literature review, analysing in detail 33 studies published between 2009 and 2013 concerning Linked Data in the educational field. The studies were classified into the technology-enhanced learning research areas: computer-supported collaborative learning, connection between formal and informal learning, contextualized learning, emotional and motivational aspects of technology-enhanced learning, game-enhanced learning, improving practices of formal education, informal learning, interoperability, personalization of learning, technology-enhanced assessment, ubiquitous and mobile technology and learning, workplace learning. The survey underlines the importance of use of LD for improving the visibility of course offerings, recommendation of educational material or expert matching; the study does not consider personalization according to the learning styles. The authors state that LD movement promises to improve existing practices of system integration, resource sharing and personalization to support learning.

Dessi and Atzori [22] propose to apply machine learning to rank techniques to the problem of ranking RDF properties used in RDF datasets, Linked Data and SPARQL endpoints. The major advantages of the approach are: flexibility/personalization, speed and effectiveness as it can be applied even when no ontology data are available by using novel dataset-independent features.

Vert and Andone [23] suggest using LD principles to discover, integrate and reuse online learning resources, using standards and principles proven to foster Web interoperability, like RDF and SPARQL. The author presents a literature review of the current efforts towards publishing of Open Educational Resources as LD and highlights some research challenges suggesting suitable approaches for open educational resources (OERs).

One more study on the OERs in Massive Open Online Courses (MOOCs) proposes to combine the description of OERs with LD approach in order to improve integration of repositories and materials [24]. The author shows a data architecture based on SW technologies that support the discovery and inclusion of open educational materials in MOOCs in engineering education. This would lead to machine-readable formats

of OERs that would facilitate automatic processing tasks. Techniques and common issues for the data interlinking process can be found in [25–28].

Figueroa et al. [6] have conducted a systematic literature review on Linked Data-based recommendation systems for diverse domains and grouped selected contributions into discussing algorithms (graph-based, statistical algorithms), similarity measures, ontologies, information aggregation and enrichment. They argue that there are still many open challenges with regard to recommendation system based on LD in order to be efficient for real applications. The main ones are personalization of recommendations, use of more datasets, and large amount of data in LD datasets. The authors did not analyse learning recommendation systems in particular, but conclude that one of the most promising directions for future work is personalization of recommendations.

Taibi and Chawla [29] present an example of use of LD with an educational purpose in mind. Specifically, they present the TED Talks dataset, which is a dataset that exposes all metadata as well as the actual transcripts of available TED Talks. As such, the comprehensive set of talks become available as multilingual and HTTP-accessible structured Linked Data facilitating the computation of links with related data and resources. The TED dataset is used by a number of educational applications, and it is included in the LinkedUp Data Catalog. The objectives of the LinkedUp Dataset Catalog (http://data.linkededucation.org/linkedup/catalog/) are to collect and make available all types of data sources relevant for education.

In another survey conducted by Navarrete and Lujan-Mora [30], the author proposes the use of LD to enhance the use of OER allowing their use, reuse, sharing and remix.

They also explain that adjustments are needed continuously to correctly represent the state of how people, groups and activities are organized. Keeping such changes updated is a major challenge in using LD in education.

A recent review conducted by Kelle et al. [31] shows efforts to apply the LD principles and technologies to solve known problems around educational technologies, such as interoperability of educational data and resources, access to data for various analyses, enrichment of material, and recommendation and personalization content. They obtained evidence regarding how the results of the recent researches in Semantic Technologies in education, more specifically the movement of LD, are being applied in practice.

11.4 Conclusion

Despite the fact that the application of SW approaches is fairly young, researchers have shown that ontology-based frameworks offer powerful benefits in education and become one of the most fashioned fields of research in educational technology.

Educational processes and learning activities can benefit from the use of a smart framework using ontologies addressing personalization of all learning process components to different learners' characteristics. Moreover, applying diversification of

ontology knowledge sources makes it easier to support interoperability between the components, achieve effective personalization, improve learning process and support of a precise and richer e-learning system structure. The overall goal is to develop evolvable context-aware systems. In addition, since gathering, evaluating and maintaining context information are expensive, reuse and sharing of domain ontologies should be considered from the beginning.

In this paper, we have presented some requirements that modelling techniques and contextual reasoning in education should meet. The currently most prominent approach to context modelling and reasoning is rooted in ontology-based frameworks for knowledge representation. The main developed ontological component makes use of open data, published ontologies and domain knowledge to construct a domain ontology consisting of common constructs, concepts, and instances.

Proposed semantic framework can be used wherever there is the need to create knowledge from information and information from data using semantic representation, reasoning technologies and incorporating domain knowledge into the computation.

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Chapter 12
Improving Writing for Romanian Language

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Abstract Writing is an essential skill for all users of a language, regardless of their age and level of expertise. Each language has a complex set of rules addressing correct writing which oftentimes contradicts the current spoken parlance. Thus, our aim is to introduce a method that automatically highlights and suggests corrections to common mistakes that people make when writing in Romanian language. Our approach relies on a multi-layered rule-based system that enforces the formal rules of writing in Romanian language by considering as reference a collection of more than 7,000 mistakes encountered in media. The provided suggestions can be easily integrated in smart learning environments centered on writing activities and can prove highly useful for all Romanian speakers, from students to professionals. Although the model is tailored for a specific language, our approach is extensible, and we strive to adjust the provided rules to several other languages.

12.1 Introduction

Writing quality, which includes a correct writing, is an important element in defining people' capabilities. Detecting writing mistakes in texts is a complex and time-consuming process, most often requiring intuition and deep knowledge of specific

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cases and exceptions for each language. Romanian language, in particular, is syntactically and morphologically complex due to its heritage. Thus, the rules that govern the correct use of the Romanian language often involve the analysis of declension—the effect that genders, numbers, and cases have on nominal parts of speech (i.e., nouns, adjectives, and pronouns); Romanian language is the only Romance languages that requires declension [1]. In addition, Romanian language has four basic tenses with more forms (*past*: imperfect, perfect, pluperfect, compound perfect, *present* and *future*—future 1, future 2, future 3, future in the past, future perfect) that are combined with two types of moods (*personal* or predicative, and *non-personal* or non-predicative). This enables a great degree of complexity when it comes to morphological forms of Romanian words, contributing to language complexity.

The aim of this paper is to introduce an automated writing evaluation (AWE) system for Romanian language capable to identify specific writing mistakes including cacophonies, repetitions, or punctuation errors, and to correct them. Due to the language complexity, a perfect system which identifies all writing mistakes is extremely difficult, if not impossible, to obtain. Native speakers and even scholars make mistakes in writing since the quantity of rules that must be considered is vast, and the process of writing involves many specific cases that are difficult to follow while editing a text. Our method employs a rule-based system, as an extension of the ReadME framework [2, 3], which aims to highlight the most common writing mistakes that Romanian speakers make. Since most mistakes are often inter-woven, we use a multi-layered approach to maximize the quantity of text mistakes that are caught, while preserving clarity. Thus, users can easily employ the system to improve the quality of their writing.

In terms of structure, the second section presents existing approaches in writing evaluation and feedback generation. Afterward, the third section introduces our integrated approach for correcting writing mistakes, alongside with the selected corpora. The forth section presents our results, followed by conclusions and future work.

12.2 Related Work

12.2.1 Automated Writing Evaluation

In the field of evaluating the quality of texts and providing feedback, two categories of systems are used, as defined by Roscoe et al. [4]. First, automated essay scoring (AES) systems simply score a given essay using various text features and perform a qualitative aggregate analysis of the essay. Second, automated writing evaluation (AWE) systems aim to provide targeted feedback to users in order to help them improve their writing skills. Most AWE systems are built on top of the AES systems and are more useful for students since they contribute to the learning process. Both AWE and AES systems use textual complexity indices to analyze the quality of the text and to measure different text aspects, starting from readability to text cohesion

and coherence [5, 6]. Our system extends the ReadME framework and offers a new dimension of analyzing text quality with regard to common mistakes.

The *ReadME* framework consists of a multi-layered AWE system that provides personalized feedback to users in terms of text quality at four granularity levels: document, paragraph, sentence, and word. *ReadME* supports both Romanian and English languages, and already includes specific language features, such as: diacritics restauration and spell checking. The *ReadME* system provides personalized feedback through an interactive web interface based on an extensible rule-based engine built on top of textual complexity indices. The generated feedback is provided using a wizard component that highlights text segments of different granularities with problems.

Various AWE systems were developed to address specific writing mistakes. For example, MyAccess (https://www.myaccess.com/myaccess/do/log) offers templates and various tools to students, such as grammatical suggestions, spell checking, and an AES component. WriteToLearn (https://www.writetolearn.net) uses summarization techniques in order to help students to write texts more clearly, together with various automated feedback components. Additional AWE systems which produce personalized feedback to users include Project Essay Grade (PEG; www.pegwriting.com), LightSide Revision Assistant (http://www.revisionassistant.com/), and Grammarly (http://grammarly.com/).

12.2.2 Automated Text Correction

Various approaches are used to perform automated text correction. Some of them include artificial errors [7], introducing noun count errors based on hand-constructed rules [8], or producing un-grammatical sentences based on an error analysis carried out on a corpus formed of roughly 1,000 annotated errors at sentence level. Foster and Andersen [9] introduce *GenERRate*, a tool for the production of artificial errors that imitate genuine errors based on two datasets: a grammatical corpus and a list of naturally occurring errors. Another approach is given by Yuan and Felice [10] who extract lexical and part-of-speech patterns for five types of errors and apply these patterns to well-formed sentences.

In Grundkiewicz's study [11], sentences corresponding to potentially unwanted edits are detected in the context of wikis. For example, updates of bullet lists, amendments of Media Wiki markup and vandalism can be effectively filtered out using heuristic rules. For example, all pairs of sentences s_i (original text) and s_j (new text) that satisfy the following conditions can be disregarded:

- Either the sentence s_i or s_j contains a bad word (determined by the list of vulgarisms) or a very long sequence of characters with no spaces (e.g., produced by random keystrokes);
- Any of the sentences s_i or s_j contains fragments of markup (e.g., "http:");
- An edit transaction contains only changes made to dates or numerical values;

- All the edits consist only of removing a full stop or semicolon at the end of the sentence;
- The ratio of non-words tokens to word tokens in s_j is higher than a given threshold (authors used 0.5).

The resulted dataset consisted of 1,775,880 (14.63%) pairs of sentences which were marked as potentially harmful, but they were not automatically removed. The main issue described related to "vandals" that made changes to the articles, as well as automatic editing by Wikipedia robots for formatting changes. The method proposed captures style errors, grammatical errors, spelling errors, and simple errors such as misused punctuation marks, misspellings, or wrong letter cases.

Rozovskaya et al. [12] focused on correcting mistakes related to articles, prepositions, word choices, and punctuations, from a given text. The proposed system uses classifiers that are based on n-grams and POS (part-of-speech) tags. However, the system does not analyze the entire phrase, but only parts of phrase (*chunks*). The used classifiers are based on a linear learning algorithm, namely a regularized version of the averaged perceptron [13] method through which an online method of feature extraction, learning, and inference is proposed with noteworthy memory requirements, which were shown to have the good results for specific natural language processing applications [14]. For word choice errors, their method is based on Naive Bayes classifiers trained on the ACL Anthology corpus (https://acl-arc.comp.nus.edu.sg/). The authors introduce methods for handling punctuation errors, namely the lack of commas or misuse of hyphens. Nevertheless, the previous methods are not applicable for Romanian language due to the lack of an equivalent corpus; thus, we propose an alternative approach described in the following section.

12.3 Method

The aim of this paper is to extend the ReadME system to provide targeted feedback for common spelling mistakes found in Romanian texts, through the use of a rule-based system that covers various linguistic aspects. While the rules presented are for Romanian language, we strongly believe that many can be generalized and easily adapted for additional languages.

12.3.1 Selected Corpora

Our corpus consists of the National Audiovisual Council of Romania (CNA) dataset which contains mistakes encountered on different media channels (both TV and radio) which were extracted by the experts from the CNA. The dataset contains 266 PDF files in which the mistakes are grouped by source and month of appearance. The CNA dataset was used as a starting point for extracting rule patterns to correct

Table 12.1 Number of mistakes for each category

Category name	#
Punctuation	740
Syntax	2,844
Semantics	629
Stylistics	195
Spelling	1,441
Morphology	1,088
Vocabulary	931
Total	7,868

the mistakes for Romanian language. Ten categories of mistakes were manually identified, from which three were removed because they did not refer to written text: pronunciation, phonetics, and orthoepic. Table 12.1 introduces the number of mistakes for the seven remaining relevant categories. Most mistakes are at syntax level (2,844), followed by spelling and morphology levels. Nevertheless, the CNA dataset had some limitations, such us: (a) overall, the dataset was quite small in order to train more advanced NLP models prevented us from using sequence-to-sequence models [15], and (b) the mistakes identified in the dataset are too varied; therefore, general rules could not be created to cover all specific cases.

12.3.2 The Rule-Based System

The proposed rule-based system extends the *ReadME* framework by offering insights into the common mistakes which users can consider revising in order to improve the quality of their productions. Our method analyzes texts in order to detect and automatically correct mistakes in Romanian texts using specific rules that can be grouped into the following three categories: cacophonies, repetitions, and punctuation errors. These categories are an initial step in the larger process of improving the quality of a text based on the feedback provided by the *ReadME* AWE system.

12.3.2.1 Cacophonies

A cacophony is not a grammatical error, but an unpleasant joining of letters that disturbs the reader. Cacophonies are caused by the adjacency of certain syllables, the most common examples in Romanian language being: “la/la” (eng. “to/to”), “sa/sa,” “ca/ca,” “ca/ce,” “ca/ci,” “că/ca,” “cu/co,” “că/co,” “că/cu,” “că/când.” Many of these examples contain diacritical marks, which are commonly found in Romanian language. While this is not a mistake per se, it is an interesting aspect of Romanian linguistics since it represents a phenomenon that is generally considered “wrong”

because they correspond to unpleasant words. However, there are some exceptions, when they cannot be avoided these syllable groupings are considered acceptable. This is mostly the case of proper nouns, such as "Ion Luca Caragiale" (prominent Romanian author).

In order to avoid a cacophony, many Romanian speakers mistakenly use the construction "ca și," also called "și parazitar" (parasitic use of the conjunction "and"). However, there are cases in which this construction can be used, for example, when it is synonymous with the phrase "the same as". These two mistakes, cacophonies, and the parasitic "și" can be easily detected with regular expressions and are very common in Romanian, especially in spoken conversations.

12.3.2.2 Repetitions

There are two types of repetitions which are considered: (a) the repetition of a specific word (in its various morphological forms) and (b) the repeated use of synonyms. The first case is considered a more serious concern since it is immediately visible, while the second may be sometimes necessary and requires a higher number of words in order to be considered aggravating.

The first case consists of the disturbing repetition of a word or of related words in a predefined window within a certain phrase. Romanian speakers are more sensitive to word repetitions, while in other languages such as English, they may be considered acceptable (especially when the repetition is used for emphasis).In the current implementation of the system, we use a 8-word window from which we removed stopwords (i.e., frequent common words that do not bring content, such as prepositions, conjunctions, and determiners). ThespaCy framework (https://spacy.io/) was used and we rely on both lemmatization and stemming [16]. Lemmatization removes word inflections in order to return the dictionary form, called lemma. In contrast, stemming is generally considered a cruder heuristic process in comparison to lemmatization as it removes, based on rules: suffixes from diminutives or augmentatives, the plurality of nouns, inflections, etc. The results of these two processes are significantly different, since stemming can generate root forms that are not usually found in the dictionary. Since the outputs are different, we used both approaches in order to detect similar words. For example, in a window containing "Copacul este copac" (eng. "the tree is a tree") the word "copacul" can be reduced to its root form "copac" which is then matched with its other apparition in the window.

The second type of repetition is given by repeating synonyms in a similar sliding window from which stop words are also removed. In order to detect whether two words are synonyms, we use the Dex Online, a dictionary of Romanian words from which we extract lexicons.

Afterward, the following algorithm is applied in order to detect groups of repeated synonyms within a sliding window: first, we perform a pairwise comparison of words to detect pairs of synonyms (two words are considered synonyms if the intersection of their lexicon sets has at least one common element); second, we assume that the synonym relationship is transitive and we group all pairs into clusters of synonym

words. As such, for a sentence such as "Pomul este un copac, sau un arbore" (eng. "The tree is a tree, or otherwise a tree") will be detected as a repetition, while the previous method that relies on word stems or lemmas would fail to identify these repetitions. Indeed, the English translation is clearly already a repetition; however, a tree can be translated in Romanian as either "pom," "copac," or "arbore," each form having subtle differences in meaning.

12.3.2.3 Punctuation Errors

Several rules were proposed to address punctuation errors that refer to the incorrect use of punctuation marks and of spaces in a phrase. Improper use of punctuation marks and of spaces is automatically detected, namely that a punctuation mark should be concatenated to the word preceding it and should have a space before the word following it. When a phrase is composed of sentences that are in a coordinate relationship, detected through the use of either of these conjunctions: "și" (eng. "and"), "sau" (eng. "or"), "ori" (eng. "or") which should not be followed by a comma. In addition, most adversative conjunctions (e.g., "dar"—eng. "but," "nici"—eng. "neither," "iar"—eng. "and," "însă"—eng. "however," "ci"—eng. "but," "ci și" and "dar și"—eng. "but also," "precum și"—eng. "as well as," "deci"—eng. "so," "prin urmare" and "așadar"—eng. "therefore") should be preceded by a comma, whereas a few should be succeeded by a comma ("în concluzie"—eng. "in conclusion").

The last proposed rule from this category refers to interleaving adverbs that require commas both before and after. The list of interleaving adverbs is: "desigur" (eng. "of course"), "fireşte" (eng. "of course"), "aşadar" (eng. "therefore"), "bineînţeles" (eng. "of course"), "în concluzie" (eng. "in conclusion"), "în realitate" (eng. "in reality"), and "de exemplu" (eng. "for example"). All the previous punctuation errors could be detected using regular expressions.

12.3.2.4 Other Common Errors

Another mistake commonly found in Romanian language is the erroneous use of the verb "a vrea" (eng. "to want"). The most used form is "vroiam"; however, this form does not exist in the dictionary and the correct form is "voiam." This is a consequence of the incorrect combination of the two verbs "a vrea," respectively, "a voi." Although in English, both verbs have the same translation (eng. "to want"), there are different forms of imperfect for the two verbs in Romanian language. The imperfect time is a time tense that expresses an unfinished action from the past. These incorrect forms can also be detected using regular expressions.

Romanian speakers also often make mistakes when it comes to the use of comparative superiority. The comparative is a comparison degree of an adjective that is present when a property of an object is compared to the same property of another object. In Romanian, the comparative superiority is built with "decât" (eng. "than"), instead of "de" or "ca" (eng. "as"). As such, "mai mare decât" is the correct form

of “mai mare de.” This mistake is often encountered in spoken Romanian, since the incorrect form is faster to say; nevertheless, it can be found in written text as well.

12.3.3 Generating Feedback

Users receive comprehensive feedback from this extension of the ReadME system, as well as the highlighting of words that were matched to one of the previously described rules. Transcending from simpler to identify mistakes to more complex ones, the system first checks for punctuation errors; feedback at this level consists of the broken segment and the corrected text, depending of the presence or absence of the punctuation mark. Second, the system looks for the improper use of the imperfect tense; the corrected text is presented with the corresponding imperfect variant of the verb “a voi”.

Third, the feedback message will also contain the words and the rephrasing suggestions in the case of a cacophony, in addition to highlighting words in cacophony relationship—for example, “Rephrase. Expression (**lala**borator) is a cacophony.” In this case, a text correction cannot be made because a rephrasing is required. We do not currently support automated rephrasing, since this task is highly context dependent and, as such, we require users to correct the text given the information they are provided.

Forth, the feedback message contains additional information in the case of the parasitic use of the conjunction “și”: besides specifying the words involved in the rule, replacement options are provided in order to correct the problem. For example, “în calitate de” (eng. “as”) or “drept” can be used instead of “ca și.”

Fifth, repetitions are detected and may be corrected through manual rephrasing. Repeated words are marked correspondingly in the text. Since words are only considered repetitions if they are found within a sliding window, we also specify which words within the sliding window triggered the rule, since the same word can appear multiple times in the text, at a distance greater than the window size. This means that windows at various positions may also represent a combined repetition; however, we did not combine such windows since we believe it may be simpler for users to gradually modify their text, rather than seeing an error spanning throughout an entire paragraph.

12.4 Results

In order to test our approach, we ran the algorithm on the following text which is riddled with errors (see Fig. 12.1).

The system detects the following errors (see Table 12.2).

Paznicul încuviințase admirând medaliile de pe pieptul bărbatului de parcă ar fi fost însuși șeful statului major. **Medaliat** cu multiple **medalii ca și** comandant, bărbatul făcu câțiva pași printre **copaci** și **pomi**. Dincolo de **copaci**, se află trei cupole mai mari **ca cea** din San Pietro. **Totuși** de ele nu a auzit absolut nimeni. "Despre ele **vroiam** să îți povestesc mai târziu", spuse bărbatul celui care îl însoțea.

eng. “The guard nodded admiring the medals on the man’s chest, as if he was even chief of staff. **Medalist** with several **medals as** commander, the man made a few steps through **trees** and **trees**. Beyond the **trees**, there are three domes larger **than the one** from San Pietro. **However** no one hear heard about them. "These are what I **wanted** to tell you about later," said the man to the person accompanying him.”

Fig. 12.1 Sample input text

Table 12.2 Identified mistakes

Incorrect text fragment	Mistake type	Feedback
mai mari ca cea din San Pietro	Cacophony	Rephrase. Expression (ca cea) is a cacophony
Medaliat cu multiple **medalii**	Repetition	Rephrase. Disturbing repetition for words (“medaliat”), (“medalii”)
ca și comandant	Parasitic use of the conjunction “and”	Rephrase using one of the expressions: “în calitate de” or “drept”
copaci și **pomi.** Dincolode **copaci**	Repetition	Rephrase. Disturbing repetition for words (“copaci”) (“copaci”)
printre **copaci** și **pomi**. Dincolo de **copaci**	Repetition of synonyms	Rephrase. Disturbing repetition for words (“copaci”), (“pomi”), (“copaci”). These words are synonyms
Despre ele **vroiam**	imperfect “vroiam”	Change into: “Despre ele voiam …”
se află trei cupole mai mari **ca cea** din San Pietro	Comparative superiority	Change into: “se află trei cupole mai mari decât cea din San Pietro”
Totuși de ele nu a auzit absolut nimeni	Adverbs at the beginning of the sentence	Change into: “Totuși, de ele nu a auzit absolut nimeni.”

12.5 Conclusions

In this paper, we introduce a structured approach to automatically detect errors in Romanian texts through a rule-based system that uses templates generated from a dataset of common mistakes made by media channels. While the system we propose has immediate applications for Romanian speakers, many of the detected rules (e.g.,

repetitions) can be easily generalized to other languages. The system was designed to be capable to accommodate new languages by adding or changing rules, and it can be used to enhance any writing activities within smart learning environments.

The main encountered difficulties relate to the syntactic and morphological complexity of the Romanian language; thus, the process of finding generalizable rules is tedious. Given the nature of the proposed rules so far, some categories of mistakes, mainly relating to context and declension, are not taken into account. We believe that, through a larger corpus, new approaches could be experimented, such as the use of sequence-to-sequence models [15] to automatically transpose texts into its correct form.

The problem of detecting mistakes in Romanian writing, as well as in any other language, can be successfully approached through a hybrid method of hand-written rules and the use of various linguistic features and markers. We believe that users can increase the quality of their written work by relying on tools that automatically highlight common mistakes, in tight connection with the statistical measures performed using the textual complexity indices computed by the ReadME system.

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Chapter 13
A Prototype for the Automatic Assessment of Critical Thinking

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Abstract Critical Thinking is a complex construct to define and understand, also due to a variety of definitions in the field. In recent years, different ways to assess Critical Thinking have been developed, based on methods such as natural language processing. The present paper describes a prototype developed for automatic Critical Thinking assessment in the presence of open-ended questions or essays. The prototype is designed to assess four areas related to Critical Thinking in open questions: basic linguistic skills, relevance, importance and novelty. Future development of the prototype will require the inclusion of new indicators, such as argumentation and critical evaluation.

13.1 Introduction

Critical Thinking is an elusive construct to define and understand, partly due to a variety of definitions in the field [9]. Liu [8] for example observed that the definitions of Critical Thinking can change according to the contexts in which the definition has been developed. She observed that the definitions provided by the HE institutions tend to be focused on the processes underlying Critical Thinking. Companies define Critical Thinking in relation to its direct outcome, for example, how Critical Thinking supports problem-solving and decision-making. Despite several definitions, many authors consider Critical Thinking as a set of skills and dispositions [4]. The general lack of agreement on the definition of Critical Thinking led to the production of different assessment methods. Indeed, the conceptualization and the assessment of Critical Thinking are interdependent issues that must be discussed together: the definition of Critical Thinking determines how to best measure it. The most common measurements fall into two categories: multiple-choice or self-report

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tests [2, 4, 14] and essay or open-ended questions [3]. Both of these measures present advantages and disadvantages [7]. Multiple choices allow the measurement mainly of the cognitive component of Critical Thinking, whereas the dispositional component is incompletely revealed. Indeed, multiple-choice tests provide a "prompt" that is unable to mirror spontaneous inclinations engaged in Critical Thinking situations. In addition, satisfactory performance in prompted thinking contexts cannot be generalized to contexts in which prompts are not given. On the other hand, essays can be used to assess both cognitive and disposition skills, although they are highly connected to a specific domain and require a big amount of effort and time in the scoring procedure.

In recent years, new ways to define and evaluate Critical Thinking assessment have been developed. According to Byrnes and Dunbar [1], Critical Thinking cannot be understood merely in terms of working alone on a reasoning task, but it is necessary to consider its role in *various types of information exchange or symbolic interaction*. For this reason, interactions mediated by the use of information communication technology could provide an emergent context for the study of Critical Thinking. For example, because of its asynchronous nature, computer-mediated discussions provide more time to think before answering. An increase in the use of formal, evidence-based reasoning and the quality of Critical Thinking can be due to an extension of the time available to think and consult sources of information, during the asynchronous computer-mediated discussion. In a well-known study of Newman, Webb and Cochrane [10], they found a similar level of students' Critical Thinking in online and face-to-face discussions, whereas other authors found [6] more evidence of Critical Thinking in the online condition, especially in terms of justification with evidence. Digital platforms (e.g. social media, LMS) automatically record a big amount of behavioural data connected to learning processes. The analysis of data collected from virtual learning environments has attracted much attention from different fields of study; therefore, a new research field, known as learning analytics, is emerged. In the field of Critical Thinking assessment, Gordon, Prakken and Walton [5] proposed a functional model for the evaluation of arguments in dialogical and argumentative contexts. Wegerif and colleagues [15] described a computational model to identify moments within e-discussion in which students adopted critical and creative thinking. Developing a computational model to identify Critical Thinking levels in students' written comments provides at least two key advantages. First, a computer program could assist the researcher in finding key aspects in big amounts of data. Second, the computational model can be used to help teachers or moderators establish when students are increasing their Critical Thinking levels.

13.2 A Prototype for the Automatic Assessment of Critical Thinking

In the present paper, the architecture of a prototype developed for the automatic evaluation of the Critical Thinking in open-ended answers is presented. The prototype is based on a model code developed in previous researches [11–13] mainly inspired by the model of Newman, Webb and Cochrane [10] and adapted by Poce [11–13]. The model code (Table 13.1) is based on six macro-indicators: basic linguistic skills, justification, relevance, importance, critical evaluation and novelty.

The first macro-indicator, namely *use of the language*, is useful to assess the language form of the text. The macro-indicator called *justification* evaluates students' ability to elaborate on their thesis and support their arguments throughout a discourse. *Relevance* is a macro-indicator that analyses consistency in the texts produced. For instance, it refers to the correct use of outlines and to the capability to accurately use given stimuli. The macro-indicator called *importance* evaluates the knowledge used in discourses. *Critical evaluation* assesses personal and critical elaboration of the sources, data and background knowledge. Finally, *novelty* concerns the development of new ideas and solutions based on the initial hypothesis and personal thesis. At the moment, the prototype has been designed to assess four areas out of six: use of the language, relevance, importance and novelty.

The compound system is composed of four main modules that allow to perform all the operations necessary to obtain the experimental results (Fig. 13.1).

The four modules are described in Fig. 13.1:

13.2.1 Authentication Manager

The module has been implemented by using the Spring Framework (https://spring.io/projects/spring-framework), an open-source application adopted to automatically configure security processes, such as authentication and authorization. Every operation within the system is logged anonymously in order not to influence the interactions with the system. The module allows online registration via email and provides a secure login form to access the services offered.

13.2.2 Input Module

This module manages the insertion of the questions and answers to be evaluated. For each question, in addition to the title and the text of the question, users are also asked to include words representing the *concepts* and the *successors*.

Concepts could be defined as the topics that should be covered in a correct and exhaustive answer.

Table 13.1 Model codes to assess Critical Thinking in essays and open-ended questions

Macro-indicators	Indicators	Descriptors	Marks	
Use of the language	Language ability (punctuation, spelling, morphosyntax, lexicon)	a. Rich and original	Excellent	5
		b. Appropriate	Very good	4
		c. Mainly correct	Good	3
		d. Not precise	Insufficient	2
		e. Not correct and improper	Clearly insufficient	1
Justification/ argumentation	Elaboration ability (thesis definition and elements of reasoning)	a. Rich and articulate	Excellent	5
		b. Clear and ordered	Very good	4
		c. Too synthetic	Good	3
		d. Quite consistent	Insufficient	2
		e. Inconsistent	Clearly insufficient	1
Relevance	Consistency (the topic under issue is mentioned)	a. Complete, deep and original	Excellent	5
		b. Complete and correct	Very good	4
		c. Generic	Good	3
		d. Partial	Insufficient	2
		e. Out of line	Clearly insufficient	1
Importance	Knowledge of the topic (main issues related to the topic are mentioned)	a. Deep and critical	Excellent	5
		b. Complete	Very good	4
		c. Appropriate	Good	3
		d. Superficial	Insufficient	2
		e. Not sufficient	Clearly insufficient	1
Critical evaluation	Personal and critical elaboration of sources and background	a. Critical and well sounded	Excellent	5
		b. Wide and adequate	Very good	4
		c. Essential and simple	Good	3
		d. Partial	Insufficient	2
		e. Contradictory	Clearly insufficient	1
Novelty	New information, ideas and solutions are added to discuss the issues raised in the questions	a. Widely, critically and originally;	Excellent	5
		b. In detail;	Very good	4
		c. Correctly;	Good	3
		d. Simply and or partially	Insufficient	2
		e. No new information and solutions are added	Clearly insufficient	1

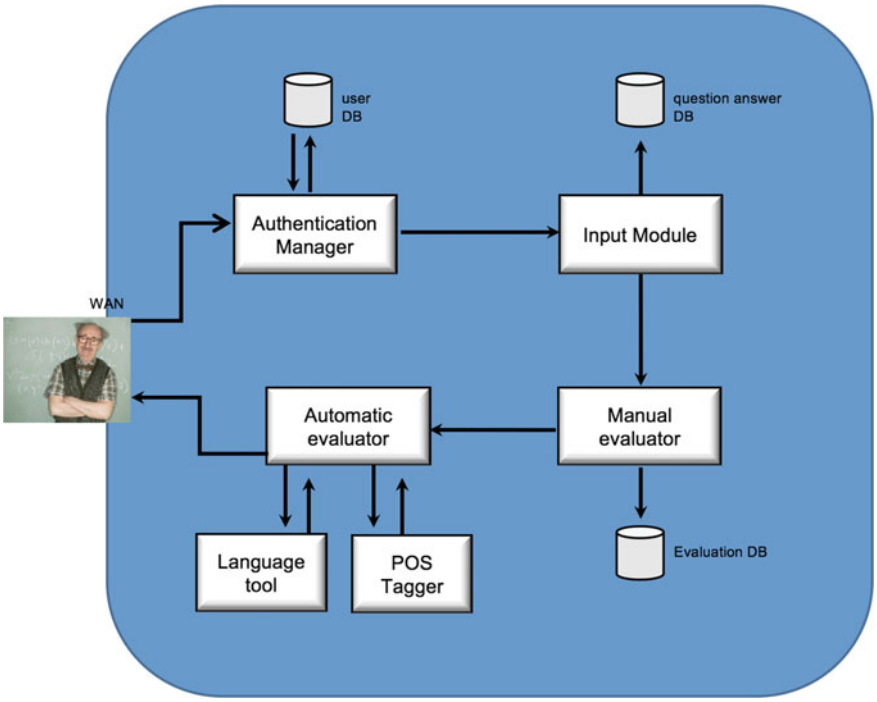

Fig. 13.1 Four modules of the system

Successors represent, instead, deepening or related topics of the given concepts. *Concepts* and *successors* will be used by the automatic response analysis module to evaluate the four indicators of Critical Thinking. It is possible to insert more questions or answers at the same time using the import function from Google forms and uploading the generated XML file. The module interacts with Hibernate, a framework for the automatic management of entities in the local database where all the questions and answers are saved.

13.2.3 Manual Evaluator

Through this module, sector experts can manually evaluate the indicators for the answers entered.

It is possible to select any question on the system, and this latter will propose in series all the answers not yet evaluated. The user can then decide whether to evaluate the answer or assign it to another teacher. For each question, it is possible to associate one or more anonymous evaluation; these evaluations will be compared with the automatic evaluations to verify the effectiveness of the proposed approach.

13.2.4 Automatic Evaluator

This module is at the heart of the system. It will use two external modules to perform the automatic evaluation of the four indicators presented.

Use of the language: To evaluate language skills, the system makes use of the collaboration of an external system, the JLanguageTool (https://languagetool.org/). This tool, developed as an online web service rest, allows you to send texts and receive information on grammatical errors within just a few milliseconds. It also allows you to receive a version of the text with the most probable corrections. This correct version of the text is fundamental for more advanced analysis since an incorrect text introduces noise that lowers the performance of the whole system. The value of the indicator is given by normalizing the number of errors considering the number of words contained in the answer.
Relevance: Relevance is assessed carrying out an analysis of the *concepts*. The text is processed by a POS Tagger (https://nlp.stanford.edu/software/tagger.shtml), which analyses the text of the response and extracts all the nouns. This set of nouns is applied to an algorithm that generates n-grams with a length from one to three, and it is hence compared with the concepts defined for the question. The number of the intersection between the n-grams and the concepts will give the relevance of the answer.
Novelty: Novelty is assessed carrying out an analysis of the *successors*. As for the relevance indicator, all the nouns and n-grams are extracted from the answers' texts. The frequency of intersections between n-grams and successors results in the *novelty* dimension of the answer.
Importance: Importance is assessed by exploiting a Wikipedia analysis. Initially, the text of the answer is sent to an online tagging service through Wikipedia pages, TAGME (https://tagme.d4science.org/tagme/). The service returns a set of Wikipedia pages associated with a given text, in our case the text of the answer.

Afterwards, each defined concept is automatically linked to its Wikipedia page. All the outgoing links of this Wikipedia page are taken into account. The importance indicator is given by the number of known Wikipedia pages that the TAGME system detects respectively from the answers given by the participants and from the concepts defined by the assessor/researcher.

13.3 A Use Case

An example of system interaction is presented here by explaining all the functional operations described in the previous paragraph. After entering the URL to reach the platform (currently locally on a Roma3 server), the first interaction that users have with the system is the login form. If the user connects for the first time to the platform, email registration is required that will be confirmed by the system administrator.

The submission of the login form redirects the user into the main page of the system (Fig. 13.2). In the first column, the user finds all the questions entered in the system. For each question, it is possible to perform a manual evaluation of the indicators by a domain expert.

If the user chooses the manual evaluation, the text of the question and the answer will be visualized. Through four checkboxes, it will be possible to insert manually the values of each Critical Thinking indicator (Fig. 13.3).

On the other hand, the system can perform the automatic evaluation of the answers and create the entry in the database for future evaluation. By choosing the automatic assessment (Fig. 13.4), the user will visualize an insertion form where to insert the text of the question, the concepts, the successors and a golden answer (not mandatory).

Fig. 13.2 Home page of the system

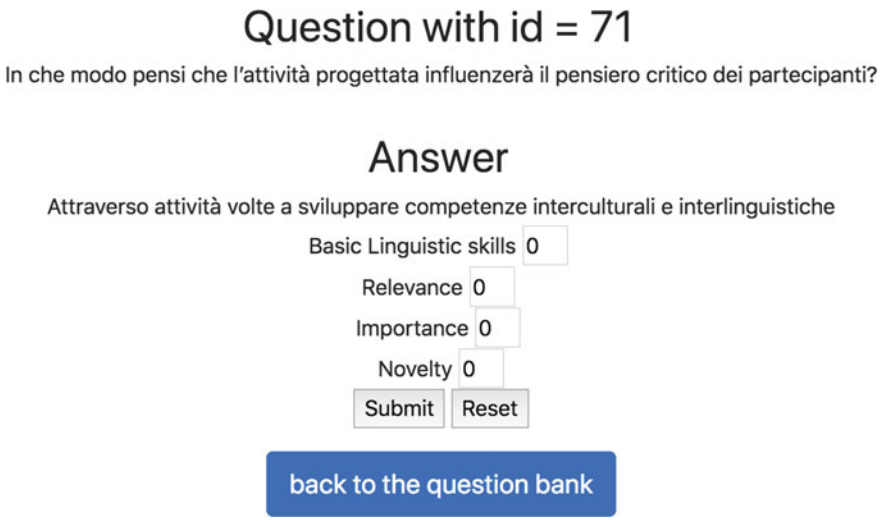

Fig. 13.3 Tool to manually assess open-ended questions

Fig. 13.4 Tool to set the automatic assessment of the open-ended questions

13.4 Conclusion and Further Developments

Since digital platforms automatically record a big amount of data connected to learning processes, linguistic data collected from virtual learning environments can be used to automatically assess Critical Thinking. The paper presents a system developed to automatically evaluate four indicators of Critical Thinking in open-ended questions and essays. The system analyses open-ended questions exploiting Wikipedia and using natural language processing (NPL) techniques. The input module system works on manually entered concepts (for the evaluation of relevance, novelty and importance). In future, the Wikipedia approach could be also used to infer automatically the concepts. In addition, it would be necessary to implement the automatic evaluation of the other two indicators, argumentation and critical evaluation, to complete the Critical Thinking model proposed in our previous work. Finally, it will be necessary to make a large-scale evaluation of the system using an adequate question/answer dataset to compare the performance of the automatic evaluations with the manual ones inserted by the domain experts.

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Chapter 14
Prediction of Newcomer Integration in Online Knowledge Building Communities Using Time Series Analyses

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Abstract In smart learning ecosystems, online communities act as informal learning environments in which members share their interests, challenges, and knowledge on a specific topic. The life span of such communities depends on sociability and usability, and therefore also on the addition and successful integration of newcomers. This study focuses on the automated classification of blog communities into integrative and non-integrative based on features derived from time series analyses applied to the distribution of contributions in time and of participants' pauses within the community. The generated features can be used to support learners with insights on which communities should be targeted in order to maximize their chance of integration. Our study is focused on 20 communities which were classified with an 85% accuracy into integrative and non-integrative. For educational research, our findings provide a starting point to follow up investigations on the impact of pauses in learning processes or learners' behavior.

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14.1 Introduction

In online communities, members create shared repertoires of resources (knowledge) on specific topics as a result of their discourse [1]. Similar to knowledge communities, blogger communities are formed around topics of interest, and members collaborate to exchange ideas, experiences, or problems. Bloggers take knowledge in their own hands and continuously engage in social interactions. Although community knowledge is obtained through learning processes, it is not guided by tutors or leaders, but achieved from a self-organized process around topics of interest. Therefore, learning comes as a result of the interaction between members. According to Scardamalia and Bereiter [1], community members are placed in the center of the community's knowledge creation processes, constantly acquiring a new knowledge or skills, and contributing to the dynamic evolution of the community. According to Preece [2], the number of participants is a straightforward indicator of a community's success. However, longevity and sociability are ensured by the constant integration of newcomers, as certain members may leave the community. Moreover, newcomers often bring new perspective and insights, as well as potential knowledge from domains unfamiliar to older members and use it to contribute to the community's knowledge base [1].

In smart communities, communication is enhanced through technology and community members use virtual communication tools to share knowledge. Thus, discussions are stored online and available for everyone, especially newcomers, as well as for tools designed to analyze them. In this study, we focus on the automated prediction of integration in blogger communities by analyzing discussions between members. The topic is challenging as, according to Levine and Moreland [3], newcomer integration depends on the qualities and tactics employed by both newcomers and oldtimers. The concept of "integrativity" was previously used by Nistor et al. [4] to describe the degree to which a community supports the integration of new members. Moreover, Nistor et al. [4, 5] previously studied the impact of newcomer inquiries in blogger OKBC responses and found that the community's response is mainly influenced by the visitor's inquiry format and the quality of the established dialog.

Newcomer integration is a topic of increasing importance which has been studied in face-to-face settings by Eberle et al. [6], or in online settings by Nistor et al. [4], under the hypothesis that community practice is reflected in its dialog. Consequently, newcomer integration was predicted with features extracted from automated dialog analyses with the ReaderBench [7] framework. In our study, we take a different approach, by analyzing the message threads as independent time series features focusing on pauses between adjacent messages.

Chronemics, i.e., the study of time in communications, is linked with personality traits or activities. Pauses in communication can be related to reflection [8], reciprocal trust [9], or reduced interest toward a topic. An increasing pause length in a discussion can be associated with more time for reflection, better content quality, and therefore an environment which favors newcomer integration. However, shorter

pauses are associated with environments which encourage participation, with similar results. As the literature on newcomer integration does not explain if there is any relation between pauses in discussions and newcomer integration, we investigate relationships between the concepts, in the context of automated prediction of integrativity.

The aim of this study is to identify features from messages' time series (e.g., posting time, pauses, frequencies, or length of the messages) in order to answer the following research question: How accurately do features derived from the time series of messages predict OKBC integrativity?

The paper is structured as follows. First, we give an overview of the corpus used for the study and our proposed method of feature extraction from time series analyses. The next section presents an overview of the extracted features, in the context of integrative and non-integrative communities, as well as the results for automated classification models, trained on distinct pairs of features. The last section presents an overview of our study and plans for future work.

14.2 Method

14.2.1 Blogger Communities Corpus

This study was carried out on blogger communities which were freely available on the Internet, on various platforms. Details on integrativity were obtained from a previous experiment [4] in which the researchers conducted a survey and invited the members of these communities to respond. Communities were deemed integrative when newcomer requests were answered and non-integrative when they were ignored. One community was excluded from the experiment because the blog format did not permit differentiating among distinct involved participants.

The corpus used in this study consists of dialog produced by 20 blogger communities within one year, covering various topics, namely cooking (8), science (4), and politics (8). These communities are classified as integrative (nine communities, with 6–181 participants) when newcomers are easily integrated, or non-integrative, otherwise (11 communities, with 18–414 participants).

For each blogger community, we recorded blog posts and their comments, and we collected the time of posting, the user name and content of each message. 15,201 messages were collected for one year: 6028 messages from 7 to 1315 blog posts per community in integrative communities and 9173 messages from 14 to 194 blog posts per community in non-integrative communities. No personal data for the participants were collected.

14.2.2 Time Series Analysis

From the corpus of blogger communities, we extracted properties at three levels: (1) *community*—we identified the number of members and the number of blog posts published within a year; (2) *blog post* with corresponding comments which can be perceived as an individual discussion thread—we computed the number of participants, the number of messages, and the time distance between the first and last contributions; (3) *individual contribution*—we considered posting time in order to measure the pause between consecutive contributions, and the number of words for each message. For each feature in integrative and non-integrative communities, we computed the average and standard deviation (see Table 14.1). As previous studies by Nistor et al. [4, 5] evaluated the role of discourse in predicting integrativity, we propose a different approach similar to the one introduced by Pasov et al. [10]. The complexity of our model is reduced by extracting features as time series at contribution level (3) and by estimating their trend. Thus, each time series of messages is analyzed in accordance with a linear regression model from Eq. (1):

$$Y = \text{intercept} + \text{coefficient} * X \tag{1}$$

where the intercept represents the normalized average value, while the coefficient reflects the variation in time from the intercept (e.g., an array of pauses between contributions is estimated with the intercept and coefficient of the linear regression which best estimates the array). Positive values for the coefficient show an increasing trend for the analyzed feature, whereas negative coefficients are attributed to values which decrease in time. In terms of the time series analysis of blog posts, we considered only the minimum, average, and maximum values as there is no information regarding the relationships between members contributing to one blog post or another or pauses within different discussion threads.

Table 14.1 Dialog properties for integrative and non-integrative communities

Feature	Integrative		Non-integrative	
	M	SD	*M*	SD
Word count coefficient	−43.49	58.45	−60.40	48.31
Word count intercept	255.07	135.95	259.82	95.77
Word count	139.85	100.90	49.55	55.65
Pause coefficient	1.96	3.87	2.02	25.29
Pause intercept	4.95	19.62	91.58	299.53
Replies per blog post	5.57	3.72	13.48	7.90
Participants per blog post	3.64	2.12	10.65	7.40
Maximum participants per blog post	10.22	5.76	47.63	41.28
Time distance between first and last message	31.55	40.72	732.47	2170
Messages per blog post	5.57	3.72	13.48	7.90

14.3 Results

Both integrative and non-integrative communities have negative average words' coefficients, meaning that the size of contributions (including user comments) corresponding to blog posts decreases in time (see Table 14.1). Intercept values are comparable, which shows that there are no significant differences between the size (in words) of independent messages. However, integrative communities use more words than non-integrative ones while relating to features extracted from blog posts. In terms of pauses, integrative communities have lower intercepts, which mean that members reply faster to others' contributions, while coefficients have a lower absolute value, meaning that pauses between messages are comparable in values. Moreover, the average life span of a blog post (from the initial post until the last message) is significantly higher in non-integrative communities than for integrative communities. This is also reflected in the number of messages sent in time.

Taking into account the limited number of communities, as well as the high number of previously proposed features, we created independent logistic regression models for every possible pair, focusing on features with high impact in the classification and features which can improve the results (see Table 14.2). Taken individually, the following features were most predictive of integrativity using binary logistic regressions: the maximum number of participants per blog post (80% accuracy), the average number of participants per blog post (75% accuracy), and the average number of words per community (70% accuracy).

The best model relying on the maximum number of participants per blog post and the average pause coefficient from the linear regression was capable to correctly

Table 14.2 Confusion matrix for integrativity prediction with different features

Feature	Predicted integrativity	Actual integrativity		Accuracy (%)
		Yes	No	
Average replies per blog post	Yes	5	4	60
	No	4	7	
Average replies per blog post Average coefficient pauses lin. reg.	Yes	6	3	70
	No	3	8	
Maximum participants per blog post	Yes	8	3	80
	No	1	8	
Maximum participants per blog post Average coefficient pauses lin. reg.	Yes	8	2	85
	No	1	9	
Maximum participants per blog post Word count intercept	Yes	8	2	85
	No	1	9	

classify 17 (8 integrative and 9 non-integrative) of 20 communities, while only three communities were misclassified (2 false positive and 1 false negative): Wilk's λ of 0.69, $p < 0.05$ and $R^2 = 0.4$. The logistic regression coefficient for the pause coefficient is positive, meaning that higher values are associated with integrative communities. A high and positive pauses' coefficient is attributed to longer and more intense discussions, where the peak of intensity is the initial message. The length of pauses increases in time after the main post. Moreover, in non-integrative communities, there are either no following messages at all, or the initial post triggers comments with the same or more impact (which change the length of pauses).

The two non-integrative communities which were misclassified have the lowest number of participants per blog post, among non-integrative communities: 5 and 14, lower than the average value, 47 (Table 14.1). Given that this feature has the highest impact on the classification, and that we have used a linear model, the result would be expected. The only integrative community classified as non-integrative is the one having the highest maximal number of participants per blog post, double than the average, and a very low pauses' coefficient.

In addition to the previous results, the average pause coefficient also provides improvements in the logistic regression when paired with the average number of replies per blog post, as seen in Table 14.2. With those features, 14 of 20 communities were correctly classified with Wilk's $\lambda = 0.66$, $p < 0.05$.

The intercept of the number of words per message is another feature which improves accuracy to 85% when paired with the maximum number of participants. This feature also negatively impacts integrativity: the lower the number the words, the more likely that the community is integrative; nevertheless, high average numbers of words can define any type of communities. This argues that a high volume of discussions might be attributed to closed groups, where members are more confident in communication between each other.

14.4 Conclusions and Future Work

Our aim was to create an automated model of predicting integrativity in online virtual communities using features extracted from the time series of contributions, and we have obtained a maximal accuracy of 85% (17 of 20 blogger communities). The most predictive individual feature was the maximum number of participants corresponding to a blog post, which alone classifies blogger communities with an accuracy of 80%. An interesting finding is that a lower maximal number of participants explain integrativity, while a high maximum number is associated with non-integrative communities. This is backed up by the negative coefficient in the logistic regression. However, this contradicts the research by Preece [2] who considered that a higher number of participants are important to newcomer integration. Moreover, the average number of participants per blog post, as well as the relative number of participants to the total number of community members, has a negative impact on integrativity. A possible explanation would be that it is more difficult for larger communities to

keep track of and integrate newcomers; similar, newcomers have to invest more effort in order to stand out in discussions.

The proposed method of representation for time series with linear regression parameters generated relevant features, which in return achieved high accuracy for the classification of communities when coupled with others. Accuracy improved from 80 to 85% with the addition of the average pauses' coefficient to the classifier. This result is interesting as pauses between messages were not previously considered for newcomer integration. The size of pauses between contributions in student chats has been proven to predict participation in the discussions in the study performed by Pasov et al. [10]. However, neither the average pause value, nor the pause intercept, is the significant predictors of integrativity. Thus, members from both types of communities respond with similar pauses between contributions.

In the context of smart communities, where learning comes as a result of members' interactions, an automated tool for predicting integrativity could provide learners with the possibility to choose which communities to join and not invest too much time with communities that do not encourage the integration of new members. Our tool is built from features independent from the community topic or the community dialog (i.e., maximum number of participants per blog post or the regression coefficient from the time series of pauses) and can be applied to any unknown community.

Since the results of this study are limited by the size of the dataset, the findings need to be further generalized upon additional communities. Research on a larger dataset will allow using multiple features for the classifications, while avoiding overfitting. The impact of pauses in asynchronous discussions in integrative or non-integrative communities must be confirmed by qualitative and further quantitative research.

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Part V
Learning Ecosystems and Regional Development

Chapter 15
Challenge of Talent Attraction in Small and Medium Urban Areas: Case of Valmiera City, Latvia

Agita Livina and Sarmite Rozentale

Abstract In many European countries, the population is declining, and among the urgent issues of city leaders and planners, and the European Commission is the question of how to make cities flourish. For business and technology to develop, cities need to attract talented people from other cities and countries. Until now, talent research has mainly focused on talent development in organizations and little on talent attraction in big cities. The topicality of this chapter is a research of the situation on attracting talent in cities with a population between 20,000 and 50,000. This article identifies the factors that are important to talented people in deciding to move to another city. The research is a case study of the economically developing city of Valmiera in Latvia with a population of 23,063. The study included 28 in-depth semi-structured interviews and the university alumni survey (n-81). The results reveal that the differences in choice factors are mainly determined by the stage of human life—the beginning, middle or maturity of family life and career. The literature research indicates a major role of the international dimension in attracting talent. The research shows that the respondents mentally support openness and the acceptance of strangers, but these statements are contradictory to the positive attitude in the feelings towards a "small, family-like, familiar, safe" city.

15.1 Introduction

15.1.1 Significant Dimensions in Urban Development

In general, the global population is growing, but some regions, countries and cities are at the same time facing a decline in population, especially the working age population [23]. Globally more than half (55%) of the world's population lives in urban areas, and the tendency to live in urban areas is increasing. In Europe, 75% of the population lives in urban areas, of which 24.2% lives in small- and

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medium-sized urban areas (hereinafter SMUA) with a population between 5,000 and 50,000 [11], the fDi rankings define micro-cities as cities with a population below 100,000 [6]. In European countries, are experiencing a decline in population; city leaders and planners and the European Commission have the development opportunities of SMUAs on their agenda looking for new solutions on both how to retain the existing situation and how to achieve the flourishing of cities [4, 25].

With urban areas expanding and looking for new scenarios for recovery, the importance of successful management of urban areas, especially in low- and middle-income countries, is increasing emphasizing innovative ways of complex management of urban areas [16, 22, 23]. Seventeen United Nations Sustainable Development Goals are important for both large cities and SMUAs, and actions are being included in long-term urban development strategies to achieve the Sustainable Development Goals.

From the United Nations Sustainable Development Goals, let us move on to the European Policy Commission document "Strategy Europe 2020", which defines three mutually reinforcing priorities: (1) smart growth: developing an economy based on knowledge and innovation; (2) sustainable growth: promoting a more resource efficient, environment friendly and more competitive economy; (3) inclusive growth: promoting an economy with a high employment rate and ensuring social and territorial cohesion [4]. This is a challenge, especially for SMUAs in terms of increasing the number of smart and talented people. Larger cities have more resources and ambitions [5], but SMUAs with limited financial and human resources also want to provide smart and sustainable development [1] in the framework of their infrastructure and space capacity; thus, the knowledge on how to move towards the Sustainable Development Goals and the Europe 2020 goals is very important. The research carried out by the authors will focus on one of the important dimensions of achieving the goals—attracting talented people to SMUA as a critical factor for sustainable urban development.

Sustainable development of urban areas is closely linked to four key dimensions: institutional, economic, social and environmental [13, 16, 20, 26]. The institutional dimension is like an umbrella—a framework for activities in the other three dimensions ensuring cooperation among stakeholders in achieving the Sustainable Development Goals.

Researchers, policy makers and developers have created various rankings, indexes for benchmarking universities, cities, countries and defined important dimensions in calculating these rankings [8]. The most frequently analysed dimensions for sustainable and smart development of cities, including creating innovations and attracting talented people, are summarized in Table 15.1 (grey cells).

The European Commission report "Mapping Smart Cities in the EU" (2014) analyses cities with a population of over 100,000 in six dimensions for smart urban growth. Of the 240 smart cities, the least characterized dimension for 52 cities or 9% was "Smart people", but the most often characterized dimension "Environment"—for 199 cities [5]. In the area of urban smart development and growth, including the important resource—the attraction of talented people—there is not much research on cities with a population below 50,000.

Table 15.1 Overview of the dimensions related to urban development

Dimension	Mapping Smart Cities in the EU	The Global Power City Index	The Global Competitiveness Report	The Global Talent Competitiveness Index
Economy	■	■	■	■
Mobility	■	■	■	
Environment	■	■	■	■
People	■		■	■
Living	■	■		■
Governance	■		■	
Culture		■		
R&D		■	■	

The report on the Global Power City Index compares 44 cities in the world, pointing out that these cities, growing in strength, theoretically have the potential to attract people and businesses from around the world. The report "Mapping Smart Cities in the EU" (2014) concludes that the incidence of smart cities decreases with the size of population, adding that this does not mean that smaller cities (the report refers to cities with 100,000–200,000 inhabitants) would not be involved in the development of smart cities [5].

In 2018, among the top 10 countries in the World Competitiveness Index six countries were from Europe, including two from Northern Europe—Sweden and Denmark [17].

The fDi European Cities and Regions of the Future 2018/19 ranking includes the following five groups: economic potential, labour environment, cost-effectiveness, infrastructure and business friendliness. Each thematic group has many indicators that cover the dimensions listed in Table 15.1. This rank is defined for micro-cities, which is the target group for this study.

In many of the indexes, the number of inhabitants is one of the thresholds, also in the development of businesses, to include cities in further analysis.

The authors summarized the number of cities in Northern European countries with a population ranging from 20,000 to 50,000. In Northern Europe, there are 168 such cities, mostly in Sweden, Finland and Denmark, but least in Iceland, Estonia and Latvia (see Table 15.2), which suggests that the results of the study are widely applicable.

The study will examine how the human resources dimension can be attributed to the development of Valmiera city in Latvia with a population of over 20,000. The city faces the challenge of attracting talent to grow.

Table 15.2 Cities with a population from 20,000 to 50,000 in Northern European countries

Country	Number of cities with a population from 20,000 to 50,000	Country	Number of cities with a population from 20,000 to 50,000
Sweden	48	Lithuania	23
Finland	42	Denmark	31
Latvia	5	Iceland	2
Estonia	3	Norway	14

Source http://worldpopulationreview.com/countries/

15.1.2 Talent and Small and Medium Urban Areas

The research on talent has been carried out from the organizations' perspective for a long time [14, 15], but much less in the context of cities, regions, on how to attract talented people to specific locations. There are only a few regions in the world where talents can be developed from their residents and educational institutions in a sufficient number. In order for business and technology to develop, talented people from other countries need to be attracted to the regions [12]. Who are the talented people that cities want to attract? Talent is conceptualised from the authors' point of view as: talented people excite others, create and implement ideas and have good reasoning skills.

For the most part, talent flows are investigated by exploring talent flow factors and building talent flow models based on these factors. Based on literature research, Ingram has identified four external factors in attracting talent: economic development, market competition, labour market conditions and national culture [10]. Only career development—work is not enough for a modern talented person, the lifestyle in the city plays an important role [7, 9, 18] and the values: the natural environment, social environment, buildings, public spaces and public and private services [12]. The acquired benefit must be higher than the comfort and salary less the cost of housing and transport—it is called the Rosen-Roback model.

The Global Competitiveness Talent Index differs from other indexes and reports summarized in Table 15.1. The index divides indicators into five actions: enable, attract, grow, retain and be global. In this talent attraction index, the top 10 in the city group includes eight European capitals [17].

The researchers Shuangshuang and Shengbang [19] have conducted a study from 2008 to 2012 in 12 provinces of China on assessing talent attraction. The results of their research showed that the key to attracting talent is technological innovation, business conditions, career development and educational conditions [19].

15.1.3 Aim of the Research

The aim of this study is to find out the dimensions significant for a person in making a decision to move to a city with a population of 20,000–50,000. The narrowing of the research is aimed at the attraction of talented and smart people in cities that are not part of direct urban agglomerations, where the population is decreasing or stagnating in the long term.

15.2 Methodology of the Research

The city of Valmiera in Latvia was chosen for the case study. The research is supported by the City Council since it is interested in the sustainable and smart development of the city by increasing the population by 5,000.

Description of the case study city: the eighteenth-century Valmiera has been the education centre of Vidzeme region. Today, it is a city of national importance with a population of 23,063 and an area of 19 km^2. Around 7000 people commute to Valmiera each day from the surrounding areas [24]. Over the last decade, the population has fallen by 20% [3]. The distance to the capital Riga is 107 km, 2 h by road or railway, but to the city of Tartu in Estonia—137 km.

Already at the beginning of the twentieth century, Valmiera was a distinctly Latvian city. Also today Valmiera retains a strong share of Latvians (83.4%, [3]).

Valmiera is the largest city in Vidzeme region with developed production, trade and services, a developed educational infrastructure (Valmiera Vocational Training Center, Vidzeme University of Applied Sciences, pre-primary educational institutions, primary and secondary schools, private training centres), a theatre, a concert hall, a swimming pool, a sports centre with an ice rink active cultural and sports life. Cultural festivals are organized in the city, and world-renowned sports stars live in Valmiera (Oskars Melbardis, Maris Strombergs).

The main sectors of the economy are manufacturing, trade, construction, but the fastest growth in the last four years is in the information and communications technology industry [3]. Valmiera takes third place in the category fDi Strategy among micro-cities in the European Cities of the Future 2018/19 ranking [6]. The fastest growth in the labour force over the last five years is 87% in the information and communications technology sector and 69% in the transport storage sector.

The research methodology is based on the theoretical findings of Ingram, Shapiro and Albouy on the impact of four external dimensions in talent attraction: economic development, market competition, labour market conditions and national culture, as well as the impact of lifestyle on choice [10, 18]. According to these dimensions, interview questions have been developed, and, by grouping the content, the analysis of the responses has been carried out.

In the first stage of the research, the analysis of the literature on urban division and talent research in cities was carried out. In the first stage of the research, a written

survey of 21 talented people who have lived abroad or who regularly travel for work was conducted in order to find out the three most important factors for the change of residence.

Interviews with three target groups were conducted in the second stage of the study: (1) people who have moved to Valmiera; (2) people who have left Valmiera, have moved to another city/place; and (3) stable, steady residents of Valmiera who are able to fascinate other people, they are opinion leaders and can be proud of their achievements. In all three target groups, the following factors were taken into account in selecting the interviewees: age and occupation (various industries, both manufacturing and creative industries).

The face-to-face interviews (except for one email correspondence) were held at the university or the interviewee's workplace, or in a café, and the interview duration ranged from 25 min to 1 h. In total, 28 interviews were conducted, representing both individual views and at the same time the vision for the city development of particular industries. We asked the interviewees about the circumstances that influenced their decision to move to and live in Valmiera or to leave it, as well as the decisive factors in deciding on the place of residence. The results of the interviews were described thematically.

At the third stage of the study, a survey of graduates ($n = 81$) of Vidzeme University of Applied Sciences, which is located in Valmiera, was conducted online with an aim of finding out the main reasons that determined the choice of the graduates to leave or stay in Valmiera after graduation, and how it correlated with the place of residence before starting the studies at the university. Since young people are one of the most important target groups, the survey of graduates was an important part of the study. In 2018, 2159 young people aged 15–24 lived in Valmiera, which was 9% of the total population [3]. 42% of them were students of Vidzeme University of Applied Sciences.

At the fourth stage of the research, a meeting was held with Valmiera City Municipality Branding and Public Relations Department employees, Valmiera Development Agency employees, Head of the Latvian Investment and Development Agency Valmiera Incubator to find out their views on attracting talented people to Valmiera, the role of the international dimension in the development of the city.

International openness is an essential prerequisite for attracting talent to the city. In order to assess how the cultural environment promotes the international openness in the public space, the offer of cultural life in 2018 in Valmiera was evaluated.

15.3 Analysis of the Results and Discussion

The factors determining the choice of a talented person in favour of a city are related to human perception. The environment can be perceived through feelings, visual image, action and the social perspective.

> Every place, like a human being, has a mystery, but the idea of a secret comes only when we like this place. The liking that arises from subtle signs that we may remember from better times initiates a mystery, and the mystery captures the mind. [21]

One of the most important issues in attracting people to a place is how people perceive this place, so we asked all the respondents the question: "What is your association with the city?" The answers may be grouped according to the perception of the respondents—the visual perspective, the perspective of feelings, action and the social perspective.

The **visual image** of Valmiera is related to natural images (the river, forest, trees), Vidzeme University of Applied Sciences, cultural institutions such as the theatre, historic buildings—the Livonian Order Castle, as well as industrial and manufacturing buildings such as Valmiera Glass Fibre. These images are also most often used in city marketing.

The residents of Valmiera **feel** and perceive their city as calm, quiet, friendly, cosy, warm, their own, safe, caring, but also dynamic, youthful, brave, intelligent, smart.

The perspective of **activity** is mainly related to development, sustainability, innovations, entrepreneurship, construction, entertainment events, sports, culture, education and active recreation.

The **social** perspective is related to friends, study mates, families, colleagues and like-minded people.

In the course of the research, these perception signals are compared with the answers of the respondents, which are more often formulated with the help of the logical mind. Sometimes there is a discrepancy between mind-based concepts and the sensory perception.

When analysing the results of the surveys and interviews, it turns out that the reasons why the city seems to be attractive for living depend mainly on the family status of the respondents—whether they live in a partnership or have children, the respondent's age and career stage. An important factor for all age groups is the emotional attachment and social ties.

In Western culture, there is a popular idea of what a person does from 18 to 25 years or a little longer—that he studies and works only as much as he needs and tries to accumulate as much experience as possible, and the urban environment is where he does it. Anthropologists admit that this idea is experiencing a serious crisis, and this "rainbow period" when to experience everything is no longer so popular. A generation up to the age of 25 lives at home and does not take risks. How to explain that? By general caution, insecurity, financial instability, early maturity or an older generation warning about the risks of living such a lifestyle. There is a new trend—neoconservatism. At the moment, the most dynamic change for a person is between the ages of 18 and 34, and a person is confused between choosing to live his or her life in a hedonic or conservative way, namely to think very carefully about whether to have children, whether he or she needs a partnership, how many children he or she needs, the gender roles in partnership [2].

15.3.1 Young People at the Beginning of Their Career and Family Life

In the interviewed youth audience at the stage when they begin their career, study, start a family and have children, the main criterion for choosing a place of residence is economic considerations—job and career opportunities, availability of living space and distance from home (parents), not Riga. The choice is also determined by the factors of the university—the offer of education, the quality and the personalities of the teachers. For young families, an attractive urban environment is associated with good infrastructure, the possibility to ride a bicycle, access to nature, a safe environment, access to education, health, sports, culture and household services and the opportunity to spend time outdoors with children. A significant factor is family ties and emotional attachment, for example, a respondent who has worked abroad for a long time and has returned says, "I came back because I wanted my children to grow up in a place with my family, parents …" (quoted from the interview). Also, the choice of university graduates to live in Valmiera is often determined by the factor that their parents, relatives and friends are here.

According to the results of the university alumni survey, 41% of the respondents had lived in Valmiera before the beginning of their studies, while 59% were entrants from other Latvian towns and rural areas. 51% of Valmiera residents and 33% of the entrants stayed in Valmiera after graduating.

56% of the respondents have indicated job opportunities, including career ambitions as the main criterion for choosing a place of residence. For 19% of the respondents, the choice was determined by social ties—family and friends. 10% of the respondents have indicated the range and quality of services and infrastructure provided by the city as an optional criterion, and 4%—a clean environment.

15.3.2 People in the Middle of Their Career

People at the career advancement stage, when children are a bit older, recognize that the key criterion for the attachment to a place of residence is career challenges. Although Valmiera is an economically developed city on the scale of Latvia, one-third of the respondents admit that the labour market is limited, especially in the area of social sciences. Opportunities for professional growth are not equal, and the corporate culture is not always favourable to newcomers. The lack of career development opportunities is often the reason why people leave Valmiera. Some respondents admit that it is easier to develop their niche in Valmiera, and there is not as much competition as in the capital.

15.3.3 People at the Height of Their Career

People at the height of their career admit that while career and business are still an important part of their lives, there are ever-growing demands for lifestyle elements including a cultural environment, a co-production space that encourages idea exchange with like-minded people.

If a city only deals with issues that are relevant only to its geography, it becomes more peripheral and less significant. The city can be relatively small, but it has great diversity, while there are cities that are big, but they do not have diversity—various lifestyles, social or ethnic groups, ideals. Lifestyle can make you a minority in a small town, but a norm in a metropolis [2].

The respondents point out that there is a lack of artists, a "creative tribe" in Valmiera that marks their unique features in every city. Valmiera has been able to attract engineers, athletes, but not artists. Although the cultural offer is recognized as good, it is not enough to spend a vacation here. The respondents point out that they would prefer to go to one of Europe's metropolises on holiday, where the art and culture offer is wider.

The representatives of the creative professions emphasize that "… there is no well-established creative environment that would encourage the exchange of ideas. The times when young people were willing to endure the inconvenience in the name of art have passed. Theatrical people go to Riga after theatre performances, and there is no creative get-together". The fact that there is no old town and no pedestrian street in Valmiera does not allow fully enjoy and appreciate the cultural environment. The symbols of art and culture are located remotely in different parts of the city and serve more as tourist attractions than cultural symbols allowing to enjoy the environment without hurry. The residents of Valmiera love and are proud of its theatre, and, to some extent, it has become a symbol of Valmiera culture.

The respondents admit that architecture is industrial and lacking brave, modern architectural solutions where Valmiera is a customer. The creative environment is formed of contemporary art and architecture.

Social anthropologists and city planners admit that the city must first of all pay attention to pedestrians and cyclists, separate streets from roads. A street is a jewellery, a road is a monoculture. The more streets become like roads, the less a city resembles a city, it becomes a "no-place". There are no cafés, no small shops. The city loses business. The more cars there will be in the city, the more unattractive it will be for other participants [1, 2].

The interviews show that part of society is not ready to give up cars in the city centre. The statistics show that 61% of the residents in Valmiera travel by car on a daily basis, which is the second highest indicator in Latvia following Riga [3]. The respondents criticize the slow traffic in Valmiera and the way to Riga which can be reached in 2.5 h. The transport of the future is train, but at the moment it is of poor quality. The capital should be reached by train in 1.5 h "while preparing a work presentation on the way and having a coffee" (quoted from the interview).

The population of Valmiera could become denser, and a larger number and more diverse people could live there. Valmiera could be made an attractive place to live not only for those who have left it but also for various other people. It is always an advantage of a city if it supports diversity. The public should become more open. Social anthropologist Celmins emphasizes that the openness to diversity is necessary not because we would be morally better, but because today's economy demands it. We must take the risk and also be ready to lose because there will be a failure many times at the beginning until it works out. The economy that will need us will require creativity, a head on the shoulders, and also the ability to make mistakes. We must be more forgiving not only against ourselves but also against each other. This also applies to urban culture. We need to develop a complex society, and there will be a necessity to experiment. In the end, the urban environment will also become better, more vital and attractive [2].

Almost all of the respondents were in favour of openness and the acceptance of strangers: "… any place with a university must have an open environment. I do not see that it would be bad if there were new people entering …" (quoted from the interview). At the same time, attracting foreign students in a small city is more difficult; if the city population is homogeneous by nationality, more support is required for immigrants to become part of the small city life. However, these statements are somewhat contradictory to the feelings of "our own, small, cosy, family-like, familiar, safe," mentioned by the respondents positively characterizing their city perception. Currently, Valmiera is not a city for all. Valmiera is a city for people who are self-sufficient, capable of adapting and living in a closed society.

The results of the interviews show that globalization and human mobility have significantly changed the cultural consumption habits of the population, also offering diverse opportunities for cultural experiences outside the place of residence, but the residents still want to have a diverse range of cultural and recreational offerings close to their place of residence.

The international dimension of Valmiera Drama Theatre is marked by works by foreign authors with their share in the repertoire of 2018 at 70%.

The long-lasting involvement of Valmiera Integrated Library in international networks has turned it into as an inspiration place for new knowledge, new experiences and knowledge of the world beyond Latvia's borders: regular art and photograph exhibitions, conferences and cultural events are an important addition to the cultural offer in Valmiera city.

Valmiera's cultural offer has a great potential to provide a space for foreign culture offer, for example, by attracting artists to important festivals, it is possible to establish regular cooperation with foreign cultural representations in Latvia.

15.4 Conclusions

Summarizing the results of the study, it can be concluded that at different stages of life talented people have different factors that influence their decisions to move to or leave another city. For young people who start their family and careers, the main

criterion for choosing a place of residence is **economic considerations**—job and career opportunities, the availability of living space, distance from home (parents), willingness to not live or live in the capital. The attractiveness of the city is enhanced by the free availability of cooperative spaces where like-minded people can meet. The existence of a university in the city plays an important role in the choice of a place of residence. After graduation, about 50% of graduates stay in a city where they have studied because they have found a job during their studies and have established partnerships. An attractive urban environment for young families is associated with good infrastructure, bicycle riding possibilities, access to nature, a safe environment, access to education, health, sports, culture and household services and an opportunity to spend time outdoors with children. Educational institutions, in particular universities and research institutions, play a decisive role in attracting talent worldwide in large cities, including the top cities of the World Competitiveness Index, but especially important are these institutions for the development of small and medium-sized urban areas. Given the fact, it would be unwise for SMUAs to eliminate higher education and research institutions, as they not only enhance the knowledge base for smarter development but also attract talent. Educational and research institutions are also a tool for attracting talented people from abroad, enriching the diversity of the city, which has an impact on productivity as illustrated by the explored examples of attracting talent (Brainport Eindhoven, Netherlands).

At the career development stage, the main criterion for the attachment to a place of residence is **career challenges**. The **demand of the labour market** in different occupational groups, where talent is needed, plays an important role here. Also, **corporate culture**, open or closed to newcomers, is an important factor. If there are only a few medium-sized and large companies in the city, then the "desirable" vacancies will soon be saturated and a newcomer will have to build their own business or wait for a vacant position. The demand of and prospects for the information and communications technology industry are higher. On the other hand, the competition is smaller in SMUAs than in the capital, and it is easier to conquer your place in the profession or in the niche business.

People at the height of their career admit that while career and business are still an important part of their lives, there are ever-growing demands for the **lifestyle** elements including a rich cultural availability and an environment that encourages creative and meaningful idea exchange.

Parks, well-planned walking paths along the waterways and pedestrian streets are urban characteristics that a modern lifestyle cannot be imagined without. These are places that are open and accessible, places with their own special character, places to meet and create. Not only do they promote talent attraction for a particular place but also the competitiveness for trade and tourism.

The **institutional framework** with the planning process and political decisions is the basis for the visual and functional improvement of places: the integration of cultural heritage in a modern environment and offer, the construction of new buildings and the development of the character of their surroundings, the improvement of ecologically and landscape valuable areas, the aesthetic and functional improvement of public spaces.

International openness is an essential prerequisite for attracting talent to the city. While the respondents were in favour of **openness and accepting the unfamiliar**, these statements are somewhat contradictory to the feelings of "our own, small, cosy, family-like, familiar, safe,' which they have mentioned positively characterizing their city perception. International culture offer promotes international openness in the mental space.

In the development of SMUAs, an attractive job offer is important in attracting talented people, including the advantage of the operation of large international companies, modern and environment friendly infrastructure with smart solutions—fast and convenient, cultural life, a clean and tidy city.

In general, SMUAs are catalysts for a faster urban change and have the advantage of attracting talent in the social and natural dimensions, but the formation of a more open society in an international and intercultural context must be strengthened.

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Chapter 16
Smart City Community Engagement Through Learning

Ilpo Laitinen and Roberta Piazza

Abstract This study discusses on how various communities learn and assimilate digital systems and services at the time when the population of Europe is ageing and the role of digital services is growing. Learning and the process of acquiring new skills and knowledge are of fundamental importance and define whether we are active participants or passive observers in the digitalization process. The challenge for us is to develop new adaptive learning communities and working methods and to ensure that people embrace change while maintaining and gradually transitioning away from old practices (Laitinen et al. in J Adult Contin Edu 23:119, [6]).

This study discusses on how various communities learn and assimilate digital systems and services at the time when the population of Europe is ageing and the role of digital services is growing. Learning and the process of acquiring new skills and knowledge are of fundamental importance and define whether we are active participants or passive observers in the digitalization process. The challenge for us is to develop new adaptive learning communities and working methods and to ensure that people embrace change while maintaining and gradually transitioning away from old practices [7].

Thus, the importance of lifelong learning is growing but, at the same time, there is very little information on how different communities are prepared for it. Lifelong learning is therefore a logical means to make the system learning process more personal and motivating for utilizing artificial intelligence and digital services [4, 5, 12, 15, 16, 18]. The views defending involvement, learning and social capital emphasize that superficially conceptualizing a smart city solely based on new technology and digitalization underestimates the significance of the community in achieving the goal. Even though current smart city models promote accessibility and openness of data and thus prepares society for changes triggered by innovative and smart

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technologies so that citizens are co-constructors of knowledge and value peer-to-peer platforms and information sharing, those models lack of high-level strategy linking 'smart' and 'learning' [6].

The data is produced in one thematic interview and three focus group interviews. The topics of empirical research are generated according to earlier studies of adaptive leadership, learning and smart city. The research focuses on the following themes: the concept of smart city, digitalization, big data and learning.

City of Helsinki is globally recognized as one of the most prominent smart cities and big data urban platforms [1]. The contents of smart city programme are very comprehensive in the City of Helsinki. The idea is that not only city employees are integrated the programme, but also, for instance, service users and stakeholders, such as private companies. The smart city programme especially brought together two activities: smart technology development and participation. In this context, learning is related to issues on the actors' participation and technological development as well. The pivotal question is how technological development is linked with actors' participation. The "smartness" of a city lies not only in infrastructures, but also in the social capital. Thus, the challenges to adoption of smart technologies are the following: (1) current smart city models focus on technical solutions for public services (e.g. transport); (2) those models bypass the dangers of new digital divides (especially by gender, age and migrant status); and (3) models are not accompanied by learning especially non-formal adult learning.

The intelligence of a smart city contains the locality and social capital, as well as learning. Activities are concentrated on creating and developing local solutions. In this model, which involves local citizens and community members in designing and developing services, the citizens are no longer considered as service recipients or authors of opinion, but as participants and enablers of the smart city. Thus, the development of the smart city is strongly linked to local and contextual factors. Therefore, the development cannot be achieved outside the community and separated from it. The collective basis of the smart city lies on social capital and the learning community, which are creating, innovating and adapting to the constant change. Pedagogically that calls forth bottom-up approaches and community-driven participatory methods in the adaptive learning.

A challenge is that communities are unlikely to invest in interpreting data, to participate learning activities, etc., unless those are linked to action that provides clear local benefits. The importance of lifelong learning in a digitalized world is growing, and learning has, in fact, become a key concept of the knowledge society. At the same time, there is very little information on how the knowledge of digitalized environments is distributed within communities and how different communities are prepared for it and what types of knowledge shafts are associated with digitalization. There are differences, related to preparedness, between different groups and local communities. Mere digitalization is not enough to cause digitalization; it also requires a change in human behaviour and community dynamics.

Empowering communities means that they not only have a voice, but they are regarded as a key stakeholder helping shape smart city. However, a key risk factor for marginalization and exclusion of citizen in smart cities is associated with

barriers to participation for those 'who are being left out of learning conversations' [11] and citizen lacking of digital literacy [2]. A broad understanding of learning in the lifewide sense, under the umbrella concepts of the 'key features' of UNESCO's Learning City model,[1] pertains to an 'extended use of modern learning technologies' when engaging citizens in learning. When dealing with local knowledge-based development, inclusion and learning, it is very important to realize the clashing values of those mainly technology-based drivers. Following Norman Longworth, it can be stated that without learning, adaptability, flexibility, diversity and versatility, smart cities will not continue to develop sustainably ([9]; see also [10]). In a highly connected information society, learning and the process of acquiring new skills and knowledge are of fundamental importance and define whether we are active participants or passive observers in the digitalization process. Importantly, it is not just about learning new skills but unlearning old ones. The challenge for us is to develop new adaptive communities and working methods and to ensure that people embrace change while maintaining and gradually transitioning away from old practices [6].

The concepts of social capital, knowledge sharing, problem-based learning, and co-operative and collective learning become pivotal features and characteristics of smart cities. It can be concluded that smart cities are not possible outside the development of smart communities; communities that have learned to learn, adapt and innovate (see e.g. [3, 13, 14], according to the lifelong learning paradigm [8, 17].

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Chapter 17
Meaningful Learning by Creating Technology-Mediated Knowledge Boundary Objects Between School and the Workplace

Corrado Petrucco

Abstract Technological innovation has changed the relationship between formal, non-formal, and informal learning leading to rethink the definition of learning context: Activity Theory can help create a model integrating formal and formal learning through collaborative knowledge building involving schools and professionals/employers. Interaction between these two "activity systems" generates "boundary objects" that can be useful in both the educational setting and the workplace. This process can provide students with meaningful situated learning experiences that boost their motivation and interest, just because they are based on real-world problems that students will face in their future jobs.

17.1 How Can Formal and Informal Education Be Integrated Through Technology-Mediated Interactions to Produce Meaningful Learning?

17.1.1 Integrating Formal and Informal Learning

The objectives of the paper are to provide some hints for theoretical reflection about how Activity Theory can help to build a model to integrate formal and informal/non-formal learning at school. Today, technological innovation has drawn attention to the relationship between formal learning and learning that takes place in informal and non-formal settings, an issue which is topical not only for schools but also for adult education. This has made it necessary to rethink the definition of learning context: Each learning process should be considered formal and informal at one and the same time, not least because today's technologies enable us to be "always on," constantly connected to information streams wherever we happen to be. The problem thus lies in understanding *how* to integrate formal and informal learning and

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promote collaborative knowledge building [1]. Coping with an increasingly complex workplace, however, requires students to develop collaboration skills and learn how to use technologies [2].

17.1.2 Three Models for Collaborative Knowledge Building

Building and sharing knowledge collaboratively can benefit from the mediating role of technology, thus improving the teaching and learning processes [3, 4]. In this connection, the research literature has emphasized the importance of an informed choice of the models and methods guiding the use of technologies in each context [5, 6]. In particular, it has been found that performance and outcome improve if teaching strategies designed to support cooperative group learning processes are used together with online collaborative knowledge building technologies [7]. Nevertheless, technology cannot be considered separately from the many other factors that contribute to making a learning environment.

Consequently, it is useful to adopt a systemic perspective such as that suggested by Activity Theory, or AT [8, 9], which regards the technology variable as part of a broader system of situated and connected socio-relational activities. An important concept here is that of distributed cognition [10] where the cognitive activity is seen as distributed among external technological artifacts, internal cognitive artifacts, and the interrelations with other people and their culture.

In addition to AT, the major theoretical approaches that seek to interpret knowledge building processes through the concept of mediation and social/collaborative practice include Nonaka and Takeuchi's [11] Knowledge Creation model, Bereiter and Scardamalia's [12] Knowledge Creation Theory, and Engeström's [8, 13] Expansive Learning model. The latter approach, however, is better suited than the others for describing and designing the processes of building knowledge with technology at the community and social level, precisely because it makes a clear distinction between the subjects, tools, artifacts, rules, and division of labor.

As a further evolution of Cultural–Historical Activity Theory (CHAT), it is essentially an adaptation of Vygotsky's mediation triangle (see Fig. 17.1). It is based on

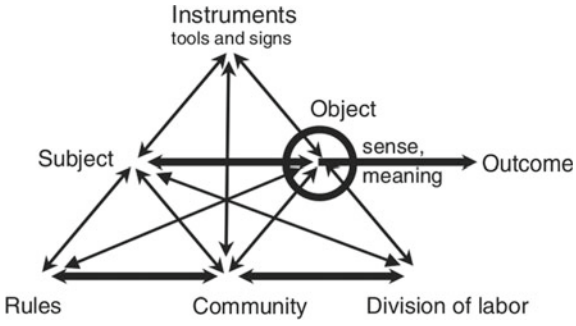

Fig. 17.1 Engeström's activity theory model, showing the elements of an activity system

the concept of "activity system", on the important role of social and cultural–historical elements, and above all on artifacts and instruments as *mediators* of any human activity.

17.2 A Systemic Interpretation of the Relationship Between Formal and Informal Learning Settings

17.2.1 Activity Theory and Technology-Mediated Learning

With the aid of Activity Theory, we can attempt a systemic interpretation of learning and knowledge building activities involving a community of people. According to the theory, technologies are a tool that inevitably restructures and mediates what is learned from the activity [14]. As the diagram in Fig. 17.1 shows, we can analyze the role of the tools that are used (e.g., LMS, social networks, Wikis, Augmented or Virtual Reality, etc.), the social relationships that are created, the rules the community sets itself, the aims and the outcomes (objects, artifacts) resulting from the activities [15].

For example, we can say that the Subjects are the participants in the online Community, and that they interact with the other members of the Community by using the Tools and following explicit and implicit Rules, and that the Division of Labor indicates the methods of organization that arise spontaneously or are dictated by a hierarchy. The Object is the prime focus of the entire activity: In the case of a community in a firm that is working to design or improve a product, for example, it will be the product itself, while in the case of a learning community it will be the content of the lesson. At the end of the process, the Object is transformed and becomes an Outcome. A teacher's Object, for example, will clearly be to have the students learn the content of a specific subject, but everything that results from this activity is an Outcome, developing the skills the students will need to solve the problems they will face in their future jobs.

17.2.2 Toward a Technology-Mediated Integration of Formal and Informal Settings

In the adult workplace, people's work engagement typically benefits when they are motivated to solve a concrete problem they see as important. In the school setting, approaches involving such real-world problems are still revolutionary, though they are gaining ground in areas such as Vocational Education and Training (VET) with work-study programs [16]: Frequently, in fact, firms work together with students in developing innovative products or processes in what can be considered as true communities of practice [17]. This process in which schools and educators share aims

and actions with workplaces can be regarded as consisting of "boundary practices". Figure 17.2 illustrates this process, as interpreted in light of Activity Theory. Cooperation between schools and workplaces is important to productivity growth and skill formation [18], where the shared goal is to train people who can work together with others in handling uncertainty, solving problems, and developing creative solutions.

For schools whose students are in the lower age groups, cooperating with firms could be more difficult. In such cases, the local area is a valuable opportunity for the education system and vice versa, providing that relationships can be formed with local agencies and institutions in order to promote students' involvement in active, constructive, and democratic learning activities. This can be achieved with the support of social software and the tools provided by Augmented Reality, Virtual Reality, and Industry 4.0, with the goal of setting up curricular projects entailing a set of socially constructed and locally situated practices [19]. In this case, the model can be that of project-based learning [20], where students are encouraged to achieve concrete goals by solving real-world problems, with all the complex and interdisciplinary aspects that this entails. However, schools tend to show a certain reluctance to adopt project-based approaches, given the widespread perception that this could require a substantial rethinking of traditional teaching and educational practices. Current didactic approaches, in fact, still center on the passive learner, with little interest in collaborative activities or openness to interaction with the "outside world".

Recently in Italy, the "Istituti Tecnici Superiori", or post-secondary vocational schools, have embarked on a particularly interesting program that is heavily oriented toward links with different social, economic, and organizational settings. At least 30% of these schools' teaching is provided through work placements, and at least 50% of the instructors are from the workplace. This encourages the development of cognitive apprenticeship, where knowing in practice, or in other words, vocational expertise, is combined with models for analyzing and reflecting on what is done

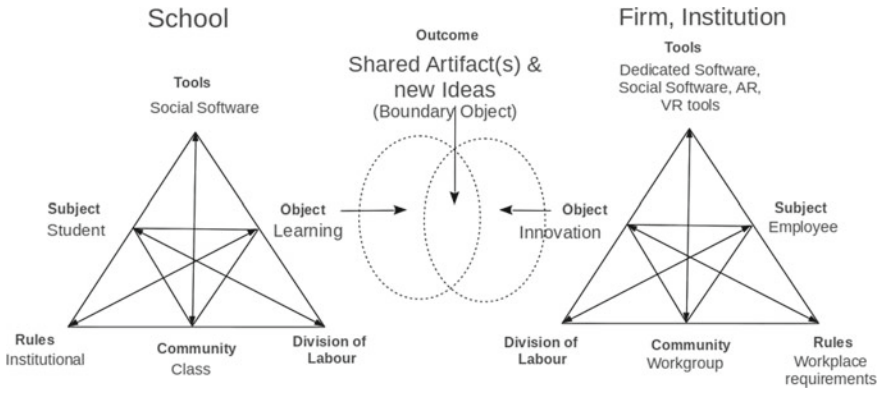

Fig. 17.2 Possible interaction between the school and workplace activity systems: though the two systems have different Objects, they share the same Outcome. The artifacts generated are true "boundary objects", and the associated activities are "boundary practices"

in practice [21]. In these experimental programs, the online collaborative learning platforms have evolved with an eye to the new Industry 4.0 digital technologies, rather than focusing on simulations of traditional teaching situations: For example, they enable Augmented Reality activities or live-streamed visits to distant or hard-to-access work sites where the students can interact and navigate in 3D space, thus enabling them to deploy their knowledge and practical skills in real-life settings [22].

17.2.3 Boundary Objects as Bridge

The activities we have described could assist in the transfer of learning from the school to the workplace, helping avoid the risk that an excessive formalization and de-contextualization of knowledge will make it difficult for students to apply what they have learned to solving concrete problems. Real-life learning is based, not only on content, but above all on activity, and it is situated around a community of people seeking to solve problems. This is a perspective that goes beyond approaches such as the flipped classroom [23, 24], precisely because the focus is no longer on the school but on the inter-system process (school–workplace, school–society, school–local area) which can create the shared artifacts, i.e., the so-called boundary objects [13, 25] that result from continual negotiation and interaction, the true driver of learning and potential innovation in both activity systems.

It is important to understand that the artifacts—the boundary objects—will be constructed with a precise purpose and will be put to the test in the real world. For example, a school and a manufacturer will collaborate in developing a new model of a hydraulic pump or in bringing their know-how in a given field up to date by monitoring patents and innovations on the Web, or a school and a municipal administration will work together on new approaches to using and managing public space. In addition, inter-system activities can set the stage for renegotiating the curriculum: The community can contribute to setting a curriculum model—"community as curriculum"—that is no longer laid down by education experts, but is also "negotiated" with outside stakeholders from professional communities and the school's local area [26, 27].

17.3 Conclusions

This hinges on the "participatory culture" [28] needed to hammer out approaches to education and training where the formal and informal merge, precisely because they are based on real-world problems and on technology-mediated contact with activity systems outside the school. There is no lack of theoretical constructs that apply here: Those advanced by Collins and Brown and Collins and Greeno [29, 30] are a good example, particularly in their use of the idea of cognitive apprenticeship to describe the innovative roles taken by students and educators when learning takes

place in real-life settings. According to this construct, the teachers' role will be that of facilitators and mediators of situated learning, and the students will become "cognitive apprentices" as well as builders of shared, concrete knowledge. Above all, then, the interactions with the world outside education and training must be problem-based, precisely in order to enable students to apply what they learn to real-life problems [31, 32]. Some of these shared activities will be situated outside the school or formal training environments and will take place via mobile devices (i.e., using Virtual or Augmented Reality) in situated fieldwork. This process will be able to provide students and adults with a frame of meaning and boost the motivation to learn.

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Part VI
Schools: Technologies and Contexts

Chapter 18
Smartwatches for Context-Aware Ubiquitous Learning

Nour Takiddeen and Imran Zualkernan

Abstract Context-aware ubiquitous learning systems use real-time or almost real-time sensor data that is an integral part of learning design for anytime, anywhere learning. Typical examples are situated learning in museums, parks, or gardens where sensors are used to enact unique learning scenarios. This type of embedded learning can be easily extended to cities, continents, or indeed the world. Traditionally, PDAs and smartphones have been used as edge devices in such learning systems; smartphones or PDA's typically collect sensor data and communicate with back-end servers to enact learning scenarios. Smartwatches can easily replace smartphones to perform these functions. Smartwatches today include a variety of sensors, are wirelessly connected to heterogeneous networks, and possess significant processing power. This paper presents a survey and design framework for using smartwatches in ubiquitous learning. The design framework views smartwatches for ubiquitous learning through the IoT lens and various types of learning designs. In addition, micro-services to implement these pedagogical services are enumerated and evaluated with respect to smartwatches. An analysis of network requirements for smartwatches is also presented. The overall conclusion is that while some challenges like power optimization remain, smartwatches represent a promising next platform for context-aware ubiquitous learning.

18.1 Introduction

Context-aware ubiquitous learning enables students to actively acquire knowledge related to their surrounding environment anywhere, anytime while utilizing sensors and wireless mobile communication to capture and disseminate the learning content and context [1]. Ubiquitous learning systems are not only composed of system interactions but also include social interactions [2] to support peer-to-peer learning scenarios. For example, a student can learn more about a certain plant when

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encountered in its natural environment. Students can also share their knowledge, thoughts, reflection, and feedback on the experience to enhance the learning experience [3].

A smartwatch is a network-enabled watch that supports a variety of sensors. Smartwatches have come of age and represent a key candidate for implementing future ubiquitous learning scenarios. This paper attempts to conduct a wide analysis of the requirements of context-aware ubiquitous learning systems and the suitability and constraints of smartwatches to implement these types of scenarios.

Rest of the paper is organized as follow. Representative examples of context-aware ubiquitous learning systems are presented next. This is followed by an analysis of such systems based on the Internet of Things (IoT) software stack. Typical components of learning designs enacted in context-aware ubiquitous learning systems, and the relevance of smartwatches for these is discussed next. This is followed by a discussion of the various micro-services that need to be implemented to enact these learning scenarios. The process of context processing is discussed next followed by an analysis of network constraints for smartwatches. Paper ends with a conclusion.

18.2 Ubiquitous Learning

Previous work on ubiquitous learning primarily used devices like smartphones/PDAs or smartwatches. Few illustrative examples from each are presented next.

18.2.1 Smartphone/PDA Based Systems

In [3], Li et al. proposed a ubiquitous learning system called SCROLL for language learners for foreign exchange students that enabled them to record their learning logs in audio, photographs, and videos using their smartphone. Logs could be words or grammar, answering quizzes, and about performing tasks. The system was personalized based on an individual's context; each time the person recorded a sentence, the system also recorded the learning content, as well as the context like the temperature, location, and time of the recording. Through this, the system, upon detecting the same context again in the learner's environment, reminded the learner to reflect on, or revise what they had learned before in a similar environment, and recommended new suitable learning content.

Another recent work [4] proposed an active learning support system (ALESS) using the MONS navigation algorithm [5]. The proposed system recommended a learning path to the individual based on their interests, curriculum material, current distance from other learning targets, and number of students present in other targets based on real-time context. A learning target could be a painting in a museum, for example. This system used active RFID tags to facilitate the learning process, as learning material could be extracted from the target by being near a target without having to search for it. The signal strength of the RFID tags

was also used to determine the distance of a target form a student. The system was tested in a museum using PDAs.

In [6], a mobile-based ubiquitous learning system called mobile learning support system (MLSS) was presented. This system enabled inquiry-based learning, where students could retrieve learning material about a certain learning target by scanning the associated 2D barcode attached to it. In addition, MLSS also provided students with context-aware situated learning; using the mobile's GPS, the system provided the students with a map of the existing 2D barcodes in their location. After the student scanned a 2D barcode and completed examining the learning content, the system by using GPS suggested nearby targets with similar learning content.

In [7], an adaptive ubiquitous learning system with personalized recommender system was developed to enhance the student's learning experience. The system was based on the Sharable Content Object Reference Model (SCORM) standard. The system used RFID tags to enable the student to retrieve learning materials. Recommendations for new materials were based on students' context that described their learning behavior, as well as learning interests and preferences. The system also included a module that allowed the system administrators to upload, edit, and review the learning material to the system.

In [8], a ubiquitous learning system called ARCHI-PODS was developed to aid architecture university students to understand principles of architecture. The system was implemented by installing microcontroller-based "pods" throughout the university campus. These pods contained sensors that measured context variables like temperature, illumination, and humidity in the location of an architectural element (i.e., arc) they were attached to. The context from these sensors could help students enhance their understanding and sense of the space related to the element. The system enabled students to both pose questions and to solve tasks provided by their university professors and peers.

Finally, in [9], a material production system called (QR-ULMPS) was proposed to provide teachers with an easy way to set up learning material for ubiquitous learning environments. Students retrieved the material by scanning QR codes related to targets using their smartphones. The system facilitated adding learning material for teachers through a simpler user interface. To add learning material to a certain target, the teacher could create content and generate a QR code to attach to it. Upon creating the content, the editing system sent the generated package to a sharing server until the targets in the environment were assigned to these packages. The system was tested on a university-level liberal arts course.

18.2.2 Smartwatch-Based Systems

Garcia et al. [10] developed a smartwatch app called Science Stories to examine the effects of gamification and storytelling as motivational structures to enhance self-efficacy and to reduce the effect of losing interest in the smartwatch overtime on the learning experience. The system was based on situated scientific reflection by

enabling and reminding students to record their reflections about the learning material via the smartwatch's microphone. The system was developed using the Android Wear platform, and a comparison between three modes (gamified, storytelling, and hybrid) was conducted to determine the best motivational structure in improving self-efficacy and increasing engagement in the learning system.

Guia et al. [11] introduced an in-classroom context-aware learning system to teach young children new languages through NFC-enabled tags attached to objects. Two types of learning tasks are involved: individual tasks, where the student was asked to collect and identify a certain object by scanning their tag; and group-based tasks, where student interacted and collaborated to complete a certain mission. The system was based on client/server architecture and used Bluetooth Low Energy (BLE) beacons to guide the children to the learning location that contains the item they were searching for. Both smartphones and smartwatches were used to test the system.

Casano et al. [12] implemented an extension to a previous work called "Estimate It," that taught students to estimate sizes of mathematical shapes. Their extension included migrating the application that was originally developed on an Arduino-based platform to a smartphone running an Android OS and a Samsung Gear S2 watch running Tizen OS.

Finally, Al-Soh and Zualkernan [13] presented a context-aware assessment platform for smartwatches using the MQTT protocol. The system used the Samsung Gear S2 smartwatch and used Google Classroom [14] to enable the teacher to provide the students with context-aware assessments. The students subscribed to a certain topic (e.g., velocity) to receive context-aware questions (e.g., how fast are you moving?) and tasks based on their current context acquired from smartwatch sensors.

18.3 Viewing Context-Aware Ubiquitous Learning Through the IoT Lens

Internet of Things (IoT) provides a convenient way to organize and describe various layers of ubiquitous learning systems and as such provide important insights into their architecture. The IoT software stack consists of a sensing layer, communication layer, middleware layer, and business or application layer.

Sensing layer collects, processes, and transmits sensor data to the communication layer. Sensor data collection may require local communications as well. For example, GPS or BLE beacons may be used to collect location data. Sensor technologies that enable ubiquitous learning systems in general include QR codes [3], 2D barcodes [6], active [4] and passive [15] RFID tags, NFC tags [11, 16], GPS, and other built-in smartwatch sensors like the light and temperature sensor, and the microphone. These sensors are used to detect and collect an individual's context, as well as context of the surrounding environment [4, 17]. While smartwatch sensors vary in accuracy, they are usually good enough to satisfy the precision requirements of context-aware ubiquitous learning systems [18].

Communication layer typically uses a variety of protocols (e.g., Bluetooth, WIFI, LTE, 3G, 4G, NB-IoT, 5G, etc.) to send sensor and other information to the middleware layer. Most smartwatches today support multiple wireless networks like WIFI, LTE, 3G, and 4G. More exotic protocols like ZigBee, Z-Wave, and LoRaWAN are currently not supported in smartwatches. However, bridge devices can be used to communicate with devices (e.g., bulbs, switches) supporting these protocols.

Middleware layer provides a variety of services that may include authentication, queuing, storage, and analytics. For example, most current ubiquitous learning systems use the request/response type of mechanism (e.g., HTTP or CoAP) to connect to middleware services in a RESTful fashion. However, publish/subscribe protocols like MQTT, AMQP, or XMPP to support real-time communication with sensors [19] are probably more appropriate for ubiquitous learning applications. From the perspective of smartwatches, only appropriate interfaces to these middleware services are required. For example, Apple, Samsung, and Fitbit watch today have MQTT clients to allow them to connect with messaging middleware over either 4G or WIFI.

Finally, the application or business layer includes the logic of the learning design. Application layer uses the middleware services to enact the actual learning scenarios. Like the middleware, the application layer also needs to support the API, and typically, these are RESTful services that are easily supported in smartwatches today.

18.4 Learning Designs in Context-Aware Ubiquitous Learning

A number of learning designs have typically been observed in recent context-aware ubiquitous learning systems: situation-based, inquiry-based, task-based, and social [1, 18]. These learning designs can be used in isolation or in combination with each other. All these learning designs can be supported using smartwatches and are briefly described next.

18.4.1 Situation-Based

In situated learning, learning material is recommended to a student depending on their personal context and the context acquired from their current environment [3, 11]. For example, when a student is near a garden, recommended learning material, or quizzes to identify plant types in the garden in conjunction with what was taught in the class are presented. Context-aware situated learning can be aided by a personalized and adaptive learning path recommendation mechanisms [4–6]. Current smartwatches support a rich collection of sensors to capture situational context. For example, the Apple 4 watch supports a large range of sensors including GPS, electrical and optical heart rate sensors (ECG app), accelerometer, gyroscope, and others.

18.4.2 Inquiry-Based

In inquiry-based learning, students actively search for and acquire learning materials based on their current context. For example, when the student notices something in their environment which they can relate to what they learnt in class, they can look it up by scanning the tag associated with the target to retrieve learning material associated with it [13]. QR codes and NFC have typically been used for this purpose. Since most current smartwatches do not support cameras, using QR code is not possible. However, NFC tags can be used as most high-end watches support NFC.

18.4.3 Task-Based

In task-based learning, the teacher can create learning activities and quizzes that require the student to go to a physical environment to enact them [1, 9, 15]. For example, a student can identify consumers, producers, and decomposers in the school garden. Results of performing these activities are processed or sent back to the teacher for assessment and feedback. Most current smartwatches can also record audio segments that can be used to create unique scenarios like record the birdcall and identify it.

18.4.4 Social

Ubiquitous learning systems also enable peer-to-peer interactions and social learning, where students can share their acquired knowledge and experiences through the system [1, 3]. Students can also jointly solve problems. Moreover, like task-based learning, students can set and send tasks and questions for each other to answer and solve [2]. The students can also act as mentors to other students. The smartwatch can be an effective edge device for social learning at the various scales described earlier because watches can connect to the Internet using a variety of networks like Wi-Fi, LTE, or 4G and establish effective peer-to-peer communications using broker-based protocols like MQTT.

18.5 Micro-Services for Building Context-Aware Ubiquitous Learning

Micro-services common to most ubiquitous learning systems can be abstracted from current systems. A summary of these micro-services, along with the description and specifications for each micro-service, is presented in Table 18.1. As Table 18.1

Table 18.1 Common micro-services for building context-aware ubiquitous learning systems

Micro-services	Required sensors	Acquired context	Description
Recommend a learning path [4–6]	GPS, active and passive RFID, BLE beacon/reader	Location, target ID/information	The order in which targets are visited is suggested based distance from a certain target and the number of students near each target
Recommend learning material [3, 6, 13]	GPS, temperature sensor, etc.	Peers' context, student's learning logs, student's context (location)	System sends personalized recommendations to students for new learning material based on their context, preferences, and peers/learners with similar learning behavior to them
Add/update learning material [6–8]	Any sensor that has interesting information (e.g., it is too hot in the courtyard)	Sensor and location information	The teacher can add the learning material associated with each learning target in the environment according to the school's curriculum
Retrieve learning content [3, 6, 13, 15]	RFID/NFC/QR codes/2D barcodes	Identifier for learning content (URI)	Students can search for and scan the tags attached to target to browse the related learning material
Send a task or learning activity [1, 7, 19]	Any sensor that makes the task of activity relevant	Sensor and location information	Teachers can devise and send tasks about the learned subject to assess student's performance
Answer tasks/questions [8, 9, 15]	Microphone, keyboard (screen), gestures	Audio recordings, text, accelerometer for gestures, etc.	Students can answer tasks like quizzes or assignment sent by the teacher. They may be required to go to the learning environment to execute the task

(continued)

Table 18.1 (continued)

Micro-services	Required sensors	Acquired context	Description
Assess and monitor student performance logs [9, 11]	BLE beacons, cameras, audio, GPS	Student performance log	Teachers can access their students learning and performance logs to monitor and assess their performance and provide any additional help if needed
Communicate with peers [1–3]	BLE beacons, GPS for nearby students	Location and performance data	peers can communicate through the system to share their acquired knowledge and reflections about the learning experience. Peers can also generate and send tasks to each other
Send context-aware reminders [3, 8]	Temperature sensor, GPS, etc.	Student and environment context	System sends reminders to reflect on learnt material when the student is in a similar environment to the one they learnt in

shows, all micro-services are easily supported on smartwatches today. For example, students can record and send their comments on an issue to their peers or to the teacher. As can be seen, most sensors being used in ubiquitous learning applications are available in current smartwatches, and thus, the required context can be retrieved from a smartwatch.

18.6 Context Processing in Context-Aware Ubiquitous Learning Systems

Context is a key component of most ubiquitous learning systems and a smartwatch should be able to process the context effectively and efficiently. This section lists and explains the system requirements for a smartwatch-based context-aware ubiquitous learning system using the four phases of acquisition, modeling, reasoning, and dissemination [20].

18.6.1 Context Acquisition

In context acquisition, sensors are used to collect the context of the individual and their environment [21]. For example, the smartwatch can collect context directly using its built-in sensors (i.e., microphone), or by scanning NFC tags installed at each learning location. The frequency of data acquisition and transmission depends on the use case and the type of context. For example, temperature data does not require frequent updating in comparison with constantly changing contexts like the current location of the student. In addition, since one of the main challenges in deploying smartwatches is the limited battery life [22, 23], it is important that only relevant context is sent at the optimal frequency to preserve power. Finally, while smartwatch sensors vary in accuracy, they are usually good enough to satisfy the precision requirements of context-aware ubiquitous learning systems, as high precision is typically only needed in more critical cases like medical applications [24].

18.6.2 Context Modeling

In the context modeling phase, the acquired context is represented using a common data model [25]. Common representation methods include key-value pairs, markup models, and object-oriented representation [25, 26]. In a smartwatch-based ubiquitous learning system, acquisition frequency varies from near real-time acquisition to event-based acquisition. In addition, assuming an IoT-based architecture, different components of the system including the teacher, databases, and the context-processing server need to access and retrieve the acquired context [11, 18], and therefore, a well-defined commonly understood data model is required.

An object-oriented approach may be suitable for context modeling. Using objects to represent each type of context separately also provides encapsulation, which works well with complex architectures that contain many system components. JSON is a good choice in this case, as it is lightweight and easy to use. JSON is also language and platform independent [27] and much more lightweight than XML used in older learning standards like SCORM. Most smartwatches support JavaScript making JSON a good choice as well.

18.6.3 Context Reasoning

Context reasoning is the process of extracting high-level context from the raw context acquired context through sensor data preprocessing, fusion, and inference [20, 21]. For example, determining that 40° temperature and 90% humidity actually means that the student is in a “hot and humid” environment.

One of the primary challenges in power-constrained edge devices like smartwatches is to decide what to process locally and what to offload to the back-end server. This decision represents a trade-off between power consumption for local computation versus power consumption for transmitting additional data to the server. Therefore, context reasoning based on an individual's context can be implemented locally or offloaded to the back-end server. However, reasoning requiring sensor fusion across learners must be implemented on the back-end servers and cannot be implemented locally. Example use cases are context-aware recommendations, retrieving learning material, and peer-to-peer learning.

18.6.4 Context Dissemination

After the context reasoning phase, high-level context is disseminated either back to the student or to other entities in the system like peers or teachers through a query or via a subscription [20]. Disseminated context includes tasks, learning material, recommendations or quizzes. Moreover, to prevent the student's from losing interest in using the system, the disseminated context must be disseminated quickly. For a smartwatch-based ubiquitous learning system, providing a voice-over for the disseminated material can provide a better learning experience, as reading from the smartwatch's small screen can be hard for some students [8].

18.7 Network Requirements for Context-Sensitive Ubiquitous Learning

To gain a better insight into the requirements and limitations of smartwatch-based ubiquitous learning systems, typical frequency of transmission, data size, latency, and bandwidth utilization for the various use cases are shown in Table 18.2. As Table 18.2 shows, retrieving learning material has relatively higher latency, data size, and bandwidth requirements in comparison with the other use cases since the retrieved learning material can be in the form of text and image, voice, or video. Response time for retrieving learning content should not exceed that of a loading a normal webpage, video, or audio. Thus, acceptable latency is estimated to be around 500 ms ~2 s to load an image or text, up to 10 s to load a video (MP4), and up to 5 s for loading audio (MP3). As for data size, a 30 s video clip (i.e., MP4 format) would require around 1.6–2 MB, assuming a resolution of 480 × 360 pixels, which is enough for the smartwatch's small screen.

As Table 18.2 shows current smartwatch-based ubiquitous learning systems do not require high bandwidth utilization. In order to select a suitable networking protocol for any IoT-based application, two points must be considered; the communication range needed for devices, and whether the devices are moving while they

Table 18.2 Network analysis of using smartwatches for ubiquitous learning

Use case	Description	Smartwatch sensor	Transmitted context	Transmission frequency	Data size	Accepted latency	Bandwidth utilization
Send time critical context	Real time context is needed in cases like real time adaptive path learning	GPS or location from BLE beacon	Student's current location	Once every 5 s	Around 8B + headers	50–500 ms	163.2 bps
Send less critical context	Non-real time context like temperature	Temperature sensor	Temperature data	Once per hour	Around 2B + headers	500 ms– 1 s	0.2 bps
Retrieve learning material	Should be at least as fast as a normal web page request	NFC	Target's ID	Event based, assuming peak activity: once per 5 min	NFC ID: ~7B + headers Audio:500 KB MCQ:1200 Bytes	Text:500 ms–2 s Audio: up to 5 s Video: up to 15 s	Audio:13 Kbps Video:0.05 Mbps MCQ:32 bps

(continued)

Table 18.2 (continued)

Use case	Description	Smartwatch sensor	Transmitted context	Transmission frequency	Data size	Accepted latency	Bandwidth utilization
Answer tasks/questions	Students attempt to answer questions/tasks sent by their teacher or peers	Microphone, screen, gesture	Audio recordings/text answers	Event based, assuming peak activity: once every 5 min	Audio:500 KB Text: up to 200 Bytes	1–3 s	Audio:13 Kbps Text: Up to 5.3 bits/sec
Communicate with peers	Peers can communicate via sending voice recordings or text	Microphone, screen, keyboard	Audio recordings, text	Event based, assuming peak activity: once every 5 min	Audio:500 KB Text:200 Bytes	50–100 ms	Audio:13 Kbps Text: 5.3 bps
Send questions to peers	Students can send and receive questions from peers via voice recordings or text	Microphone, screen, keyboard	Audio recordings, text	Event based, assuming peak activity: once every 5 min	Audio:500 KB Text:200 Bytes	1–3 s	Audio:13 Kbps Text: 5.3 bps

*Header size will vary. For example, typical header sizes for various protocols are MQTT (2 Bytes), TCP (20 Bytes), IPv6 (40 Bytes), 802.11 (32 Bytes)

communicate or not [28]. In the case of a ubiquitous learning system, the range depends on the size of the environment. In small environments like gardens, learning targets are typically located in close proximity of each other. However, if a ubiquitous learning system were to be implemented for a larger environment like a city or a neighborhood, the distance between learning targets would be much greater. In many cases, learning targets are in a fixed location. Therefore, Cellular and WIFI networks are more than sufficient for most such systems [28]. For citywide learning scenarios, WAN protocols like LoRaWAN can also be deployed. Such protocols cover a large range with low-power consumption for the edge devices, with a reasonable uplink bitrate. However, such protocols are not optimal for sending or streaming video because the supported downlink bitrate is only 100 Kbps [28]. Finally, ad hoc low-power network protocols like ZigBee are not currently supported on smartwatches. However, like LoRaWAN, bridge devices can be deployed to create heterogeneous networks that include smartwatches as edge nodes.

18.8 Conclusion

This paper presented a survey and a comprehensive analysis of why smartwatches present a great opportunity for implementing context-aware ubiquitous learning scenarios. A framework that analyzed the use of smartwatches from various perspectives like pedagogy, micro-services, context-processing, and network constraints showed that in general smartwatches are good candidates. One key challenge, however, that needs to be addressed is the power utilization and battery drainage. Techniques from prior work in edge analytics can be used to address this issue in the future. However, it is very clear that today's smartwatches are very much prepared to enact a large class of novel context-aware ubiquitous learning scenarios.

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Chapter 19
Game-Based Mobile Learning with Augmented Reality: Are Teachers Ready to Adopt It?

Margarida Morais Marques and Lúcia Pombo

Abstract Although only recently mobile augmented reality (AR) games have been adopted for educational purposes, research recognizes their potential and offers guidelines for their use in education, to create smart-learning ecosystems. It is time for teachers to adopt these technologies, but are they receptive to them? The aim of this study is to reveal teachers' readiness to adopt mobile AR technologies in their practices, after training, bridging the gap between educational practices and research in educational sciences. This paper reports a case study based on a workshop designed to support teachers' adoption of teaching strategies involving game-based mobile learning (mLearning) with AR. The workshop was conducted under the EduPARK project and offered trainees the opportunity to collaboratively experience the use, *in loco*, of the EduPARK app for outdoor learning with AR, as well as prompted them to plan educational resources appropriating these technologies. Data were collected through individual questionnaires and focus group interviews, and they were analysed through descriptive statistics, the computing of the educational value scale (EVS) and of the system usability scale (SUS), as well as content analysis. The results show that teachers consider they are ready to integrate mobile AR games in their practices, but they are foreseeing difficulties that need to be addressed. This paper contributes to the field of teacher training in game-based mLearning with AR as it unveils teachers' readiness to adopt these technologies and why. Moreover, it characterizes a typology of teacher training in this area that, according to the trainee teachers, is successful.

19.1 Introduction

Nowadays, the ubiquity of mobile technologies is highly recognized both in academic and in non-academic contexts. The use of mobile devices for educational purposes has been a growing field of research with a history of positive empirical results [1]

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and their use in game-based learning approaches has also been documented as effective [2]. These educational approaches, when combined with emerging augmented reality (AR) technologies, can enhance learning experiences, as they can enrich and contextualize learning information offered to learners [3].

Mobile AR games have been adopted for educational purposes only recently [4]. Yet, research so far has been quite enthusiastic regarding their potential for education [5] and offers guidelines for their use in education [4, 6], to create smart-learning ecosystems. It is time for teachers to adopt these approaches, but they must feel familiar with those technologies. Additionally, literature has reported the need of teacher training in AR [7], game-based learning [8] and mobile learning (mLearning) [9].

With the purpose of unveiling teachers' readiness to adopt AR game-based mLearning practices, after teacher training on these issues, a case study was conducted on a workshop designed to support teachers' adoption of these strategies. The choice of this case study is related to the authors' privileged access, who were involved in the workshop, thus allowing an in-depth analysis. The workshop was developed under the EduPARK project (http://edupark.web.ua.pt/?lang=en) and offered trainees the opportunity to collaboratively use, *in loco*, the EduPARK app. The workshop also prompted trainees to plan educational resources appropriating these technologies.

The following sections of this paper include: (i) a brief theoretical framework on mLearning, game-based learning and AR use for educational purposes; (ii) the case study methodology, which includes the case/workshop description and the performed data collection and analysis; (iii) the results' presentation and discussion; and (iv) the concluding remarks that summarize the results, presents this study's limitations and emergent recommendations.

19.2 Theoretical Framework

The increasing mobile devices' pervasiveness has set the stage for the use of technologies to support learning 'anytime, anywhere'. Devices, as smartphones or tablets, allow user interaction with learning content and with others (both learning peers and experts) across physical locations, educational contexts and time [10, 11]. Among mLearning advantages are their potential to promote innovation in teaching and learning practices, to extend the learning environment and to promote collaborative practices [9]. The proliferation of mobile hardware and apps supports a high variety of contextual and situated learning activities [12], which, according to the literature, are linked to positive cognitive and effective results [10, 13]. Nonetheless, mLearning criticisms include students' off-learning task behaviour, cheating, cyberbullying and accessing inappropriate content on the Internet [9] and instruction involving mobiles require a high teachers' preparation [13], who may not be tech-savvy.

Mobile devices can support the use of game-based learning approaches in education. Games capitalize the natural human activity of playing, which has an important

role in learning [14, 15] and their motivational and engagement qualities are recognized in the literature [4, 15, 16]. Therefore, it makes sense to use these approaches in education, as games potential include keeping students in learning tasks [14], transferring game-acquired capabilities or attitudes to nongame contexts [15, 16], among others. However, their learning gains may result from increased time spent by learners playing them [16]. Games have been pointed as disruptive of the traditional formal instruction structure, as they require longer lessons, cross-subject approaches, social learning, etc. [15]. Nevertheless, to be effective, game-based approaches need to be carefully designed and integrated into the curriculum, for learners to achieve the desired learning goals [13, 14, 16].

Finally, AR is one of the most recently emerging technologies that can leverage educational gains. Mobile technologies can support AR experiences, which involve real-time visualization and interaction with virtual elements (e.g., 3D models, annotations, and videos) overlaid on top of real objects from the physical world, through a real-time camera feed [4, 17]. AR content can be triggered, e.g., by image recognition or by the user's location (from GPS or wireless network). In educational contexts, AR can make boring learning content more enjoyable and can be used to provide immediate feedback as well as support autonomous learning. So, AR has the potential to increase learning performance; however, its pitfalls include its usability and GPS-related problems [18].

19.3 Methodology

This work follows a case study approach [19] as it analyses in depth a workshop designed to support teachers' adoption of teaching strategies involving game-based mLearning with AR, conducted under the EduPARK project. The research question is 'What is teachers' readiness to adopt game-based mLearning with AR practices after a teacher training intervention on the topic?' so, the objectives are:

1. To assess teachers' self-reported training needs that prompt them to seek teacher training and if those needs are perceived as met;
2. To elicit teachers' perceptions on the development of mLearning strategies in their practice, after attending a teacher training on these issues;
3. To uncover teachers' assessment of an app—the EduPARK app—that aims promoting approaches of game-based mLearning with AR, regarding the app's: (i) learning value, (ii) intrinsic motivation, (iii) engagement, (iv) authentic learning, (v) lifelong learning, and (vi) conservation and sustainability habits;
4. To determine the usability of the EduPARK app.

19.3.1 The Case: EduPARK Workshop for Teachers

The project EduPARK's main challenge is the creation of original, attractive, and effective strategies for cross-subject learning in science. For that, the project team developed a mobile application (app) for Android devices through a design-based research methodology, which was presented in previous works [5, 20, 21]. The app, freely available in the Google Play Store, is interactive, includes AR contents and contains cross-subject information and challenges, following geocaching principles (hunting virtual treasures/caches), and promotes outdoor learning. The app was developed for teachers, students, and the public to explore an urban park in Aveiro (Portugal), the 'Infante D. Pedro' Park, with a high botanical diversity and historical patrimony [22]. The EduPARK team designed and integrated into the app cross-subject learning guides or quiz games, developed for specific audiences, from basic to higher education, but also for tourists/public in general. These guides were developed in articulation with the Portuguese National Education Curriculum.

To better articulate educational practices and research in educational sciences, the EduPARK project promotes accredited teacher training that incorporates recommendations from the literature on AR game-based mLearning. One teacher training initiative was the '*EU AMO EduPARK - Educação Ubíqua com a Aplicação Móvel Outdoor EduPARK*' [I LOVE EduPARK—Ubiquitous Education with the Outdoor Mobile Application EduPARK], a 4 h-workshop conducted entirely in the outdoors, after the end of school year. The main purpose of the workshop was to disseminate the app and educational practices involving AR game-based mLearning in the park. This workshop was based on the assumption that being familiar with new practices is a requirement for developing new competencies and changes in the installed practices. The workshop followed the subsequent structure: (i) presentation of the EduPARK as an example of a research & development project based on games and mobile AR technologies in the outdoors; (ii) exploration, *in loco*, of the EduPARK app for collaborative game-based learning with AR, as if teacher trainees were students; (iii) collaborative work to plan activities and to create educational resources that may be integrated into an AR mobile game-based educational app, to implement with students; and (iv) evaluation of the implemented activity and of the workshop. The workshop involved a total of 26 teacher trainees from several subjects and school levels.

19.3.2 Data Gathering and Analysis

Data were collected immediately after the workshop, through individual questionnaires and focus group interviews, providing multiple sources of evidence to answer the research question. Both data sources give access to teachers' opinion on their readiness to adopt game-based mLearning with AR, taking as an example their experience with the EduPARK app, which explores those strategies.

The questionnaire comprises five sections, mainly with multi-choice closed questions in a Likert scale. One section collected basic demographic data, such as age and gender, use of mobile devices to promote learning and their advantages and disadvantages in education. Other section is about the interest regarding the activity of playing the EduPARK game in the park, the intention of use of this approach with their classes and if they would recommend it to other teachers. Other section refers to the educational value scale (EVS), and another section is based on the system usability scale (SUS) [23, 24] as teachers' perceived mobile technology ease of use seems to be positively related to their intention of use in their teaching practice [25]. The last section is for the workshop evaluation.

The focus group initial question is about teachers' perceptions of the experience of using an app in outdoors as a teaching strategy. This is followed by questions regarding the EduPARK app impact on: (i) learning value, (ii) intrinsic motivation, (iii) engagement, (iv) authentic learning, (v) lifelong learning, and (vi) conservation and sustainability habits. The final question prompted teachers do add any further reflections.

As to data analysis, individual SUS scores and EVS score were computed according to Brooke [24], with values varying from 0 to 100. In the present study, SUS scores were interpreted according to Sauro [26] and to Bangor et al. [27]. The remaining data were analysed through descriptive statistics and content analysis with predetermined categories. These sets of data were triangulated to provide a more comprehensive knowledge of teachers' readiness to adopt game-based mLearning with AR practices. This analysis is presented in the next section.

19.4 Results and Discussion

This study's teacher cohort comprises 23 female and 3 male trainees, with age ranges from 28 to 62 years old (about 48 of average), revealing an experienced group (from 15 to 38 years of teaching, except for one teacher who was in her first year) that might not be as proficient in the use of modern technology as their students. All teachers had high education courses, mostly high degree (21) or higher (remaining 5).

Regarding **research objective 1**, teachers expressed their training needs by selecting reasons for enrolling in the EduPARK workshop (Fig. 19.1). The three main reasons were: (i) getting access to new resources (23 teachers); (ii) professional development (19); and (iii) knowledge update (16).

The relevance of providing adequate teaching material for mLearning [28] and game-based approaches [29] was pointed before; however, our results empirically support these claims, despite most teachers enrolled in this workshop having 15 or more years of teaching experience. These teachers are still interested in updating their professional knowledge, although not necessarily in what concerns mLearning, AR and game-based approaches. This is illustrated by this citation from the focus groups: 'We can't teach now how we taught five years ago; we have to be constantly updated because the way the technology and society are evolving' (teacher A). The

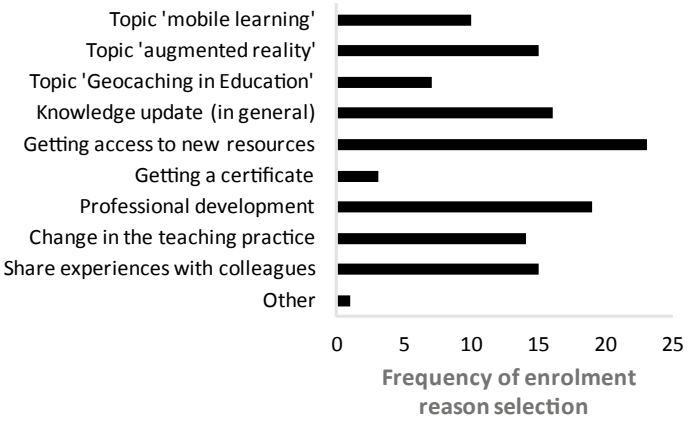

Fig. 19.1 Teachers' reasons for course enrolment

less selected reasons for enrolment were: (i) getting a certificate (3); (ii) the topic 'Geocaching in Education' (7); and (iii) the topic 'mLearning' (10). The workshop topics reached a moderated-low importance, with a total of 32 selections.

Teachers' evaluation of the EduPARK workshop was very positive (Fig. 19.2), revealing feelings of at least partially fulfilled training needs. They highlighted that the workshop resources—mainly the EduPARK app—are very interesting (23 teachers) or interesting (1), with not too hard activities (23). Hence, the vast majority was strongly pleased to have attended the workshop (25) and many reported they were prepared to integrate mobile devices in learning (15 strongly agreed and 7 agreed).

To elicit teachers' perceptions on mLearning, **research objective 2**, several aspects are analysed, such as devices ownership, their use in teaching practice and their advantages and disadvantages. Most teachers (22) referred owning an Android device and claimed they sometimes used mobile devices to promote learning (20). Only three teachers mentioned they never had used mobiles for that purpose and also three claimed they used them frequently to promote leaning. Considering that Prieto et al. [25] found that male future teachers have a better disposition towards the use of mobiles in teaching practice, one could expect this study's cohort of mainly

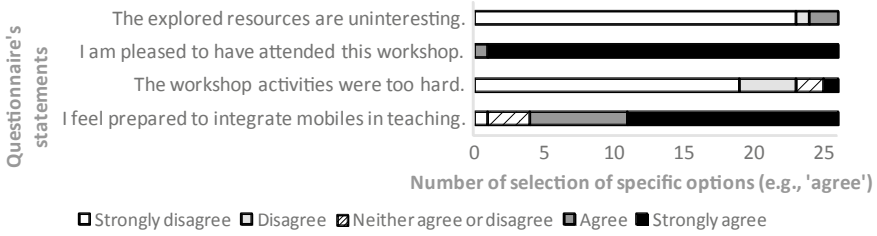

Fig. 19.2 Teachers' evaluation of the EduPARK workshop

female teachers to reveal a low propensity for mLearning. However, participating teachers showed a positive perspective, as each one acknowledged 2–7 advantages of mLearning, with an average of 5. These results point to some degree of teachers' openness to the adoption of these technologies in their practices.

Figure 19.3 shows the level of agreement with each mLearning advantage sentence. The most selected were: 'it motivates to learn' (22), 'you can learn in a fun way' (21), and 'you can learn in a different way' (20). Also, two teachers added new gains: 'it facilitates teachers work, namely in assessment' and 'it prepares for future technological advances'. This concern aligns with the literature regarding the aim of 'equipping young people with the skills for living and working in a digital age' [30, p. 3].

One teacher did not recognize any difficulties in the use of mobile devices to promote learning (Fig. 19.4). The same teacher claimed she was already using them frequently in her practices, indicating some relation between difficulties recognition and mobile devices adoption. However, the majority selected 1–5 difficulties, with an average of 2.8. The most mentioned were 'increased battery consumption' and 'risk of developing mobile device dependence' (both pointed by 16 teachers), followed by the 'prohibition of mobile device use in classes' (10) and 'access to distractions'.

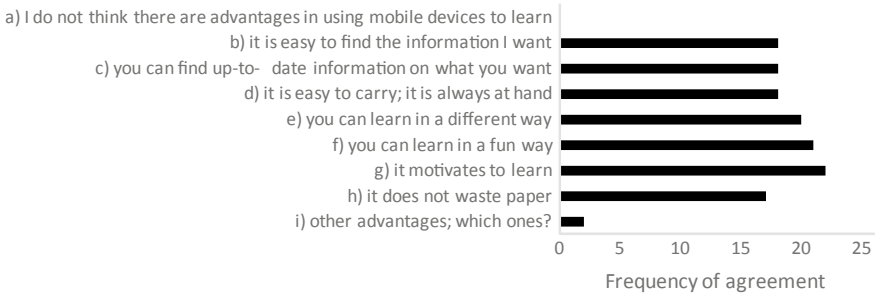

Fig. 19.3 Teachers' opinion about advantages in using mobile devices to promote learning

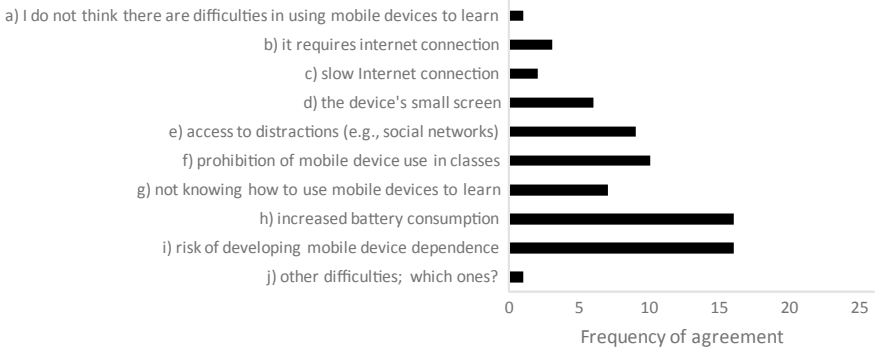

Fig. 19.4 Teachers' opinion about disadvantages in using mobile devices to promote learning

Finally, one teacher identified an additional difficulty, the lack of access to mobile devices from some students. These results indicate teachers are foreseeing some difficulties in the integration of these technologies in their practices that need to be addressed, e.g., by presenting them battery charging solutions for the outdoors. This cohort of teachers echoes concerns found in the literature regarding students' off-task behaviours [9, 30], reinforcing the position of those that support mobile technologies ban in schools. Curiously, this prohibition was pointed by this group of teachers as one of the main difficulties in mobile integration in teaching practices. The EduPARK approach contributes to reduce some of these constraints, as it promotes teachers' support of the use of mobile devices to learn and reduces students' use of other mobile devices software, as they are engaged with the game in the park [5].

All teachers found the EduPARK activity very interesting. One even mentioned 'Excellent. I was amazed!' (teacher E). However, being interesting does not always mean integration in their practices. Nevertheless, it seems an activity they would recommend to other teachers (22 strongly agreed and 4 agreed).

Under **research objective 3**, teachers revealed a positive perception regarding the EduPARK game educational value (Fig. 19.5). For instance, 21 teachers strongly agreed and 2 agreed with 'This app helps you fostering curriculum related learning' that assesses positively the app's learning value. Similarly, but opposite results emerge from 'This app shows information in a confusing way', with 17 strongly disagree and 7 disagree classifications. These results are in line with the focus group data: 'This is a way of taking advantage of (…) a technology they [students] handle

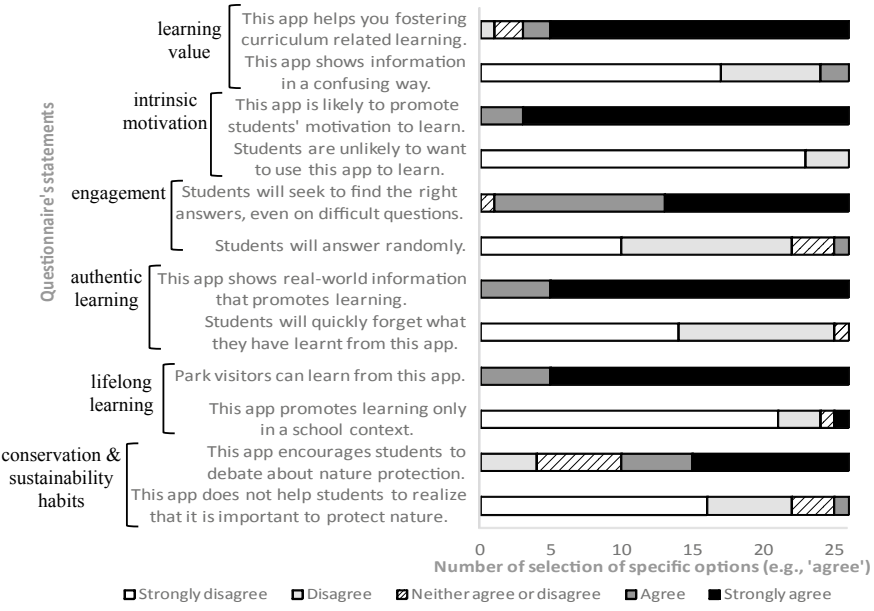

Fig. 19.5 Teachers' opinion regarding the educational value of the EduPARK app

very easily, and that is part of their daily lives, to increase their scientific capital' (teacher A).

Identical results can be found for the remaining indicators. Teachers' classification of sentences regarding intrinsic motivation reveals they consider the app motivator for students, which is reinforced by the focus groups: 'It motivates students. The game serves a competitive spirit and helps them to want to learn to win' (teacher B); 'what will make a difference (…) is the part of the augmented reality. (…) for most of them it will be a novelty and it is a novelty to use it in learning' (teacher C).

Regarding engagement, teachers seem less enthusiastic (questionnaire data), but still on a positive view: 'a 2nd/3rd cycle student would probably see half of what I saw (…). I think just the simple attempt (…) is very positive' (teacher D); 'It can increase students' engagement in learning because if they are motivated they will try harder' (teacher E). Teachers also consider this app can promote authentic learning: 'It's not just exploring the information on the device, but also seeing the reality (…). And then all the scientific knowledge they will appropriate from this observation' (teacher E). Moreover, the app's contribution to lifelong learning was also reckoned: 'Anyone, who is minimally curious and likes to learn, comes here and [with the app] remembers things that he/she has learned and that were forgotten' (teacher G). Finally, the indicator that gathered the least consensus was the app contribution for conservation and sustainability habits: 'This would imply changes in their daily life. (…) I think that required a more direct connection to how they would make decisions in their daily lives' (teacher A); 'I think so. Knowing more about a tree, maybe we end up liking it, and then we start creating habits of conservation and sustainability' (teacher F). EVS score values ranged from 66.7 to 100, with an average of 88.9, which seems to be a high value, although more studies are needed to sustain that claim. These results reveal that the EduPARK game has educational value for this workshop teacher cohort.

At last, in what concerns **research objective 4**, teachers' opinion of the EduPARK app usability is also positive (Fig. 19.6) as, e.g., 19 teachers strongly agreed and 4 agreed with the statement 'This app was easy to use' and 19 strongly disagreed and 5 disagreed with the statement 'This app has many flaws'. SUS score values ranged from 60.0 to 100, with an average of 87.5, which is a higher value than the average SUS value (68) computed by Sauro [25]. Moreover, according to the classification of Bangor et al. [26], the app achieved an excellent usability for this cohort of teachers.

19.5 Concluding Remarks

This case study analyses teachers' readiness to adopt mobile games with AR in their teaching practices after a workshop on these issues under the EduPARK project. The workshop cohort comprised mainly very experienced female teachers, who identified their training needs as: (i) getting access to new educational resources, the EduPARK app; (ii) developing professionally; and (iii) updating their knowledge, although

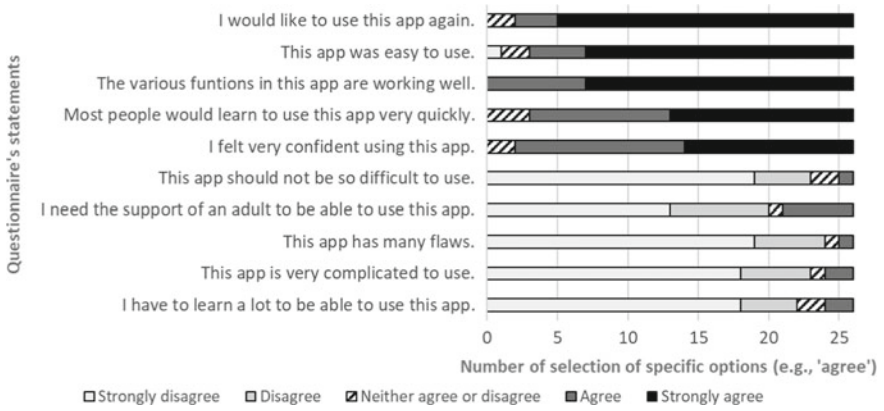

Fig. 19.6 Teachers' opinion regarding the usability of the EduPARK app

not necessarily in what concerns mLearning, AR and game-based approaches. The EduPARK workshop fulfilled those needs, at least partially, although not all reported feeling prepared to integrate mobile technologies in their practices.

Overall, teachers' perceptions on mLearning are positive. Most of them possess their own device and even claim to sometimes promote learning with these technologies. Teachers acknowledge in mLearning both advantages, such as increased motivation and learning in a different way; and difficulties, such as increased battery consumption and risk of mobile device dependence. However, they selected more benefits than constraints, reinforcing the claim of teachers' positive view regarding mLearning. This indicates some degree of teachers' openness to the adoption of mobile technologies in their educational practices. Nevertheless, as most teachers are not currently using mobile technologies to promote learning on a regular basis, the difficulties identified in this study must be taken into consideration and properly addressed.

Teachers' evaluation of the EduPARK app educational value and usability reveals that it can be a good starting point to promote mobile AR game-based learning. They acknowledged the app's high learning value, in an authentic way, as well as its capacity to promote students' intrinsic motivation and engagement in learning. Moreover, teachers mentioned the app can be used in a context of lifelong learning. Regarding the app contribution to the promotion of conservation and sustainability habits, data revealed that there is no consensus in these teachers' opinion. Furthermore, this resource has the additional advantage of being open, free of charge and easy to use by teachers, students, and any other visitors.

The results of this case study need to be interpreted with caution. Further studies are needed with bigger and more diverse samples to better understand teachers' opinions on mobile game-based learning with AR after teacher training. Another limitation of this study is the use of a convenient rather than random sample, which is due to accessibility issues to teachers' opinions. Nevertheless, this study accomplished its purpose of eliciting this teacher cohort readiness to adopt game-based

mLearning with AR in their practices, a feature that contributes to the creation of smart-learning ecosystems.

In sum, this study reveals that teachers seem ready to adopt mobile AR game-based approaches, factor that must be taken into consideration by educational researchers and teacher trainers concerned with these topics when planning their work. They may get inspired by the EduPARK workshop, as its relevance relies on: (i) the integration of new technologies and teaching approaches—mobile devices, AR and game-based learning—a need identified by [7–9]; (ii) presenting to teachers a mobile AR game exemplar—the EduPARK app—offering them time to explore and to experiment an existing tool; (iii) prompting teachers to develop learning content for the presented tool, as indorsed by [15]; (iv) effectively promoting teachers adoption of new teaching strategies, involving technological innovation, and increasing their confidence in using those technologies with their students; (v) being entirely in an outdoor environment, illustrating the aimed educational methodologies *in loco*; and (vi) making available the resource used to illustrate new practices, which is open and free, not being a common situation in the literature [1].

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Chapter 20
Services, Schools and Skills: Mobile Media and Local Development in a South African Rural Area

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Abstract The proliferation of mobile phones and increasing access to the Internet in Africa, and South Africa in particular, is extensively documented and attempts have been made to explore its impact on development. This paper explores mobile media in relation to development within a marginalised rural community in South Africa. Focus groups and interviews with a wide range of participants highlighted several areas where mobile media contributed to positive change, such as lowering the cost of access to information and communication, staying in touch with distant relatives, increasing access to services and providing entertainment. However, mobile media on its own cannot be expected to address the challenges of infrastructure and public service delivery. Research findings also revealed that mobile media might interfere with sociocultural values of respect, human dignity and privacy. Findings suggest significant differences in digital access and skills, particularly along age lines.

20.1 Introduction

The present paper explores the relationship between mobile media and development in a rural area of South Africa, with a particular focus on mobile services in relation to infrastructural challenges, support for the activities of local schools and existing as well as necessary digital skills. Because of past Apartheid discriminatory policies, members of rural communities live in widespread poverty and enjoy a low quality of life compared to those in urban areas. Information and Communication Technology (ICT) and particularly mobile technology have the potential to support MDGs activities such as:

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(1) Developing and implementing a comprehensive rural development strategy: Mobile media can reach citizens in areas characterised by lack of infrastructure and services and can be integrated with the existing ecosystem.
(2) Strengthening the skills and human resource base: Rural dwellers can use their mobile phones to enhance their participation and effectiveness, gaining ICT skills in the process.
(3) Building cohesive, caring and sustainable communities: Mobile media can catalyse and enhance existing social networks and improve communication and interaction within the community.
(4) Building a developmental state, including the improvement of public services (e.g. schools) and strengthening democratic institutions: Mobile platforms can be used by citizens to communicate with local public servants, to monitor service delivery and to alert stakeholders of pressing issues.

20.2 Background

20.2.1 Development and Mobile Media

The notion of development has several meanings, which makes it ambiguous, contested and complex. Development is largely a political term that has a range of meanings which depend on the context in which it is used, and it raises issues about power [1]. The concept of development gained momentum from many historical events such as the Industrial Revolution in Europe and the USA colonialism in Latin America, Africa and Asia, quantitative empiricism in North American social sciences as well as capitalist, economic and political philosophy [2]. Definitions of development in the 1960s focused on economic growth with gross national product (the total value of goods and services produced in a country in one year by its nationals) and per capita income (the average income earned per person in a given year) as indices for measuring development. Criticisms were levelled at the use of economic data as the main index for development, especially among non-economists, but there were relatively few proposed alternatives. The current consensus is that development is dynamic, changing from one state or condition to the other and can be both progressive and regressive. As an example of the latter, Information and Communication Technology for Development (ICT4D) projects may be criticised for reinforcing dependency of developing communities on external funders [3].

Over the past two decades, the importance of ICT4D in areas such as education, health, environment, human rights and socioeconomic growth has been increasingly acknowledged [4]. The claim that has been put forward in these discussions is that ICTs has the potential to change people's lives for the better, shaping the way we think and act, the way we engage with others in our interpersonal relationships, attitudes and cultural values and the way we learn. The discourse around digital access leads to the classification of people on a binary opposite of information rich

and information poor and developed and underdeveloped/less-developed [5]. Despite the increasing diffusion of ICTs, the distribution of access to the ICT resources is not uniform within and between developing communities [6]. The diffusion of ICTs may reinforce existing inequalities rather than overcoming them. The inequalities in access to and use of ICTs, mostly the Internet, are captured by the concept of the digital divide [7, 8]. There is a need for a distinction between an ICTs (particularly Internet), access divide and a digital skills divide, known as the second-level digital divide [9, 10]. A focus on the beneficial outcomes of Internet use has led to the development of the third-level digital divide concept [11].

Definitions of mobile media emphasise the Internet capability of modern mobile devices. Mobile media has the potential to provide ubiquitous connectivity and greater interactivity [12, 13]. In most developing countries, mobile phones are the primary means of accessing the Internet [14]. In Africa and South Africa in particular, Internet access is often mobile first, mobile-only and mobile-centric [15]. A significant number of people in marginalised communities access the Internet through mobile devices [16]. Over a decade since mobile phones started to spread in Africa, they have become popular even in the continent's poorest regions. Researchers have speculated that because of the absence of fixed-line telephony infrastructure and the explosion of new wireless technologies, Africa will be able to leapfrog the development trajectory into an ICT revolution through the adoption of the newest cutting-edge technologies [17].

20.2.2 Context

The African continent is experiencing a mobile technology expansion and is the world's fastest-growing mobile technology market [18, 19]. Across the region, mobile phones are more than a communication device; they are the primary channel of connecting and accessing life-enhancing services which aid digital and financial inclusion and innovation. This is particularly the case in rural areas where half of the continent's population live with limited economic opportunities, skills and infrastructure gaps [20]. Through mobile media technologies, rural farmers in Uganda access important agriculture information and can communicate instantly with district agriculture extension officers [21]. Rono [22] documents how mobile phones are used to identify children with correctable visual impairments in rural schools in Kenya using an eye-scanning technology. Similarly, mobile phone-based money transfer and microfinancing services like M-Pesa (M for mobile, Pesa for money in Swahili) have enabled people in rural areas to withdraw, deposit and pay for goods and services with their mobile devices [23].

South Africa is regarded as the most developed society in the sub-Saharan region. With a population of 57.06 million, 67% of the population has access to a mobile phone [24]. There are about 87 million active mobile connections in South Africa, which would account for 153% of the total population [24]. Research has shown that some people have more than one mobile phone and rely on different carriers to

take advantage of promotions and favourable tariff plans. Approximately 54% of the connected mobile phones in South Africa are Internet-enabled which accounts for 30.8 million users [24]. It is estimated that 78% of all Internet traffic in South Africa is through mobile devices [20]. Despite having the most mature mobile industry on the continent, South Africa is behind other nations when it comes to access to broadband because of the cost of connectivity and mobile telephony in general. Data tariffs are among the highest in the region, affecting especially the 31 million South Africans living below the poverty line.

Internet access in South Africa is influenced by race, age, gender, income and level of education. The clearest divide is shown in income inequality with Internet penetration at 82.4% for those earning more than R 30,000 a month and only 27% for those earning below R 2500 a month. The Eastern Cape Province, which is largely rural, has the lowest Internet penetration in the country with only 25.2% of its population connected [24]. This suggests that most people in rural areas cannot be active digital participants. As in other parts of the country, the rural/urban divide [25] is compounded by the time span (approximately five years on average) from being online for the first time to being sufficiently familiar and comfortable with technology to be able to perform online activities/tasks and use cloud-based services [14]. This implies that mobile penetration and subscriptions are not accurate determinants of active digital participation as many people in marginalised communities are relatively recent mobile media users.

20.2.3 The Dwesa Area

The area under consideration in the present study is home to a rural community of Dwesa in the Eastern Cape Province of South Africa. Dwesa is representative of the realities of many South African rural areas in terms of lack of services and infrastructure, high levels of unemployment and poverty. The local population consists mainly of old people, single mothers and young children, while most of the young men and few of the women migrate to the towns and cities seeking a better life and employment opportunities [26]. As a source of income, most of the households rely on subsistence farming as well as government social security grants and remittances from family members working in urban areas [26]. The community of Dwesa experiences various forms of underdevelopment which range from poor infrastructure (transport, clinics, schools and administration) to poor public service delivery. The community members must travel about 60 km to the nearest town to access public services. Travelling to and from the nearest town costs R 90, and a full day of travel as transport options is limited.

ICT may contribute to addressing local issues in the area. Since 2005, Dwesa has been the site of a multidisciplinary project seeking to contribute to the socioeconomic development of the area through the free provision and maintenance of ICT infrastructure, ICT and mobile training and co-creation of e-services [27]. The ICT project was initiated in 2005. Five schools were chosen as initial access sites because

of their secure building infrastructure and reliable electricity supply. Schools are natural centres of knowledge, and members of the community can access the Internet through a computer laboratory and can connect via Wi-Fi using their mobile phones near school premises [28]. Educators with an interest in ICT became the primary drivers of the project at a local level, and this model of train the trainer was adopted as a way of passing down the skills to the community [28]. Funding by the local Department of Education enabled close to 100 local teachers to attend professional development courses focusing on ICT at a University in South Africa. The project provides a platform where government, research institutions and industry partners can explore possibilities in the development and deployment of telecommunication infrastructure and services for rural communities [28]. Several proof-of-concept mobile applications have been developed to address some of the challenges that the community faces and which were identified in consultation with community representatives, local researchers and potential users of the mobile applications [29]. Examples include a prototype mobile application to warn drivers of dangers on the road such as veld fires, sharp curves, flooding and potholes) and organise shared transport to the nearest town.

While television and radio signal is relatively weak in the area, mobile network coverage by either of the two main mobile service providers is well established. It is estimated that 98% of the population has access to a mobile phone and recent studies have shown that each household has access to at least one Internet-enabled mobile device [30]. Apart from creating and consuming multimedia content, members of the community share such content with their family, friends and neighbours. Approximately 80% of mobile users share multimedia, stories and news locally and 69% share with people outside the community. A significant portion of the population (26%) transfer airtime, and this sometimes serves as a method to send money to friends and family [31]. The study revealed that about 21% of mobile phone owners claim to browse the Internet, 10% use their devices to send and receive emails and about 8% do some form of online shopping with their phones. In Dwesa, 99% of the population have access to a bank account, 40% interact with their accounts online either through mobile browsers or mobile banking applications. About 80% of the community that receives the government social welfare grants access their South Africa Social Security Agency (SASSA) accounts using mobile devices and purchase airtime and electricity using Unstructured Supplementary Service Data (USSD) codes [32]. Purchasing airtime is expensive in the area as there are few resellers and they often charge an additional fee. A baseline study [33] indicated that a considerable portion of a household's disposable income is spent on purchasing airtime. The researchers estimate the figure to be as high as R 160 per month against an average combined household income of about R 1000. Relatively little is known about the actual or perceived benefits deriving from such comparatively onerous costs.

Education, age and gender appear to have a significant effect on the way members of the community adopted ICTs. The study revealed that teachers adopted ICTs in order to improve their teaching skills as well as for their own personal benefits, e.g. being able to access news, online shopping and Internet banking. Young people

who had completed their studies or at least had some high school education showed interest in participating in ICT training and activities. Uneducated community members, however, felt inferior to the teachers and depended on them for help as they are considered knowledge experts. Women showed greater interest in adopting and becoming skilled in the use of ICTs than men. Although elderly men and women accepted and were interested in ICTs, they could not really adapt. They perceived young people as the ones who should learn and adopt ICTs.

20.3 Methodology

20.3.1 Research Design

The focus of the present study is the subjective understanding of the role of mobile media in relation to development in Dwesa community. The inquiry is based on the fact that although there is extensive research on the adoption of mobile phones in developing communities, there is still lack of evidence that demonstrates their effectiveness in solving developmental challenges [3]. This research is situated within an interpretive paradigm and is informed by a qualitative methodology. We used focus groups, individual semi-structured follow-up interviews and observation as methods of data collections. We employed focus groups in this study as they enable us to generate a rich understanding of the participants' shared meanings and perceptions [34]. Focus groups also provide data about a wide range of ideas and feelings that the participants have about the relationship between mobile media and development. Group interaction between members of the group encourages participants to make connections to various concepts and issues which might not occur during individual interviews. Meanings and responses arising from focus groups are socially constructed rather than individually created.

We identified two participants in each focus group to take part in an individual semi-structured follow-up interview. Semi-structured interviews consist of several predetermined questions that are meant to define key themes to be explored. An interviewee can diverge in order to pursue an idea or a response. Because of its flexibility, this approach enables the discovery and exploration of information that participants might consider important but may have been overlooked by the research team. We also used observation to complement our data collection. We identified the participants through the contacts we have made during mobile training workshops. The participants, in turn, pointed us towards other representative categories of participants. We used audio transcriptions and field notes as techniques for data recording. We analysed the data thematically, contrasting the views of different categories of respondents.

20.3.2 Participants

We grouped the participants into three distinct groups in order to capture the diverse perceptions of mobile media and development. Dwesa is not a homogenous society and mobile media affect the members differently. In order to categorise the participants into the three respective groups of early adopters, majority and late/non-adopters, the following criteria were used: Early adopters had access to an Internet-enabled mobile device for five or more years; majority adopters had access to an Internet-enabled mobile device for six months to four years; late adopters had access to a feature phone or to an Internet-enabled mobile device for less than six months. Non-adopters made a decision not to use mobile phones at all.

The early adopters' group comprised of seven participants (four females of ages 19, 20, 22 and 35, and two males of ages 27 and 40). The majority group comprised of five participants (four females of ages 28, 32, 39 and 45 and, one male 30 years old). The late/non-adopters' group included five participants, who were generally older than those in other groups (three females of ages 36, 50 and 63, and two male of ages 24 and 46).

20.3.3 Methodological Challenges

In terms of language, we had to change our choice of a translator from a student to a community member who could speak and understand the local variety of isiXhosa. This was important to build rapport with the participants and to capture linguistic nuances and contextualised meanings. Although it was not made explicit, there seemed to be some discomfort among the participants about the fact that we could not explain directly in isiXhosa some of the issues ourselves. Despite some language issues, we are reasonably confident that our involvement in teaching and training activities built sufficient rapport to enable us to gather reliable knowledge from the participants.

A few of the participants were slightly nervous to speak in the presence of an audio recorder although we had reassured them about the confidentiality of their personal information. The fact that they had to fill in a consent form with their name, surname and signature might have contributed to this fear. Eventually, some of their peers in the focus groups managed to convince and assure them that their information was confidential and would be kept safe as we declared.

20.4 Findings

20.4.1 Mobile Media and Local Services

Participants stressed that because of the bad conditions of the road, a round trip to the nearest town 60 km away is long and uncomfortable and takes almost the whole day. A good transport network would contribute to the socioeconomic status of the area as more businesses and services are established. One of the interviewees explained how mobile devices have greatly improved their family business. She states that by converting her mobile phone into a hot spot, she can now use her computer to perform various business transactions which she would otherwise travel to the nearest town for, thus saving time and money. Another participant noted that mobile devices are only as effective as other components in the ecosystem and further on argued that in case of a medical emergency where there is a need for an ambulance, mobile phones assist in making contact with relevant authorities for the request. However, because of the bad conditions of the road, the ambulance service takes longer to reach the patient. She states that:

> My grandmother was unwell, and we called the ambulance, and it only arrived after 9 h and by that time her condition had worsened. Phones alone cannot solve all our problems. Yes, they help because we can call and the like…but we need good roads.

A social development officer visits the area frequently and often provides information about job opportunities in and around the community. The jobs range from skilled to semi-skilled in public offices, non-governmental organisations as well as private businesses. Using WhatsApp, he gets in contact when there are opportunities, and a number of young people have been employed this way. The participants stated that whenever there is a job opportunity in and around the area, people circulate the message using instant messaging applications like WhatsApp. However, the participants stated the need for basic skills like writing a curriculum vitae as most of the job opportunities require them. Because of the few socioeconomic activities in the area, there is a high rate of unemployment which forces most of the young people to migrate to urban areas. They keep in touch with their family through mobile phones. As put by one of the participants:

> My brother left three years ago to look for a job in East London. He now works as security personnel. Because his job is demanding, he rarely gets enough days off to come visit us. However, we now talk every day on WhatsApp, and sometimes he even calls us. It almost feels like he is just here with these technologies. It is funny you know…because my relationship with my brother is actually better than what it was like when he was around.

Instant messaging applications like WhatsApp have reduced the cost of communication and possessed an advantage over SMS and voice calls which requires a significant portion of airtime. Instant messaging applications like WhatsApp enabled people to share useful information with community members with ease. The participants argued that mobile applications like WhatsApp enabled people to create groups which support and align with physical groups that do exist in the community. This

enables people to communicate remotely eliminating the need to meet and discuss issues relevant to the group physically. They cited that public meetings are often poorly attended because people are usually not aware or are informed at short notice and a significant portion of the population is old and has difficulties in walking to meetings. WhatsApp enabled people to recreate family groups and communicate with their relatives that are far away. Family WhatsApp groups are considered important for communicating information like contributions for a family ceremony and announcing celebratory news like birthdays and graduations within the family.

Many participants stated that they have a bank account and they do some form of Internet payment using their mobile devices, such as buying airtime and electricity vouchers. One of the participants stated that she uses the mobile banking service to transfer money to her relatives as well as pay for her local stokvel commitment. Local women who are part of local stokvel use WhatsApp groups to manage their contributions and facilitate communication and transparency. Two participants stated that they use USSD to perform bank transactions as it does not need airtime or data to work. They stated that the mobile banking application was useless, especially for those people who still use feature phones. The participants agreed that this development had saved them time and money as it eliminated the need to travel to the nearest branch or ATM to perform these transactions. Three of the participants acknowledged that they participate in some form of mobile data exchanges (lending and borrowing) where one would borrow airtime and return it topped with an "admin fee" airtime, usually around R5–R10 depending on the amount.

20.4.2 Mobile Media and Local Schools

Participants emphasised that the area needs government support in order to have up-to-date infrastructure specifically in schools. A member of the School Governing Body (SGB) of one of the local schools confessed that all the schools in the area still use pit latrine toilets. There have been several incidents of pupils drowning in school toilets in the province. Another participant added that some of the local schools have poorly maintained buildings with broken windows and loose or missing doors. Participants also noted that the schools do not have sufficient teaching and learning materials like books, and often, the pupils have to share some of the resources. The poor infrastructure in schools makes it difficult to attract and retain teachers and those who are there have to teach more than one class.

A local teacher explained that she uses mobile media in the teaching and learning process. Mobile media, as she states, enables learners to interact in class discussions and tasks which improves the learner's interest in geography and science. She discussed how she used Google Maps in a geography class by asking students to look up the map of the area using mobile devices connected to the school's Wi-Fi. However, the use of mobile devices in classrooms is subject to criticism with the participants citing that it causes a disparity in knowledge. Learners come from different

socioeconomic backgrounds, and some do not have access to mobile phones at their homes.

Parents of pupils at a local school use WhatsApp to communicate instantly with the school governing structures about important issues relating to the school and other parents. Before, the school administration would send some of the communication through the pupils, who often forgot or delivered incorrect information. They also stated that a significant segment of the parents is illiterate and finds it difficult to read. Through WhatsApp voice notes, the teachers can overcome this challenge in communication with the parents. Teachers use WhatsApp to manage urgent matters that develop through the course of the day at the school like exchanging teaching materials and important communication from district offices. Instead of waiting for breaktimes and meeting slots, some matters can be addressed and actioned remotely. However, a local teacher confessed that this sometimes causes distractions and to a certain extent interferes with class activities.

20.4.3 Mobile Media and Skills

Mobile phones can be used to spread rumours and circulate inappropriate content which degrades the social and cultural values that people subscribe to. The participants provided a few personal examples of incidents where relationships were destroyed because of rumours that were being circulated through WhatsApp. According to one of the participants, most of the community members were not aware of the privacy issues around mobile media. One of the participants highlighted the need for awareness programs to teach people the importance of protecting private information and provide tips on how to safely navigate the Internet. She urged that the awareness programmes needed to be initiated in schools even to lower grade pupils. She narrated an incident where she discovered that her son was sharing images of a sexual nature with his friends:

> These phones cause a lot of problems for us now. People can share your pictures, and the whole world will know even if those pictures were not meant to be shared. You will see some young people sharing nudes and viewing inappropriate images and videos, and it is all in these phones.

Mobile communication often bypasses the traditional protocols that exist in other forms of communication. An example of the need for critical skills in using mobile media consistently with values and beliefs relates to a message of the death of a community member in another city. The message of the passing was circulated on social media before the word had reached the family. As a way of showing respect to the bereaved family, it is an important cultural practice to wait for the family to be informed before spreading the news. Some older participants also noted that mobile phones have negatively impacted on cultural values of respect. They maintained that mobile devices negatively affect interpersonal communication, especially amongst family members. One participant noted that:

> Young people have destroyed our cultural values with [mobile devices]. I can not even send my grandchild to buy things from the grocery store because they will not come back. Even if they are still in the house, they have [earphones] plugged in and I have to shout at the top of my voice for her to hear me. This is not good for us. Young people need to respect their elders.

For young participants, however, entertainment through mobile phones is critically important and they display a considerable set of multimedia skills. One participant pointed out that: *"here, there is not really much to do like people in towns can go to clubs and other [social] activities. These gadgets [mobile phones] provide us with entertainment because I can listen to music with my friends"*. Many use the Bluetooth capability of their devices to share music, videos and pictures as a way of bypassing the data costs that come with sharing or downloading content via the Internet. Some of the young people had Bluetooth capable speakers that they connect their mobile devices and listen to music with friends and family. Mobile phones enable people to create and share media like pictures and videos. The group highlighted that this capability of mobile devices has made it easier and cheaper for people to document important functions in the community like weddings, religious and other cultural ceremonies. People can then share the media with family, friends and neighbours through instant messaging applications and via Bluetooth. This has bypassed the traditional methods of having the pictures and videos in print and on DVDs, respectively, which is expensive, and the materials can be easily damaged or lost. Young people acquire social prestige because of the type of mobile devices they use and the applications they can use on their phones.

20.5 Conclusions

Participants identified several areas where mobile media has a role to play in relation to development. These include addressing challenges such as poor infrastructure, limited access to information and services, community and family disintegration due to distance. Mobiles brought about positive change in the way local people work and entertain themselves, but also pose a threat to traditional values and personal finances. While most participants converged around a number of themes and appeared to share similar positions, the research highlighted differences between various adopter categories, particularly in relation to the age of respondents. Young participants generally viewed mobile phones as reinforcers of traditional and cultural values, while the older participants viewed mobile phones as a threat to a certain extent. The inclusion of late/non-adopters added a critical perspective to the study.

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Part VII
Disabilities and Interaction

Chapter 21
A Cognitive-Driven BCI-Based E-Learning Platform for Learning Disorders: A Preliminary Study

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Abstract E-learning represents a consolidated practice in education, as a support to traditional classroom-based lessons, in distance, blended and continuous education and, in more recent times, increasing enough as a mean for self-assessment and self-training to maximize learning results. Despite this overall interest, however, little attention has been devoted to adopting advanced technology-based e-learning approaches in developing specific platforms to support students experiencing learning disorders (LDs) difficulties. Among all, cognitive technologies could be integrated into advanced training platforms to empower students' abilities, especially in case of LDs. Indeed, several studies focus on LDs, especially analyzing: correlations among them, theories about their intern relationships and certain biological models on their basis. Also, computer-aided supports have been studied as a booster in learning process, to compensate individuals' difficulties. Despite this, few studies focus on the use of cognitive technology to trace a possible integration of these latter with pedagogical approaches to enhance learning processes. The present article focuses on experimenting a prototype of a web-based e-learning environment, preliminarily focused on helping students with dyslexia, considering some results obtained with priming and BCI from our previous researches. The preliminary results are reliable enough to allow future developments, studying deeper the potentiality of learning empowerment through cognitive technologies integrated into e-learning environments.

21.1 Introduction

Learning disability indicates a neurological disorder affecting specific areas of learning such as, specifically, these recognized types: Dyslexia that affects reading skills, Dysgraphia, damaging writing abilities, Dysorthography that involves problems in

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spelling in writing, and Dyscalculia, causing problems in mathematics skills. LDs occur in a situation of normal intelligence, and in the absence of neuromotor, sensitive and pre-existing psychopathological disorders.

In the Italian students' population, these disorders affect about the 4% of the learners in developmental age, and they are usually diagnosed in co-occurrence with two or more LDs rather than in a single form. As a consequence, we can state that LDs represent a complex topic and it is not easy to provide effective instruments to help such kind of learners in overcoming the related problems in studying scholastic disciplines, in which all depend on writing, reading and calculus abilities. Also, often these disorders are associated with easy loss of attention and concentration, due to the great effort and workload these learners must put on commonly easy learning activities, causing them a great stress, discomfort, and discouragement in studying. Moreover, notwithstanding the progress in neuro and cognitive technology, current ICT technologies are mostly used to provide compensation or dispensation tools for students and not to help them to recover from these difficulties.

Recently, thanks to artificial intelligence-based (AI-based) algorithms adopted for the analysis of the large quantity of data collected during the experimental sessions, technological tools such as brain imaging open a wide scenario of opportunities to study and analyze relationships among learning and technology. The main improvement that these technologies brought to the research in the education field is due to the possibility of observing the brain "in action", that is, the observation and analysis of brain functions such as memory, language, and perceptive task of an individual response to a specific stimulus. Several non-invasive brain imaging techniques currently allow to verify in real time the brain response of an individual under stimuli: magnetic electroencephalography (MEG), electroencephalography (EEG), functional magnetic resonance (fMRI), and positron emission tomography (PET). Among them, EEG is the most used technique to investigate mechanism such as learning abilities, due to its low invasiveness and high time resolution, which make it particularly suited to measure increase in learning abilities. We identified in brain—computer interfaces (BCIs) the EEG-based cognitive technology most suited for the described purposes. Being a simplification of EEG medical equipment [1], the BCI headsets allow to detect and collect the cerebral rhythms from an individual, then analyzed by AI and signal analysis methods. BCIs are currently widely used in research, thanks to their high accuracy, perfectly comparable to the medical EEG devices, and also to their low cost and high portability. They are completely non-invasive and present the advantage to keep in comfort the individual wearing them. Moreover, most of them are wireless, within a range of some meters, and allow the individual to a wider movement freedom in the experimental environment. BCI devices allow to collect different brain frequencies, grouped in rhythms reflecting the frequency range they belong. Following literature [2, 3], alpha waves (7–14 Hz) are associated with meditation, relaxation, contemplation; beta rhythms (14–30 Hz) are related to attention, active thinking, concentration; the delta band (3–7 Hz), have been registered in children and associated with continuous attention activity, as in [4]; the theta rhythm (4–7 Hz) is generally related to emotional engagement [5]; the gamma signal (30–80 Hz) are usually related to the cognitive interpretation of multi-sensory

signals. Thanks to the possibility to collect the brain rhythms described above, BCIs allow to investigate the mechanisms of learning, memory and attention, isolating reactions to specific stimuli. Due to their flexibility, BCI devices have been widely used in research to register the response to musical and visual stimuli and recognize the emotional valence [6–10] but also to reveal the mechanism of visual creativity [11]. The aim of past and current researches is to evaluate the emotive and cognitive response to stimuli, in order to understand what are the mechanisms that trigger these processes or characterizes them in terms of brain rhythms. The headsets have also been used in some experiments aiming at evaluating the response to colors [12, 13], to stereoscopy and monoscopy [14] and also the cognitive response to visual-perceptive stimuli [15], based on the concept of priming [16–18].

Currently, the research focuses on the comprehension of the cognitive mechanisms at the basis of learning, emotional intelligence, and expression. Considering the potentiality of these technological, cognitive tools we evidently have the possibility to verify, as Vygotskij stated [19, 20], how the human ontogeny is strongly influenced by cultural tools available in this historical and social context and, at the same time, how to adopt such technologies to empower learning skills.

21.2 A Technological Model Based on Priming

In their research, Vygotskij [19, 20] and Piaget [21, 22] underlined how the interaction between objects and subjects stimulates the constitution of superior psychic processes, as well as how the cognitive evaluation is subjective because it is also influenced by social factors and the cultural context of each individual. They stressed how this process can influence education and their thought can be easily applied also to advanced technology. Indeed, e-learning, being based on computer fruition, is particularly suited for studying activities performed by individuals experiencing LDs. In this context, the potentiality provided by new cognitive tools could have a strong impact on this individual learning empowerment. Starting from this consideration, we state that observation of the brain in action jointly with consolidated teaching methods and technological devices could allow to design effective learning environments to overcome learning difficulties, especially if considering priming techniques.

Priming is an automatic cognitive mechanism according to which the exposition to a certain kind of stimulus can modify the response to a subsequent stimulus. Priming refers to an increased sensitivity to certain stimuli based on information previously stored. This is considered an unconscious phenomenon. When exposed to a stimulus, this may influence the response to a subsequent stimulus thus generating a priming effect based on implicit memory. It can occur following perceptual, semantic, or conceptual stimulus repetition. This way, our brains keep track of what we encounter in order to interact efficiently with the world around us.

Some studies [23, 24] recorded event-related potentials (ERP) during semantic priming tasks with pairs of words. The results showed that evoked potentials have a late component called N400, which was significantly related to semantic anomalies.

It seems that N400 priming effect is produced by processes that are involved in integrating semantic information into context. The easier it is for new information to be incorporated into immediate context, the smaller is the amplitude of the N400 component [25]. Automatic and controlled semantic priming are critical for changes in activation of distinct parts of anterior cingulate cortex (ACC). Putamen and hippocampus both react differently to semantically related and unrelated words. Matsumuto, Haneda, Okada and Sadato [26] found changes in the anterior cingulate cortex, and also, changes in various regions of temporal cortex and inferior frontal cortex activity. Decreased activity was usually observed for semantically related pairs of words.

Despite in literature scholars have widely dealt with this phenomenon, still few experiments analyze the effects of priming in learning and their neural correlates. We hypothesized that the learners, which received a semantic priming, would show behavioral patterns faster than those who do not receive the same stimulus, and that the priming effect would result in a lower general cognitive load correlated to a lower engagement of anterior cortical areas, saving, in this way, the ability to keep concentrate during a learning session. Hence, a possible learning environment specifically designed for LDs and based on the priming concept and on the use of BCIs, has been proposed.

Our research addresses the following question:

– Is it possible to improve learning abilities using new cognitive technologies, such as, for example, priming-based systems and brain–computer interfaces?

A key challenge in this scenario is to identify science-based methodological frameworks and validate new tools, methods, and teaching paths suitable to grant more effectiveness, in order to assess the impact of tools aimed at strengthening cognitive learning abilities [12, 13].

21.2.1 Priming and E-Learning Platform as Triggers for Self-repairing LDs

In order to develop a first concept of an e-learning platform based on priming, from 2012 to 2016, several workshops were made in primary and secondary schools.

We involved about 500 students and more than 50 teachers and educators in about 200 h of stages and laboratories working on “Augmented Didactics” [27, 28] in order to design new learning tools and techniques, able to engage all students in defining a “self-learning process”.

These workshops were driven by the following aims [29]:

– Help all students succeed through customized learning;
– Meet the demand for new technology, especially Wi-fi and tablet, in student-centric classrooms;

– Help students get ahead, not only using digital technologies (mobile devices, APPs, and e-learning platforms) but also using their social attitudes: collaboration, sharing, and trust.

Since consolidated studies in neuroscience [30] reveal the way we learn does not always match up with the way we are taught, especially when we consider learning disorders [31], we started working on the following questions: if each of us learns differently (in terms of: pace, style, speed) why do we have to use a single teaching program and a single evaluation method? What kind of stimuli do we have to use for engaging students' curiosity? How can we make learning an experience that everyone wants to repeat?

During the first set of workshops, we started proposing to teachers and students a range of topics and issues without a precise pre-established order: complexity, change, digital technologies, evolution, collaboration, and conflicts were the first stimuli we primed in these school eco-systems.

This had the advantage of stimulating exploration, investigation, and learning, in order to placate the impulse to collect information from the environment to interact with it. Each learner chose different digital media, designed different solutions, provided different deliverables, working alone or in team, and then they shared results with others. All girls and boys involved were attentive, engaged, and focused on the same subject. [27].

A second set of workshops was based on purpose and methods of evaluation process.

Traditional evaluation models are based on getting good performances, where "good" means "based on a unique standard scale". The focus on competence assessment rather than the discipline cuts off the desire to experience new things, to learn and to evolve, especially in students with LDs.

Leaving evaluation standards, we returned the responsibility for personal and professional growth to learners, giving them the choice of timing, steps and ways to learn [27] and [28].

During our workshops, we never used standard evaluation criteria, and this has unleashed in the students a sort of self-evaluation and self-repair process. During our laboratories, students with specific learning problems were able to completely customize the experience of learning and did not show any substantial difference in the attainment of a knowledge or a competence.

21.3 Methods

We developed a prototype of an e-learning platform implementing priming stimuli, accessed by students while wearing a BCI device. Our aim was to collect and then analyze the registered rhythms, as we hypothesized that during tasks primed by semantic-related cues beta and gamma frequency bands will show a lower activation with respect to non-primed ones.

21.3.1 The Experimental Platform

The platform prototype has been developed using HTML5 and php. In this phase, it has been only used in order to present the three experimental tasks described above. Moreover, it has been designed according to the general final structure, with the aim to test it in a future development direction. Indeed, the e-learning environment, we will develop in a future step of this research, will be designed to consider the results collected in this phase.

Also, the 15 principles related to dyslexia-friendly test and several principles related to website design have been implemented [32], such as a clear presentation of the text, avoiding the use of italics and capitalization, justification, abbreviations and long periods, improve the readability of a web page both for dyslexics, as expected, and for non-dyslexics as well. Also, background colors have been chosen carefully, avoiding excessive contrast or brightness and the presence of images behind the text. Currently, the web pages are not designed to be compatible with screen reader technology, as needed by dyslexics using text-to-speech tools, but we aim to implement this feature in a future step.

The current version of the e-learning environment is composed by a main page (home), where a student can access to the registration form, also taking a preliminary test aiming at evaluating his/her preferred learning style. On the registration form, the student is also asked to describe his/her learning difficulties. In this phase, this part is not presented to the user, because it will be included in the final version of the website since it is not functional to this study. The same is for other features of the platform, such as "choose the subject", "improve your skill", "help", "contact" that will be working on the final version. On the main page also a "login" button will be present, allowing registered users to access to their personal profile page, where they can control their learning and personal skills progress.

In our study, the platform has been used to present to the participants the task described in the following paragraph devoted to the procedure that will be part of the section "improve your skills" in the final version of the e-learning environment.

21.3.2 The Experimental Procedure

Three conditions have been implemented and a Neurosky Mindwave B.C.I. device was used to collect frontal EEG data. The Neurosky Mindwave B.C.I. device mounts a single dry sensor located in the frontal area of the scalp (that is enough for our aims), and it collects all the EEG rhythms listed in the previous paragraphs. It is connected to a personal computer through a Bluetooth connection.

We designed three tasks: the first and the second were inspired by literature in order to confirm the semantic priming effects using a not yet used technology (Neurosky Mindwave). The third one, due to its complexity, was planned on purpose to evaluate if semantic priming can actually be considered as a method to enhance some cognitive

performances. In all tasks, a group received related primes and a group received unrelated primes before a stimulus target, which varies according to the task. A group did not receive any prime.

Task 1 (Letter): participants were asked to read the stimulus shown on the computer monitor in front of them in order to accomplish a delayed letter-search task [33]. The sequence of the stimulus is the following: fixation cross (1800 ms), prime word (110 ms), blank screen (850 ms), target word (110 ms), one letter (250 ms), and a fixation cross until the subject answer. During the last fixation cross, the subjects had to report if the letter was part of the last word they saw.
Task 2 (Word Recognition): participants were asked to read the stimulus displayed on the monitor in front of them, to perform a word recognition task. Subjects had to spot if the target stimulus was an actual real world (i.e., existing in Italian vocabulary) or a fake word. The sequence of the stimulus is the following: fixation cross (1800 ms), prime word (110 ms), blank screen (850 ms), target word (300 ms), and fixation cross until the subject responds.
Task 3 (Definition): This last exercise brings a higher level of difficulty than the experiments that are usually proposed in literature and because of this it is useful to evaluate if semantic priming can be considered as a good way to improve cognitive performances of subjects.

Subjects were asked to spot the name of an object that was described by a definition taken from the Italian dictionary. Before the definition, the subjects of the prime-related group saw a list of words, most of which were semantically related to the definition, while the prime-unrelated group received semantically extraneous words. The sequence of the stimulus is the following: fixation cross (1800 ms); a list of words, shown one by one (each one for 1500 ms); pop-up window containing the description of the object and the prompt box to be filled by the subject.

Each condition had 50 trials. Each subject underwent the three experimental conditions in three different sessions (randomly sequenced). In the following sections, we will refer to "related group" intending the subjects who received words semantically related to the stimulus target.

21.3.3 Participants in the Experiment

Twenty-eight right-handed volunteers (age range 18–29) with normal or corrected to normal visual acuity and without neurological illness, but with certified learning disabilities participated in the study. We focused on disorders related to text reading (dyslexia).

21.4 Results and Discussion

The outcomes were promising since we found significant differences in all conditions.

The first task consisted in Letter recognition. In this test, the related group reported an average reaction time (RT) of 1.51 s while the other two groups (unrelated prime and no-prime) reacted slower (respectively, 1.82 s and the 1.81 s).

In Word recognition, the related-group RTs had an average of 1.29 s versus 1.56 and 1.55 of the other groups.

In the third task (Definition), the prime-group answers took an average of 6.51 s to respond, versus 7.71 and 7.95 of other two groups.

In addition, looking at the correctness of the answers (accuracy), subjects in the related group gave more corrected answers than the others. In particular, for the Letter task accuracy was 94% for related, 91 and 93% for no-prime. For the Word task, the accuracy was 92% for related, 81% for unrelated, and 84% for no-prime. Finally, for the Definition task, the accuracy was 90% for related, 82% for unrelated, and 81% for no-prime. This first analysis suggests that the priming effect has an important role, not just in speeding up, but also in optimizing the responses to a specific task.

We also used the MATLAB's tool EEGLab to analyze EEG correlates of behavior resulting from the data recorded by the B.C.I. Following our hypotheses, primed participants reported a less average activation of Gamma rhythms, registered immediately before and after the onset of the stimulus. As expected, the EEG data showed that in the frontal area the priming effect appears to be correlated to a reduced activity, consequently revealing a cognitive discharge (see Fig. 21.1).

In particular, focusing on the third task the gamma, the power decrease in the related group, and this effect may suggest a focused activation due to the activation

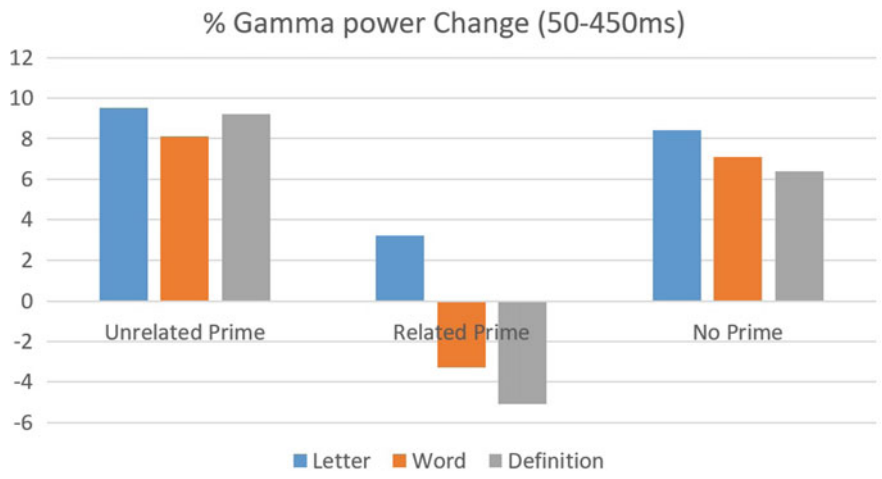

Fig. 21.1 Priming effect detected by the analysis of Gamma rhythm power

of a related semantic representation and the automatic spreading activation, which accompanies priming stimuli.

The gamma power difference at the single-front electrode may reflect local networks in this area thought to be involved in top-down semantic processing. Gamma frequencies are thought to transiently bind together cell assemblies [34–36] and work on a more local scale [37]; thus, they are a likely mechanism for dynamically forming local networks involved in semantic processing. It is possible that priming has the role of stimulating the semantic representations which are used to perform a semantic task, before the presentation of the task itself. This way, when individuals have to give an answer, their brain needs less effort than those who do not receive any prime.

The obtained results suggest that education material including priming stimuli effectively modulates the cognitive load of participants during specific tasks implying the working memory functioning. Though, we have not data directly indicating an increase in learning performance it is well known that a major problem for dyslexics is working memory functioning, with a negative impact on learning when it is overloaded [34]. Consequently, a strategy aimed at reducing cognitive load during reading and studying might have a positive effect for dyslexics, especially in demanding tasks. Furthermore, this strategy might be helpful also to approach learning activities that implies much information to be learned in a short time for all students.

In our experiment, we used a BCI device to collect EEG data, but this device might also be used to assess the cognitive load providing specific feedback when excessive, less-functional level of cortical activity is reached. This latter use of a BCI might be a valid self-assessment tool for learners, to improve their own learning skills. We believe, indeed, that a systematic use of BCI devices will foster the implementation of cognitive-driven education and enhancement programs. Additionally, other experiments could concern EEG response from dyslexic people, including not only semantic, but also visual, textual, and audio stimuli. This comes from our previous works, in which we have already analyzed EEG signals, collected by BCI devices to investigate the response of users to sounds and music [8, 9], to visual stimuli [15], to video [14], and the engagement of cognitive and memory processes in learning [12]. As an example, in neuroscience studies, a considerable interest is devoted to the cognitive empowerment obtained thanks to music learning [12, 20, 38] suggests that a cognitive-driven design of the artificial illumination and of colors used in working and didactic materials should strongly improve learning performance. This might be particularly important in case of learning disorders, allowing to use colors and illumination priming to further improvements in the learning process.

21.5 Conclusion and Further Developments

In order to produce a prototype of a technological and cognitive platform oriented to LDs (TCLD) able to fulfil the above-stated requirements, we have experimented methods and tools from the fields of Psychology, Pedagogy, and Cognitive Sciences,

using new technologies of brain imaging that allow the cognitive impact on the individual to be assessed [32].

As a starting point, we have developed a prototype of a cognitive technology-based platform, including some semantic priming stimuli, and we experimented it on individuals with LDs disorders in the University learning environment.

Our study outcomes replicated the results of a previous study on subject without reading problems [39], showing that the semantic priming is effective in helping individuals in reinforcing their learning abilities and, also, that BCI devices represent an important feedback tool allowing learners to regulate their workload and, as a consequence, their effectiveness in learning. Differently by the previous experiment, we did not find any effect of the priming on beta modulation, but only on Gamma. If replicated in future studies, this datum could suggest that BCI-driven intervention for dyslexics could target higher EEG frequency ranges.

The obtained results allow us to argue that the use of priming and BCI tools could be useful within a pedagogical program in order to contribute improving users' ability to focus attention on abstract cognitive tasks and in translating abstract thinking in concrete operations. Furthermore, the use of BCI regulates attention levels, improves the ability to stay focused and keep attention on mental tasks and may contribute to the development of multitasking abilities, now considered particularly important in different contexts. BCI-based tools, differently from other techniques or method to improve attention and concentration requiring specific skills, may be enjoyed by everyone, without any prerequisite both in stand-alone and in group settings.

Our future aim consists in improving our research, introducing feedback mechanisms and more priming stimuli, such as those based on colors and sounds. The presented study is innovative insofar because it promotes cross-fertilization among several disciplines and in the joint use of EEG-based brain imaging technologies, allowing us to observe learners' cerebral reaction to educational stimuli and methods within a web-based e-learning platform. This approach represents an innovation not only in education, but especially in the perspective of future job placement of LD-affected people, who can acquire skills useful to improve their productivity as socially well-introduced members of society. This is a vital outcome for children and youth worldwide because the number of LD students is dramatically increasing.

The spread of mobile technologies and online communities means that digital natives communicate in a very different way from ours and they required customized paces, times, and ways to maintain a high involvement in culture and knowledge evolution. It is necessary to create different styles and levels of communication between teachers, students, and parents: they are a real community, and social networks are their "augmented place" to share, spread, and imitate.

A new e-learning platform based on augmented formats gives us a possible way to highlight talents, skills, and attitudes that often remain latent, because levelled in a unique model.

New technologies allow teachers to broaden the field of observation and evaluation of learners. Through digital data collected in social profiles teachers can verify the evolution of talent and the peculiarities of each "young person". They can open the diaphragm to focus on individual learning solutions and progress.

Opening new channels of expression, girls and boys with specific learning disorders have definitely excelled in making original solutions, showing their skills in unconventional disciplines. It is therefore important to consider that through new technologies, they will be able to learn with passion, selecting by themselves channels and alternative methods of communication.

We have a great opportunity to join forces to improve the educational system and cultural development of future generations, based on cooperation, reciprocity, fairness, and transparency, focusing continuous improvement of the process of learning and cultural evolution of our whole society.

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Chapter 22
The Structured Methodological Framework "Deejay": Foundation and Its Application to the Design of an ASD-Oriented AAC Tool

Tania Di Mascio and Laura Tarantino

Abstract The growing diffusion of ICT-based innovative learning tools raises the need for methodological approaches able to effectively guide the activities of interdisciplinary R&D teams. This problem is often underlined in the literature related to the exploitation of ICT for training people with autism spectrum disorder (ASD): Despite consolidated agreement on general design principles, studies in this field may suffer from the gap between ASD researchers on the one side and computer scientists on the other side, and the need for more structured approached is often advocated. In this paper, we give a contribution in this direction by introducing *deejay*, an action-research-based methodological approach oriented to interdisciplinary R&D projects, stemming from our experiences in projects aimed at designing learning tools oriented to children with cognitive disabilities. The paper discusses the general features of *deejay* and its application in a project aimed at designing an ICT-based augmentative and alternative communication (AAC) tool specifically designed for ASD treatment.

22.1 Introduction

Autism spectrum disorders (ASDs) are characterized by restricted, repetitive, and stereotyped behavior and core deficits in social communication and interaction, which severely interfere with the process of building relationships, functioning occupationally, and integrating and participating into community [1]. Starting from Colby's theoretical premises [2], information and communication technology (ICT) tools have been initially adopted in the ASD field primarily with education purposes, showing a greater ability in engaging ASD people compared to more traditional, non-ICT-based, teaching intervention (see, e.g., Pennington [3]). The positive results encouraged the exploitation of ICT for communication and speech therapy

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aspects (see, e.g., Porayska Pomsta et al. [4]), which led to a number of commercially available communication-oriented tools. In the last decade, research has explored a variety of ICT-based approaches to ASD treatment related to social issues as assistive technologies, as cognitive rehabilitation tools, and as special education tool bypassing ASD impairments, to help children to acquire social and academic skills [5–7]. Despite limitations of the proposed tools (typically evaluated on small samples of users [5]), domain experts generally agree on the potential of ICT in learning of emotional competencies and social skills in individuals with ASD.

It has to be observed that—as in other learning-oriented applications—the adoption of innovative technology does not only bring improvements to existing approaches but also allows domain experts to conceive innovative solutions not possible otherwise. Researchers agree on the fact that engaging the perceived beneficiaries in the design process potentially facilitates social acceptability of the designed product (e.g., Parsons and Cobb [8]) and that therefore the design process has to be based on the co-construction of knowledge by a variety of stakeholders who highlight the different contextual factors involved: Psychologists, educators, computer scientists, parents, caregivers, and ASD people (often children) should all be involved with different roles in the design process, to achieve successful technology design (see, e.g., Brosnan et al. [9]).

Though integrating research within real-world practices is mandatory for developing evidence-based therapeutic and educational interventions [10], such integration is not without challenges. Bozgeyikli et al. [11] and Brosnan et al. [9] discuss the gap between ASD researchers and computer scientists, who may have not only different working approaches but also different expectations on what the design outcome should be. Milton in [12, 13] highlights that while all stakeholders generally wish to contribute to design ideas and to provide feedback about relevance and usability, not all of them like to be responsible for definitive design decisions. Although recent literature on ICT-based ASD treatment actually reports on a significant number of experiences based on participatory design (see, e.g., Brosnan et al. [9]), the main endeavors have been so far in the engagement of the autistic community (ASD people and caregivers) with less concern for harmonization of the different professionals involved in the multidisciplinary design process. The lack of clear methodological approaches is viewed as a crucial issue by many researchers: [4] observes that one of the challenges in developing ICT tools for ASD people is to coordinate the diverse and divergent perspectives of the involved stakeholders, [11] underlines the need for more structured approaches and well-established guidelines for design, [10] underlines the necessity of a partnership model between the autistic community and researchers, and [14] observes that partnership with stakeholders requires a rethinking of how research is designed.

Actually, the ASD case may benefit from results achieved in similar fields since it is one specific example of application domains where multidisciplinary teams have to conceive, implement, and validate novel learning methods within the framework of research and development (R&D) projects with given budget, time, and organizational constraints. In this paper, we aim at contributing to the above-discussed methodological issues by proposing a structured iterative approach based on action

research (AR), which—by its very nature—is based on the integration of research and practice and committed to the production of scholarly knowledge while addressing specific real-world problems [15, 16]. In particular, in Sect. 22.2, we introduce the structured methodological framework denoted "*deejay*" (deriving from our AR experiences in learning-oriented R&D projects), aimed at providing a general guideline for organizing the activities of a multidisciplinary team, specifying roles and responsibilities of involved actors. In Sect. 22.3, we discuss how the approach is successfully being used for an ongoing project aimed at developing a personalizable ASD-oriented augmentative and alternative communication (AAC) tool [17, 18] and carried out by a multidisciplinary university laboratory including computer scientists and psychologists, in cooperation with a regional center of autism including medical doctors, psychologists, families, and caregivers. Finally, in Sect. 22.4, conclusions are drawn.

22.2 The Methodological Framework "Deejay"

In this section, we present the main ingredients of the proposed methodological framework, starting with its roots in action research and following the experimental steps that led us to its definition.

22.2.1 Introduction to Action Research

Action research (AR) seems to provide an appropriate answer to the demands outlined in the Introduction, for its juxtaposition of action (practice) and research (theory), its iterative nature, and its commitment to the production of new knowledge through the seeking of solutions or improvements to "real-life" practical problem situations and interventions in ecologically valid contexts [15, 16]. Differently from other SW development methods, AR is motivated by scientific prospects and committed to production of scholarly knowledge along with the solution of a specific problem at hand [15].

AR is performed collaboratively by researchers and an organizational "client," under the principle that social processes can be studied best by introducing changes into the processes and observing the effects of the changes, within the framework of a cyclical process repeated until a satisfactory outcome is achieved [15, 16]. According to the view in [19], after the establishment of a research–client agreement (establishing focus, boundaries, and objectives of the project, defining roles and responsibilities of the participants, selecting data collection, analysis methods, and measures to evaluate the results), five phases are iterated (Fig. 22.1a): *Diagnosis* corresponds to the identification of primary problems causing the organization's desire for change and develops a theoretical framework to guide the process; *action planning* specifies actions that, guided by the theoretical framework, should relieve

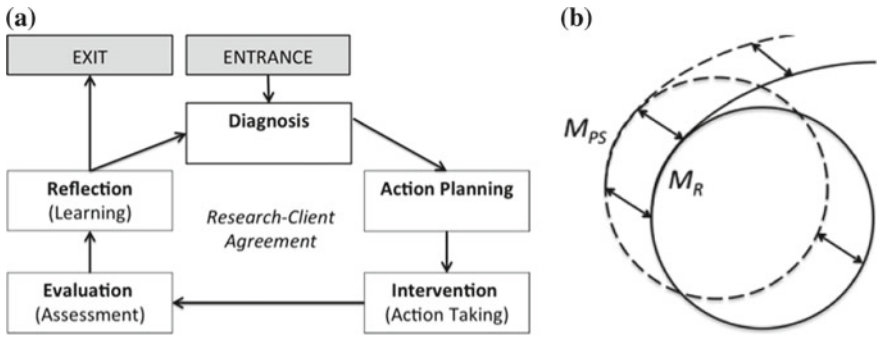

Fig. 22.1 Models for AR processes: **a** the cyclical process model by Susman and Evered [19] and **b** the tandem model [20]

the organizational problem; *action taking* implements the planned action; *evaluation* determines whether the effects of the action were realized and produced the desired results; *learning* formalizes the knowledge gained by the process with respect to the problem situation and the scientific community.

To enforce the AR mission of production of scholarly knowledge, [20] proposed a model including two cycles running in tandem (Fig. 22.1b): One cycle addresses the client's problem-solving interest, while the other one addresses the researcher's scholarly interest. Two methods are hence used: M_R is action research itself used to investigate on a real-world problem situation A, while MPS is the method adopted for the problem solving of a real-world example of A (see Table 22.1).

Anyhow, though aimed at overcoming the lack of direct guidance on "how-to-do" AR, the work in [20] still leaves to researchers the burden of structuring the AR process. To overcome this lack, we here propose a structured framework deriving from our AR experiences in learning-oriented R&D projects. Our framework blends the Susman and Evered cyclical process model and the tandem approach and provides an additional level of detail about the design of the overall process (in terms of time scheduling, information exchange, actors involved), in the tricky case in which the outcome of the research cycle is the problem-solving method of the real-world problem (a common situation in learning-oriented R&D projects).

Table 22.1 Elements of an AR intervention according to McKay and Marshall [20]

A	A real-world problem situation
P	A real-world example of A allowing the researcher to investigate A
F	A theoretical premise declared by the researcher prior to any intervention in A
M_R	The research method
M_{PS}	The method (M) which is employed to guide the problem solving (PS) intervention

22.2.2 The "Deejay" Framework

Our first occasion for experiencing AR methods was the European FP7-ICT multidisciplinary project TERENCE, aimed at developing an adaptive learning system for supporting 7–11-year-old poor text comprehenders and their educators [21]. We followed a canonical AR approach [16] blended with the tandem view [20], following the Susman and Evered cyclical process model for individual cycles of the tandem, with the multifaceted objective of (i) generating/testing a new children-oriented data gathering technique, (ii) solving the immediate problem (i.e., defining users' classes and personas), and (iii) translating the experience into scholarly knowledge [22]. Post-project reflections on the experience allowed us to derive meta-results related to the relationships between the two cycles of a tandem-based AR project in which the outcome of the research cycle is the problem-solving method of the immediate problem and led to a first definition of the "deejay" framework.

The framework is based on the regular structure in Fig. 22.2 that rules time scheduling (what happens before/while what) and exchange of information to steer the relationships between the two cycles and the actors involved (activities on the problem-solving side on the left are tagged "PS", while activities on the research side on the right are tagged "R"). Specifically:

- **Diagnosis$_{PS}$** is the first to start and informs activities in **Diagnosis$_{R}$**, which, among others, has to single out, survey, and assess relevant literature with respect to the problem to solve. Objectives and research questions are singled out/refined in these stages. Notice that often the **Diagnosis** stages of the first iteration actually start even before the official entrance in the AR process, since they include the preliminary analysis of the organization situation that leads to the AR project.
- **Action planning$_{R}$** refers to planning/designing the research project so to adequately address research questions, validate hypothesis, and *guide the overall process*. It is hence particularly crucial in the first iteration, since decisions in that stage may impact on the whole process (though corrections based on the evaluation outcomes will be clearly always possible due to the iterative nature of the process).
- **Action planning$_{PS}$** refers to planning problem-solving activities for the specific problem at hand (in the TERENCE case: designing/refining games).
- **Action Taking$_{R}$** refers to design/refinement of the problem-solving method and must start before the method is used within **Action planning$_{PS}$** for planning activities that will be carried on during **Action Taking$_{PS}$**: Once the method (or intermediate versions of it) is available, the team (client and researchers) can start to use it, while action researchers monitor in **Action Taking $_{R}$** executions of activities.
- For **Evaluation/Learning$_{PS}$** and **Evaluation/Learning$_{R}$**, we have the same kind of relationships observed for the diagnosis stages: The team (1) evaluates effects of actions on the problem and effects of intervention in terms of research questions, so to determine if the results are satisfactory and then exit, or, otherwise, to single out issues to be addressed in the next iteration, where previous results are amended,

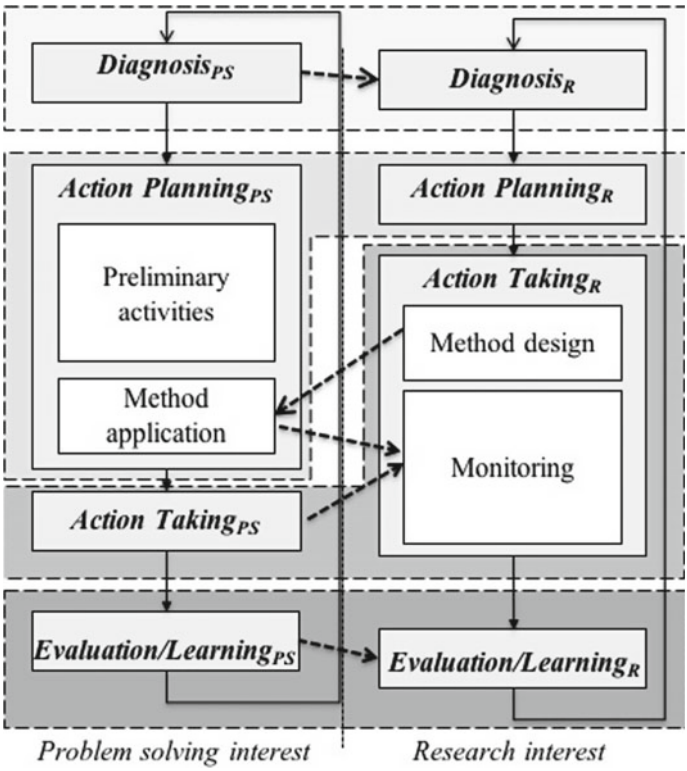

Fig. 22.2 The "deejay" view for a structured tandem-based AR process. The name *deejay* comes from the regular shapes of the dashed meta-blocks of diagnosis, action planning, and action taking, resembling respectively a *domino (d),* and two different rotations of a *j tetramino* (Dominoes and tetraminoes are specific examples of polyominoes, i.e., plane geometric figures formed by joining one or more equal squared blocks edge to edge, as defined in [23].). The schema highlights activities and relationships between the two cycles in terms of time scheduling (vertical arrangements) and information exchanged (dashed arrows) among the various stages of the problem-solving cycle (on the left) and the research cycle (on the right)

and (2) reflects on gained knowledge at the immediate problem level and on the generalization of its solution according to the research questions.

Successive applications of "deejay" in learning-oriented R&D projects confirmed the regularity of activities observed in TERENCE and allowed us to single out additional regularities related to client/professional actors engaged in the project activities. In particular, while the composition of the client is project-specific, the panel of experts has a predefined structure including *action researchers*, *computer scientists* (typically both *designers* and *developers*), and *domain experts,* with specific responsibilities in the various activities of the AR project. We illustrate involvement and responsibilities in the following section by a case study related to the application of "deejay" to an ongoing project aimed at the design of an ASD-oriented

communication tool to support nonverbal people in the communication of needs. While for the analytical description of the project we refer to Di Mascio et al. [17], we focus here on the discussion of methodological issues related to the application of "deejay."

22.3 Applying "Deejay" to the Development of an AAC Tool

Children with ASD suffer from impairments in early-developing social abilities that are considered precursor to language development, and, as a consequence, they have significantly delayed language [24]. Studies report that between 25% and 50% of ASD individuals never acquire functional language, though early diagnosis and interventions may make this estimate decrease [24–27]. A number of applications and tools have been proposed to support high-tech aided augmentative and alternative communication (AAC), a term embracing tools and strategies that an individual with speech/language impairments can use to supplement or replace speech or writing[1] [18, 25]. The efficacy of AAC methods based on visual cues (see, e.g., Grandin [28]) along with the availability of low-cost interactive devices (such as tablet and smartphone) which proved to be effective technological aids for ASD individuals [29–31], fosters the investigation on ICT-based AAC tools specifically designed for ASD treatment.

Our ongoing project goes in this direction, starting from an initial request of consultancy that the Abruzzo Regional Reference Center for Autism (CRRA) asked to the multidisciplinary laboratory TetaLab,[2] related to the development of ad hoc AAC visual tools to support two specific nonverbal low-functioning ASD individuals in the age range 18–22.[3] Starting from this request, the analysis of the organization situation began (as noted in Sect. 22.2, it coincides with the **Diagnosis** of the first iteration).

[1] AAC systems are defined 'unaided' or 'aided' depending on whether they do not or do require an external tool, and, in turn, aided AAC systems are classified as 'low-tech' or 'high-tech', depending on whether they do not or do utilize electronic devices.

[2] Technology-Enhanced Treatment for Autism Laboratory, a multidisciplinary laboratory of the University of L'Aquila, based on the cooperation among the Dept. of Information Engineering, Computer Science and Mathematics, the Dept. of Applied Clinical Sciences & Biotechnology, and the Center for Autism of the University of L'Aquila.

[3] The ASD diagnosis was provided by experienced clinicians according to the new criteria of the DSM-5 [1]. ASD diagnosis was confirmed using the Autism Diagnostic Observation Schedule, Second Edition [31]. Verbal mental age was assessed with the Test for Reception of Grammar, Version 2 [32, 33].

22.3.1 The Organization Situation and the RC Agreement

The context analysis carried out jointly by TetaLab researchers and CRRA people led to the choice of shifting the focus from the idea of ad hoc tools to a more effective advanced high-tech interactive tool customizable toward any possible ASD individual, including a front end for the ASD person and a backend for the professional caregiver (generically denoted as operator) responsible for the front-end customization. A solution of this kind allows operators to log and analyze the usage of the tool by the ASD nonverbal person, to be guided in an incremental personalization.

Requirements were elicited with CRRA people, and selected commercial AAC tools conceived for nonverbal people (among which Niki Talk, Immaginario, IoParlo, Proloquo2Go, AAC Talking Tabs, and Blu(e)[4]) were assessed against requirements. It came out that none of the available commercial tools met all requirements and that the tools—not conceived for ASD—are too difficult to use by individuals with low-functioning autism, characterized by severe impairments in cognitive functioning and verbal communication, and in some cases also by medium-functioning autism, characterized by echolalic language and reduced or absent social reciprocity. Furthermore, these tools are aimed at supporting the development of a structured language, while *in severe ASD cases the primary goal is to support basic communication of needs and feelings independently from a formal language*. It was also noted that in ASD treatment it is necessary to aid also professional caregivers (e.g., medical doctors, psychologists, and rehabilitation technicians) responsible for the treatment: Continuous assessment, monitoring, and dynamic reconfiguration of the tool have to be supported.

These considerations led to the decision to launch a deejay-based R&D project with the features of Table 22.2, based on a **Research–Client Agreement** between CRRA (client) and TetaLab. The working team is composed of two panels: the CRAA panel, including one medical doctor (MED), ASD operators (OP), and families (FAM), and a panel of experts including domain experts (DOM) from the TetaLab team [two psychologists, two action researchers/designers (AR) with background in

Table 22.2 Elements of the "deejay" intervention (instantiation of Table 22.1)

A	Issues/challenges in supporting operators for communication with ASD nonverbal people
P	Setting up a personalized AAC tool of specific ASD nonverbal persons
F	Aided high-tech personalizable AAC tools may improve the efficiency of operators' work
M_R	Action research
M_{PS}	The new multisensorial AAC model

[4]Official sites of the reviewed tools (last accessed 2019/02/21): http://www.nikitalk.com/; http://www.fingertalks.it/immaginario/; https://itunes.apple.com/it/app/ioparlo/id406247136; http://www.assistiveware.com/product/proloquo2go; http://www.aactalkingtabs.com/ T6: http://www.tabletautismo.it/.

computer science and HCI, and a SW developer (DEV)]. The project has three milestones: (M1) a backend with customization functionality, (M2) personalized front end with logging capability, and (M3) backend with monitoring functionality. The discussion in this paper is related to milestone M1, focused on operators' needs and expectations.

22.3.2 The Cyclical Process

So far, the cyclical process related to M1 required three iterations, respectively focused on (1) assessment of main features of the ASD person's front end, (2) trial, and (3) assessment of operator's customization backend. The process is shaped according to the "deejay" schema in Fig. 22.2, where "method design" is to be intended as "*visual AAC model definition,*" and "method application" as "*model instantiation.*"

Process Overview As observed in Sect. 22.2.2 the Action Planning$_R$ stage of the first iteration has the crucial role of designing the overall project. It was decided to model the whole process as the iterative alternation of concrete and abstract levels (Fig. 22.3): The first step is the creation of a low-fidelity prototype of a front end conceived for one specific ASD nonverbal person, to allow an expert-based evaluation of the guiding ideas (first iteration); results from this evaluation would be the basis for generalizing the specific example, leading to the definition of an AAC model and the implementation of a corresponding backend (to be done in Action Taking$_R$ of the second iteration); once the model and the backend are available, they can be used by CRAA operators on the problem-solving side, respectively, in Action Planning$_{\backslash PS}$ and Action Taking$_{PS}$ of the second iteration, to conceptualize the personalized AAC environment (model instantiation) and setting it up by the backend; then, results from the EVALUATION/LEARNING stages would guide the next iteration aimed at refining the model and the prototype; the process is iterated until results are satisfactory. Summarizing:

- The *first iteration* was aimed at designing, building, and evaluating a simple low-fidelity front end conceived for one specific ASD person (one of the two persons of the study, a 22-year-old nonverbal female). The EVALUATION/LEARNING stages then assessed the mockup and refined requirements.

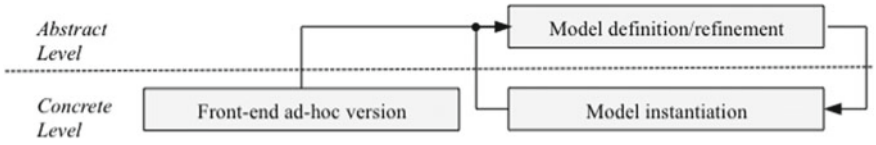

Fig. 22.3 Iterative alternation of design focuses

Table 22.3 Involvement of actors in the "deejay" stages and substages

Problem-solving side			Research side		
Phases		Involved people	Involved people		Phases
Diagnosis_{PS}		$\text{Client}_{\_MED,OP,FAM}$ $\text{Expert}_{\_AR,DOM}$	$\text{Expert}_{\_AR,DOM,DEV}$		Diagnosis_{R}
$\text{Action Planning}_{PS}$	PA	$\text{Client}_{\_MED,OP,FAM}$ $\text{Expert}_{\_AR,DOM}$	$\text{Expert}_{\_AR,DOM}$		$\text{Action Planning}_{R}$
	MA	$\text{Client}_{\_MED,OP,FAM}$ $\text{Expert}_{\_AR,DOM}$			
$\text{Action Taking}_{PS}$		$\text{Client}_{\_OP}$ $\text{Expert}_{\_AR,DOM}$	$\text{Expert}_{\_AR,DOM,DEV}$	MD	Action Taking_{R}
			$\text{Expert}_{\_AR}$	Mon	
$\text{Evaluation/ Learning}_{PS}$		$\text{Client}_{\_MED,OP,FAM}$ $\text{Expert}_{\_AR,DOM}$	$\text{Client}_{\_MED,OP}$ $\text{Expert}_{\_AR,DOM}$		$\text{Evaluation/ Learning}_{R}$

PA preliminary activities, *MA* model application, *MD* model design, *Mon* monitoring, *MED* medical doctor, *OP* operator, *FAM* family member, *AR* action researcher, *DOM* domain expert, *DEV* developer

- The *second iteration* generalized the assessed concrete example and released first prototype for the backend as a responsive Web application. In the EVALUATION/LEARNING, the prototype underwent an expert-based usability evaluation, which highlighted some efficiency drawbacks in the overall procedure needed to customize from scratch a new user front end.
- *The third iteration* refined the model according to the criticism and released a second version of the prototype. In the EVALUATION/LEARNING, the prototype underwent a second expert-based evaluation, which approved all design choices related to the functionalities so far introduced.

Evaluation of the Results The design process was analyzed on two different levels, respectively, related to (1) the actual outcome of the project and (2) the efficacy of the project structure. This stage relied on expert-based evaluation and focus groups with ASD professionals responsible for the configuration of the front end and involved two AR researchers with background in HCI, three psychologists and one medical doctor. As to the first point, results of the EVALUATION/LEARNING stages of the third iteration stated that milestone M1 was achieved. As to second point, the clear attribution of roles and responsibilities to the actors involved in the project was appreciated; this attribution is derived from the general features of the "deejay" framework instantiated for the specific AAC project in Table 22.3.

22.4 Conclusion

In this paper, we introduced the novel AR-based structured methodological framework "deejay" and its application in a case study dealing with the design of an AAC tool for nonverbal people with ASD. The framework offers methodological guidelines for multidisciplinary projects for which AR is appropriate, in the tricky case

in which the outcome of the research cycle is the problem-solving method of the real world. The paper provides a contribution to design issues raised by a number of researchers in the area of ICT-based ASD treatment (generalizable to other e-learning domains), specifically centered on the engagement of stakeholders into the design process and on the harmonization of different professionals (e.g., computer scientists and psychologists) with different views and expectations on both the design process and the design outcomes, leading to the necessity of an overall rethinking of research organization.

Summarizing, "deejay" aims to answer to the following requests: (i) integration with real-world practices, (ii) involvement of stakeholders, (iii) respect of stakeholders' will with respect to design participation, (iv) structured partnership models, and (v) structured design approach, also trying to bridge the gap between different professionals in multidisciplinary projects. The approach blends canonical AR [16] and the tandem approach of [20] and goes one step forward with respect to [20] by providing an additional level of detail about the design of the overall process (in terms of time scheduling, information exchange, and actors involved), in the tricky case in which the outcome of the research cycle is the problem-solving method of the real-world problem (common in learning-oriented projects). Moreover "deejay" proposes a general organization structures for working teams and guidelines for attribution of role and responsibilities of stakeholders and researchers, as illustrated in Table 22.3 (though instantiated for the specific AAC project, the schema is easily generalizable). One may notice the involvement of the client panel into all stages of the problem-solving side (all stakeholders generally wish to contribute to design ideas [12]) and in the EVALUATION/LEARNING phases of both the problem-solving and the research sides (all stakeholders generally wish to feedback about relevance and usability [13]).

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Chapter 23
Creating New Learning Experiences for Students with Dyslexia: A Design Thinking and Human-Centered Approach

Jailma do Socorro Uchôa Bulhões Campos, Alberto Signoretti and Ana Margarida Pisco Almeida

Abstract In the context of special education, teachers may understand that flexibility and variety of teaching strategies are the keys to an effective learning. In many cases, it is necessary to explore different ways to create pluralistic opportunities for students to develop specific skills. In the case of students with dyslexia, it is essential to focus on strategies that help them to get involved in diversified activities and engaged in reading practices, for successful learning. Nevertheless, in the current variety of available activities, there are few standard models' strategies for dyslexic students; in this scenario, it is important to focus on collaborative and individual educational practices that teachers can use to create appropriate learning contexts, namely the ones that appeal to pedagogical strategies for learners' motivation and engagement. Using design thinking and gamification can be an effective path in this domain. It is under this scenario that this study aims at understanding the role of design thinking and gamification in supporting the creation of new learning experiences for students with reading and writing disabilities. A new gamified solution was created using the design thinking method as a tool to understand participants' needs and difficulties, define the problem, ideate to choose the better solution and create prototypes to test and evaluate. Besides reporting on this process, this paper presents the paper-based prototype as an output and discusses the meaningful educational contributions of the whole iterative process of design thinking to the creation of a gamified learning experience.

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23.1 Introduction

Creating new opportunities for learning may be a teaching purpose in the education of students with specific learning difficulties such as dyslexia [1, 2], by specifically appealing to strategies that can motivate and engage students in developing specific skills. Thus, this paper presents the development process of a gamified prototype to support the learning process of students with dyslexia. A design thinking approach was used during this qualitative study in which two students with dyslexia and two teachers have participated.

The study was conducted in Brazilian elementary schools located in the city of Belém/Pará, in 2018, using various research tools, such as interviews, field notes, reading/writing activities, empathy maps and documental reports analysis. A paper-based prototype using a gamified approach was developed, revealing that design thinking is a positive iterative process for centering the development process on the specific needs of both students and teachers. This user-centered approach allowed a better understanding of the learners' reading difficulties and its accommodation in solutions and features of the prototype. Besides summarizing the process of exploring context and learners' difficulties at school, designing, prototyping and testing, this paper also includes a discussion about the advantages of using design thinking as a human-centered, iterative and innovative tool.

23.1.1 Gamification and Learning

Gamification is about using game elements (nor full games) [3] and game thinking. It does not involve necessarily the development of a game: it is more about exploiting the way games are designed and the idea behind games [4] in non-game scenarios [5]. From an educational perspective, gamification approaches have been reported as useful strategies to engage and motivate students and promote learning [6]. A gamification approach can provide learners with a sense of achievement; encourage them to progress through the content; evoke competition, collaboration and sharing to motivate action and also engage in the learning experience [6, 7].

The integration of this strategy in the creation of a new learning experience, and more specifically under the context of special education, means the use of game elements (such as game dynamics or mechanics) aiming to reproduce the same benefits achieved in the act of playing [8].

Gamifying school activities should not be confined to the use of points and badges as representations of conquering. Using gamified strategies can help dyslexic learners to be focused on activities (as reading/writing) and to create new opportunities for building skills [6].

23.1.2 Design Thinking

Design thinking (DT) is an innovative and human-centered approach applied to define solutions in order to solve complex problems [9]. Its nature helps us to focus on students' needs because it is (i) collaborative—that is, DT embraces differences and permits to know others' ideas; (ii) empathic, because it allows us to know the person behind the learner; (iii) innovative, since its process enables a creative approach which can be used to build new solutions [10]; and (iv) human-centered [11], as it involves target users in an attractive way. Design thinking is a nonlinear and iterative process organized in small phases: empathize, define, ideate, prototype and test. These phases are not sequential, but it takes many iterations to get the final product. Hence, the idea is essentially not to follow sequential models, but to allow errors, learn from the failures and iterate in order to take new opportunities to recreate a product [10, 12].

DT represents in education a consistent approach because it is human-centered. It puts the student in the center of the process by matching their needs and expectations. This emphasis on empathy underlines the importance of (i) observing learners' behavior, needs and difficulties in their educational context; (ii) interactive encounters among teachers and students for interviews; and (iii) knowing each other by immersing in learning experiences.

Various studies have been conducted using DT [11, 13] in the educational field. They showcase how this humanistic method was used to identify problems, ideate, design and prototype solutions in different learning scenarios. Design thinking can also be employed with approaches such as gamification. Using DT in gamified products emphasizes the importance of involving learners and bringing them to the center of the design process, which calls for a more profound knowledge of their specificities (what they think, say, do or want), in order to design solutions to overcome their challenges and help them to engage in the process of learning.

23.2 Methods

23.2.1 Study Design

This study follows a qualitative approach: meaning is a central concept [14]. This research does not try to find certainties in the use of gamification strategies to support the reading of dyslexic students, but, instead, it is concerned with understanding the meanings built in the context to be investigated. Besides this qualitative context the main methodological inspiration is design thinking as a research method divided into a number of five regular steps: exploration and immersion, analysis and definition, ideation, prototyping and testing.

23.2.2 Case Selection

A multiple-case approach is being used in this study. Two elementary school students with dyslexia were selected from two Brazilian schools:

Case 01—one student with dyslexia supported by the multifunctional resource room at Francisco Nunes Elementary School;
Case 02—one student with dyslexia supported by the multifunctional resource room at República de Portugal Elementary School.
The two schools are part of the public educational system of Belém, Pará, Brazil.

23.3 Results: Applying Design Thinking to the Development of a Gamified Prototype

This study was conducted in five main phases, adapted according to the research aims, as shown in Fig. 23.1.

Phase 01 started by exploring the learners schooling experiences. During this stage—exploration and immersion—we focused on the learners, with the aim to identify their reading/writing difficulties and to explore the most appropriated educational context of assistance. In order to understand and characterize the students' difficulties, we applied structured interviews with teachers and learners and developed specific reading/writing activities/sessions with the students.

After the exploration and immersion, we conducted Phase 02—analysis and definition—in which content analysis was used to analyze data. The results were synthesized and organized using both tables and empathy maps representing information about the students' profile.

The results of Phase 03—the ideation phase—were used toward the co-creation of sessions with students, teachers and the researcher. These sessions allowed the generation of ideas to conceive and design the gamified prototype. The main result

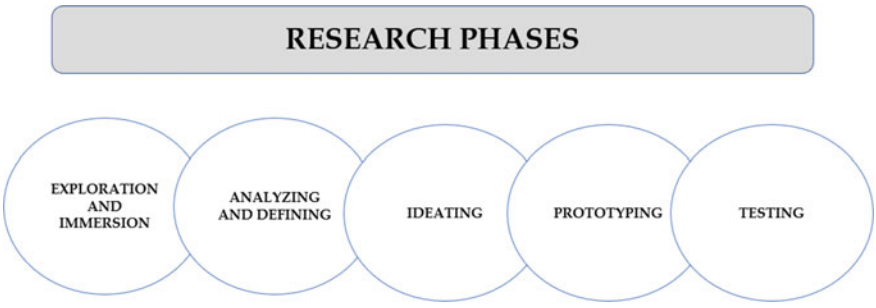

Fig. 23.1 Design thinking phases in research. *Source* Elaborated by the authors

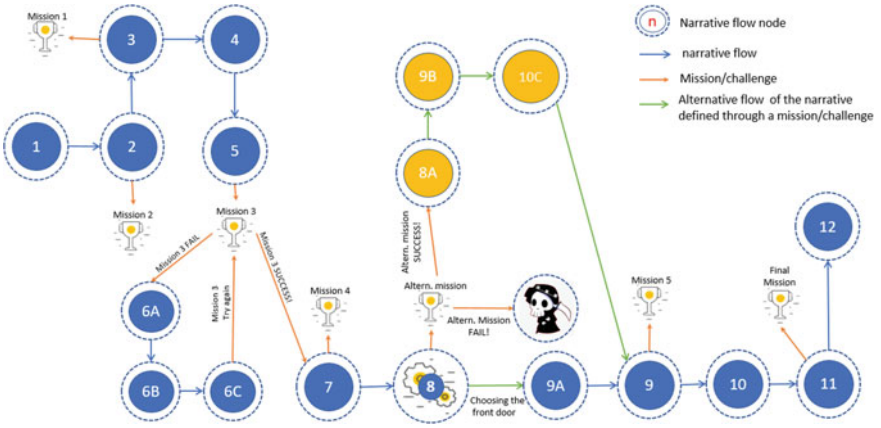

Fig. 23.2 Narrative journey. *Source* Elaborated by the authors

of this process was the structure of the prototype that resulted in the form of a gamification plan describing the narrative journey, as presented in Fig. 23.2.

The narrative journey is structured as follow: (i) each level represents a scene/chapter of a same narrative. Levels are motivational game elements and represent the player's evolution in a game; (ii) trophies symbolize achievements rewarding the player and representing performance; (iii) the direction arrows represent the paths (green arrows show an alternative path) as a way to achieve a goal. Alternative paths are relevant in challenging players to go into different ways, in order to meet same results; (iv) the death figure is the game over and is used as a type of feedback in a game.

A *game-based* approach was used in this specification.

During the co-creation sessions, and after discussion themes, narrative elements and plot, we finally decided on the creation of a narrative "*Piazinho em uma Aventura com seres fantásticos da Amazônia/Piazinho in an Adventure with fantastic creatures from the Amazon*". Based on Amazon legends of fantastic creatures, the story presents the adventure of the character Piazinho in a small village located in the Amazon region. It is a story full of missions aiming to help Piazinho to overpass challenges.

The main focus of Phase 04 was the development of a prototype. *Prototyping* is consolidating. It involves getting ideas and making them tangible and actionable [15]. In this study, the first cycle of prototyping was completed assuring the development of a paper-based prototype addressing the students' needs. This prototype is constituted by: an adventure map; an avatar; a scoreboard; achievements cards; feedback cards (badges and rewards); and points cards.

Testing was the main objective of Phase 05. *Test* provides feedback [13]. Its purpose is to know what does or does not work and then iterate in order to modify/redefine the prototype. This first paper-based prototype was *tested* in different sessions with the two students with dyslexia and with teachers. In all missions/challenges, we used materials as apps, paper and some computer tools. Its purpose is to know what does

or does not work and then iterate in order to modify/redefine the prototype. This first paper-based prototype was *tested* in different sessions with the two students with dyslexia and with the teachers. In all missions/challenges, we used materials such as apps, paper and some computer tools. Feedback from students and teachers was collected in post-test interviews.

23.4 Discussion and Conclusions

23.4.1 Interpretations and Inferences

The process of creating a gamified prototype allowed a deeper understanding of the advantages of using design thinking in five main areas, described below:

A human-centered process—focusing on students' stories meant emerging in their school context and knowing who they were. "What are his/her interests/fears/needs?" were key questions that allowed a deeper understanding of the challenges they face at school. Observing them during reading activities and endorsing their real learning experiences and difficulties were tasks of major importance. The whole process led to a clear vision on the learners' motivation, needs and difficulties, making it possible to define a student-oriented solution that inspired [16] further stages of the project.
Iteration—this process of cyclical and iterative nature [10, 15] enables revisiting any phase at any point of the time. This helped us to tackle different challenges and to collect data about learners' stories relating them to the next step of prototyping—the creation of a digital version with improvements accordingly to the learners' and teachers' feedback.
Using Design thinking and gamification represented an important method for creating gamified solutions for three main reasons: (i) Both involve engagement; as DT is based on exploring, creating, prototyping and implementing, it actively engages the researchers in the process of getting ideas to the development of the gamified product; (ii) both are feedback-oriented approaches. DT and gamification are both based on feedback cycles; thus, it is possible to recreate the gamified solution from the participants' feedback after testing a prototype. In this study, a test–refine was developed from which we gathered feedback about game elements and strategies; accordingly, the future prototype will be redefined taking into consideration the contributions of learners and teachers; (iii) both gamification and DT are action-oriented [13], meaning that these two approaches engage people into action and into creating solutions rather than exploiting a discussion-based work [13]. In this study, this concept of an action-oriented method creates a space for engaging learners, teachers and researchers in the process of getting inspiration and sharing for the development of prototypes.
Collaboration was not developed as in the strict sense of design thinking [10, 15], because students with dyslexia have individual educational attendance at multifunctional rooms at school. Therefore, we could not involve another group of students.

Co-creation sessions and prototype testing highlighted the collaborative dimension of our work. During those sessions, all participants could express ideas, feelings and thoughts, as well as make suggestions to the gamified solution.
Innovation was ensured by the DT approach as it allowed the creation of a strategy of learning through experience, opening the research process to new ideas that came from learners and teachers and using creative thinking in order to promote innovation. The concept of innovation in a study like ours is related to the renewal of pedagogical strategies with the aim to help students develop new skills. In this case, our greater purpose was helping students with dyslexia to be engaged and motivated in reading lessons.

In sum, DT represented an effective method to understand learners' needs and to better connect with their learning environment. The results of the process showed that DT is also flexible, making it possible to fail, learn and refine educational products in a collaborative way. Furthermore, it generated framed knowledge on how to better engage students in reading activities.

23.4.2 Conclusions and Future Work

The case study has resulted in a relevant learning experience for the participants. DT gave us the opportunity to better explore the context of students with dyslexia and to better know their needs and difficulties. This abductive experience highlights two important dimensions in DT: (i) interaction/collaboration is a key aspect in designing solutions. We learn from interactions to go deeper in empathy in order to comprehend what works or what does not with the students; (ii) improvements must be grounded in feedback gathered from learners and teachers. The end of testing was quite valuable in our research, providing new data for evolving the artifact and moving to short-cycle innovation processes.

According to the iterative nature of design thinking, future research will focus on the redefinition of the prototype leveraging a new test. The first paper-based version is currently being improved and redefined in order to create a digital version that will be tested again with the same participants. The main goals of these new stages of prototyping and testing are as follows: (a) to create an improved gamified artifact; (b) to verify what the effective impacts of the paper version versus the digital version on students' engagement and motivation are; and (c) to compare the main contributions of the two versions to the amelioration of the learners' reading difficulties.

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Chapter 24
Development of a Smart Cycling Support Device for People with an Intellectual Disability

Kenneth Deprez, Emiel Holvoet, Esther Reynders, Michelle Vandepoele, Maud Verstringe, Francis wyffels, Steven Verstockt and Jelle Saldien

Abstract While cycling in traffic, people encounter many different situations with external triggers, that need special attention, such as vehicles, other bicycles, pedestrians, road surface and intersections. Furthermore, people need to remember the route to their destination and take into account the traffic regulations. For people with an intellectual disability, this can be a challenging task.

24.1 Introduction

While cycling in traffic, people encounter many different situations with external triggers, that need special attention, such as vehicles, other bicycles, pedestrians, road surface and intersections. Furthermore, people need to remember the route to their destination and take into account the traffic regulations. For people with an intellectual disability, this can be a challenging task. Many way-finding apps give the possibility to easily find your way from point A to point B. However, people with an intellectual disability need more guidance in traffic to safely reach their destination. They might be too careless in risk assessment while parents or caregivers do not trust them alone in traffic. The purpose of this research is to develop an aid for these people, so they can cycle to school or sport clubs and improve their independence. The most optimal outcome is a reliable, trustworthy, easy and self-explanatory solution that guides the user in traffic and gives confidence to both the user and the parents. The proposed solution is based on user research and feasibility tests with the target group. In this paper, the complete prototype, evaluation, results and future work are discussed. The problems of people with an intellectual disability in traffic are a relatively undiscovered subject. Therefore, an online survey has been conducted

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Table 24.1 Results of the survey

What do you find important in a product that supports people with a disability in traffic?	Chosen (%)
Indicates to other road users which direction they are going	70
Possibility for an emergency button that contacts us	70
Indicates to other road users that this person may need help	68
Works with a voice that explains the route and gives warnings	60
Works with symbols	53
Possibility to set the route yourself, in advance	53
Route description	40
Automatic safe route	40
Traffic sign recognition	36
Possibility for an emergency button that contacts an alarm centre	21
Indicate the statements you agree with	**Chosen (%)**
It is mostly in unexpected situations that cycling in traffic would give a problem	79
He/she has not enough knowledge of the traffic regulations	77
Traffic is too crowded for him/her	66
If he/she is alone on the road, there is no way to check if it goes well	64
I have too little confidence in him/her following the route	55

and selectively shared on social media groups and pages with parents and relatives of people with an intellectual disability, Down syndrome or Autism. The survey targeted parents, relatives, teachers and caregivers. The results of this survey ($n = 53$) inspired the solutions for a first prototype. Table 24.1 shows the responses to the two questions that had the most impact on the design process.

24.2 My Bike-Hero

The problems of people with an intellectual disability in traffic are a relatively undiscovered subject. For this reason, an online survey has been conducted to get more insights in the problem. The most relevant information for this case study is about people who can already ride a bike but do not participate alone in traffic (in total 53). The results of this survey inspired the solutions for a first prototype. The proposed solution consists of two elements: a helmet sleeve and an application. The sleeve contains several electronic components. The two LED strips and a LED panel make for a visible and eye-catching blinking system. In Fig. 24.1, the helmet sleeve is displayed. The blinking system can be controlled by buttons which are placed on the handlebar. When the user presses one of the buttons, the corresponding LED strip on the same side will blink. The LED panel then displays an arrow to indicate in which direction the user will turn. This guarantees that both the people in front and

Fig. 24.1 Helmet sleeve

the people behind the user will get this indication. Based on the survey, a decision was made to use spoken instructions to guide the user in traffic. The advantage of using a helmet with spoken directions is first of all that the safety is improved by wearing a helmet. Furthermore, spoken directions are less of a distraction compared to visualizations on the handlebar or elsewhere. Now a device is required which can give directions to the user related to their position. A smartphone has both a GPS and can connect with headphones to give commands to a user. The second element of the solution is thus an application: 'Mijn fietsheld'. The phone connects with bone-conducting headphones, so it can give spoken instructions to the user. The design of the app should be intuitive and clear to the user. There is a section made for the parents, who can customize the app entirely to the needs of the user.

24.3 Conclusions

This paper presents a solution for people with an intellectual disability who need more guidance to be able to cycle alone in traffic. The solution consists of buttons on the handlebar, a helmet sleeve, bone-conducting headphones and an app. The application tracks the user while cycling and sends commands to the headphone, so the user gets auditory guidance. The buttons on the handlebar can be pressed to activate the blinker LEDs on the helmet sleeve, improving the visibility towards other vehicles. Overall the result is useful, yet improvements in usability can be made in next prototypes and iterations.

Chapter 25
Social Coordination in Human–Robot Interaction Through Reciprocal Engagement

Patrizia Marti, Iolanda Iacono, Oronzo Parlangeli and Jelle Stienstra

Abstract In this paper, we provide a theoretical and experimental investigation on human–robot interaction scenarios where collaborative activities are perceived more meaningful and easier to perform by the human agent in the situation of reciprocal engagement with the robot. Inspired by the perceptual-crossing paradigm (Auvray and Rohde in Front Hum Neurosci, [1]), we defined reciprocal engagement as an interaction concept that seeks to extend perceptual crossing to functional purposes. For instance, when a robot and a person face a door and they both intend to go through it, a designed behaviour negotiates who is to go first in appropriate manner, either the human or the robot. The objective of the study is to explore social coordination mechanisms that are easy and natural for the human agent in order to engage in interaction with a robot. Two experiments were conducted which explore interaction scenarios with and without reciprocal engagement between a person and a robot to appreciate their significance for the human actor. In the first one, interaction scenarios are evaluated on the basis on video clips; in the second one, participants were asked to interact directly with the robot according to the same scenarios. The results show a preference of participants towards reciprocal engagement situations which were considered more meaningful and easier to learn. With this work, we hope to inspire design thinking to shift from discrete, procedural design mechanisms to continuous and action-driven mechanisms of social coordination when addressing the interaction between humans and systems in smart environments.

25.1 Introduction

This paper focuses on robot's behaviour designs based on expressive movement to engage in interaction with a human. The robot's behaviour design was inspired by the notion of the "perceptual crossing" as defined by Auvray and Rohde [1], a notion

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that has received a growing attention also in recent studies in embodied interaction design.

Perceptual crossing denotes situations in which two perceptual activities of the same nature interact with each other (as in the case of mutual touch or catching one another's eye). Perceptual crossing allows to recognize the presence of another intentional subject [2–4]. For example, two people encountering from the opposite directions might step towards the same side for a while without being able to walk past each other. This is how we dynamically form mutual coordination and adjust our movement influenced by other's movement and behaviour. With perceptual crossing, we are able to perceive while being perceived and this particular perception affects our interaction behaviour and stimulates implicit learning on mutual coordination.

In what follows, we provide a theoretical background that frames the concept of perceptual crossing and our elaboration towards "reciprocal engagement". To investigate the possibilities of exploring reciprocal engagement in the field of human–robot interaction, we designed three simple interaction scenarios that are used to conduct a study to evaluate the paradigm's potential. The three designed situations were evaluated in two steps: using video-recorded clips and using a robot able to show reciprocal engagement. In both cases, the assessment was conducted comparing the scenarios in two conditions, with and without reciprocal engagement.

In the first experiment, we evaluated reciprocal engagement taking a third-person perspective using video-recorded scenarios. The scenarios were assessed by 60 subjects from 18 to over 70 years old in two conditions, with and without reciprocal engagement [5]. The results of the experiment show that the scenes with reciprocal engagement between robot and human were preferred over the one without, regardless of the age of the subjects.

In the second experiment, we evaluated reciprocal engagement taking a first-person perspective. We involved six subjects who experienced the same scenarios with and without reciprocal engagement at first hand with a real robot. The outcomes of the experiment confirmed the results of the first study.

In the final section of this paper, we reflect on the results and implications for design.

25.2 Theoretical Background

Perceptual crossing is rooted in the phenomenology of perception by Merleau-Ponty [6] and regards the reciprocal nature of our perception in the emergence of meaning. The mutual perception of two actors influences their reciprocal behaviour. This phenomenon may occur visually (e.g. when a person sees what the other person is looking at) but also as touching and movement coordination. Perceptual crossing is a social behaviour that initiates a "conversation" within a shared context even if it does not necessarily convey functionality.

Perceptual crossing was studied in different fields of research, and the applications of this notion are manifold [1, 7]. The term was originally coined by Auvray et al.

[8], Lenay [9] and further explored by Liang et al. [7], Deckers et al. [10], Marti [11], Anas et al. [12] in the field of interaction design.

Auvray et al. [1] carried out experiments in which subjects were able to distinguish animate objects from inanimate ones with the same appearance and movement only by perceiving very simple tactile stimuli. Empirical evidence has been found in their experiments to sustain the central role of dynamic mutuality and shared intentionality in forming several aspects of an ongoing interaction.

Liang et al. [7] developed InTouch, a social network system where individuals can express their consideration for friends. The interface enables two-way interaction: a person can perceive colour and temperature triggered by another person connected at the same time, while being sensed by temperature in the other's device. The shared perceptions are triggered by single movements on the interface, forming a crossing of perception between the two agents. The ultimate goal of the project is to stimulate a conversation by exploring how meaning emerges in interaction.

Deckers et al. [10] designed PeP, "Perception Pillar", an artefact capable of detecting a person's presence (perceive the body-image), perceptive action (perceive other perceiving me), and expressivity (perceive others' mind). Experiments with PeP show that designing a perceptive activity in an object to allow for perceptual crossing between subject and object positively influences the user's feeling of involvement.

Anas et al. [12] analysed social interaction evolving from the perceptual crossing between a person and an everyday object. They designed an experiment where the gazing behaviour of the person is used as the input modality for the system. The ultimate goal of their research is to design interactive systems where human's gaze behavioural patterns influence the system's ability to respond during the perceptual crossing.

Marti [11] draws inspiration from the perceptual-crossing paradigm in order to develop robotic systems capable of a mutual regulation of joint actions. In one of the scenarios presented in the article, the robot companion IROMEC follows a child at a fixed distance taking the same trajectory, pace, and speed as the child. The child's teachers who analysed the video recording of the scenario agreed that the child was remarkably able to sustain activity across a number of tasks, suggesting that her capacity to focus attention was better than usual. The experiment suggests that the perceptual crossing can be used in the design of technological artefacts to improve the motivation to act, attention to mobility, coordination, and basic interpersonal interaction.

In the examples above, perceptual crossing predominantly explores subject–object relations (transforming the object to have subjective qualities) [13]. However, third party (the context of action and the intentions of both subjects towards the environment) plays only a minor role. We see an opportunity in pushing the *perceptual-crossing paradigm* towards *contextuality* where the knowledge resulting from practising a mutual coordination of action improves the performance. We pursue an interaction paradigm in which two entities (person and artefact) go beyond an awareness of sharing context and come to share intentions (understanding and acting upon them). This we call "reciprocal engagement".

The study presented in this paper applies principles of perceptual crossing tuned towards reciprocal engagement thus incorporating "contextuality" to achieve mutual understanding. This is relevant for both entities (robot and person) to immerse in a shared context and to "grope" the intentions of the other. The "groping" and the acting upon in our paradigm go hand in hand. They happen at the same time in the active perception loop.

25.3 Interaction Scenarios

Three different scenarios were designed and developed to investigate reciprocal engagement between the person and the robot. The scenarios depict situations in which a person lives at home with a robot designed to help him in simple tasks and engage in social interactions.

The scenarios were implemented using two different robotic platforms: (1) a low-fidelity robot prototype implemented of the mobile platform Magabot; (2) Care-O-Bot®3, an existing robotic platform utilizing a multitude of sensor arrays in a simulated smart home environment. In the context of the accompanying project, Care-O-Bot®3 was explicitly designed to support the autonomy of older people at home [14].

The Magabot platform was used to record video scenarios to be evaluated from a third-person perspective [5]. It mounted a shell to simulate the appearance of Care-O-Bot® 3 used to carry out the same scenarios from a first-person perspective.

Below we report the descriptions of three different scenarios and related robot's behaviour with and without reciprocal engagement.

25.3.1 Scenario 1—"Let's Move"

Alex is sitting on a chair and the robot is in front of him. Alex has been sitting for a long time. It is healthy for him to get up and take a little walk in the room to prevent problems related to inactivity (see Fig. 25.1). In the condition with reciprocal engagement, the robot invites the person to get up by moving backward and forward in front of him. Perceptual crossing occurs when the person manifests the intention to stand up and the robot makes room for him so that he can walk.

In the condition without reciprocal engagement, the robot does not do anything. The robot is still in front of Alex. Even when the person starts rising, it remains in the same position.

Fig. 25.1 Scenario 1 "let's move" with reciprocal engagement

25.3.2 Scenario 2—"Walking Together"

When two people walk together, they coordinate each other movement, both in pace, direction and speed. In this scenario, Alex moves to the next room to take something to drink. Along the way, he stops unexpectedly because he does not remember if he took his medicine (see Fig. 25.2). In the condition without reciprocal engagement, the robot moves at its pace and continues to do so by moving to the next room even when Alex stops for a while. The robot is programmed to go from A to B. In the

Fig. 25.2 Scenario 2 "walking together" with reciprocal engagement

Fig. 25.3 Scenario 3 "walking together" with reciprocal engagement

condition with reciprocal engagement, the robot moves at Alex's pace and stops when Alex stops. The robot starts moving again when Alex decides to go on.

25.3.3 Scenario 3—"Let's Cross-Paths"

When two persons cross a door at the same time, they don't bump in one another since they are aware of the space constraints and the reciprocal speed and movement (see Fig. 25.3). By cultural habits, one of the two may also decide to let the other person passing first, e.g. as a man would do in the presence of a lady. In this scenario, Alex and the robot walk together from one room to another room through a door. In the condition with reciprocal engagement, the robot stops to let the person cross the door first. In the condition without reciprocal engagement, the robot keeps walking crossing the door, actually preventing the person from crossing first.

In the following, we describe the experimental procedure used to assess the interaction scenarios from a third- and first-person perspective.

25.4 Scenario-Based Evaluation from a Third-Person Perspective

Sixty participants (M = 30; F = 30) aged between 18 and 92 years old were involved in the study. All the participants voluntarily joined the study.

Ultra-septuagenarian participants (M = 4; F = 9) had a mean age to 82.92. They lived in a residential home for self-sufficient seniors in Siena, Italy.

The scenarios were video-recorded in two conditions: without reciprocal engagement (condition A) and with reciprocal engagement (condition B). The subjects were asked to watch the video scenarios randomly assigned.

The video scenarios are available at the following link: (https://vimeo.com/user22680386).

The evaluation was performed by administering different questionnaires:

(1) Scenario evaluation questionnaire included three statements on the robot's attitude, to be answered on a linear continuous scale with four adjectives coupled with their opposites: rude/kind; distracted/focused; individualist/altruist; and indifferent/emphatic. Participants were invited to assess the robot's attitude, from 0 to 4. The questionnaire also contained statements to be answered on a five-point Likert scale from 0 to 4. The participants were asked to respond to each statement in terms of their own level of agreement or disagreement: 0 = strongly disagree, 1 = disagree, 2 = undecided, 3 = agree, and 4 = strongly agree.
2. Comparison questionnaire included two closed-ended questions: "*In which version is the robot's behaviour socially acceptable?*" and "*Which version of the scenario did you like most?*" The questions were used to compare the two conditions A and B and to assess the preferences of the subjects towards each situation depicted in the scenarios.

All subjects stated that they clearly understood the scenes depicted in the videos. The participants preferred condition B (with reciprocal engagement) for all scenarios. The differences between the two conditions "without reciprocal engagement" and "with reciprocal engagement" were less evident in Scenario 3, "Let's cross-paths" since older participants reported that the scene described in this scenario could have different interpretations. For example, if the person is autonomous, it is better if he goes through the door first. However, if the person is not fully autonomous and needs assistance, it is better for the robot to go first, in order to be able to help if needed.

A statistical analysis based on the Wilcoxon signed-rank test was conducted. The analysis was conducted to assess whether there were statistically significant differences between the two conditions. The test was used to compare the scores of respondents for both conditions to all the statements included in scenario evaluation questionnaires based on the Likert scale. The Wilcoxon signed-rank test was applied only for two groups of subjects: Group A aged 18–35 and Group B aged over 70. The test revealed for the group aged 18–35 a statistically significant difference ($p < 0.01$) between the two conditions for all the statements related to Scenario 1 and Scenario 2. Regarding the scenario 3, the Wilcoxon signed-rank test for the group over 70 showed a statistically significant difference ($p < 0.01$) for all the statements related to the Scenario 1, while no significant difference was found for one statement about Scenario 2 or for any of the statements regarding Scenario 3. Further details about the results of this experiment are contained in [5].

The outcomes of the study provided grounds for a new experiment where reciprocal engagement was experienced from a first-person perspective. Since reciprocal engagement is about how actors engage in resonant movement interaction, thus it is important to appreciate the benefits of reciprocal engagement from actually experiencing resonant movement instead of assessing the phenomenon from the perspective of a third party (video-based assessment).

25.5 Scenario-Based Evaluation from a First-Person Perspective

The results of the experiment described so far show that reciprocal engagement can positively influence young or older persons' behaviour in interaction with the robot.

The same scenarios were implemented on the Care-O-bot platform (see Fig. 25.4). This made it possible to evaluate them in the field, with direct experience of real people interacting with the robot.

The study was conducted at the Fraunhofer Institute—IPA in Stuttgart. A smart environment recreating a living room was used as the setting for the experiment. Six subjects participated in the study voluntarily; including 4 (M = 2; F = 2) aged 55–70 and 2 (M = 1; F = 1) over 70. These subjects did not participate in the previous experiment.

The subjects were invited to enact and then assess situations similar to those described in the three video scenarios used in the previous experiment, under both conditions, that is, with and without behaviour oriented towards reciprocal engagement.

The experimental procedure was based on the one used in the evaluation conducted with video scenarios.

The test scenarios were presented, asking the people to imagine themselves in the situation described, which included the presence of the robot. As in the previous evaluation, the scenarios included simple circumstances such as sitting down in the sitting room (Scenario 1); walking together in the room (Scenario 2); and going through a door into the adjacent room (Scenario 3). All the subjects said they clearly understood the scenarios prior to the test.

Fig. 25.4 Experimental setting at the Fraunhofer Institute—IPA in Stuttgart (Photograph courtesy of Fraunhofer IPA)

The scenarios were proposed in condition A and B (with and without reciprocal engagement) in a random sequence. Every time a scenario was enacted in one of these two conditions, the subject was asked to fill in the same questionnaire as was used in assessment with video scenarios. When both conditions had been enacted, the subject was asked to fill in the questionnaire for comparative assessment of the experience.

Figure 25.5 illustrates the frequency of the responses obtained to the question "*In which version is the robot's behaviour socially acceptable?*" and "*Which version of the scenario did you like most?*" contained in the comparison questionnaire.

The figures reveal a clear preference for the scenarios in which the robot displays behaviour based on reciprocal engagement. The only scenario in which the difference seems less clear is Scenario 3 "Let's cross paths". These figures are in line with the figures collected in the assessment conducted on video scenarios.

The subjects said that Scenario 3 could be interpreted in different ways, and their comments revealed the same reflections as were expressed by the senior subjects who assessed the video scenarios. For example, an ultra-septuagenarian lady said, "*If I have a problem to walk autonomously, the robot should go first, but if I can walk well I would like the robot to let me pass first*".

On the other hand, another participant, a man aged over 70 commented: "*The robot is rude if it goes first. It is nice if it shows me the way*". The same person said, "*I have the impression that the robot understands that someone has to go first*".

As in the analysis of the data conducted on video scenarios, in this case, a Wilcoxon signed-rank test was conducted to assess any significant difference between the averages under both experimental conditions. The test was used on the responses to questions included in the scenario evaluation questionnaire based on the Likert Scale.

The Wilcoxon signed-rank test did not reveal any significant difference ($p < 0.01$) in any of the questions contained in the three questionnaires with respect to the corresponding scenarios. The data on Scenario 2 and Scenario 3 reflect the data obtained on the video scenarios for the group of subjects over 70.

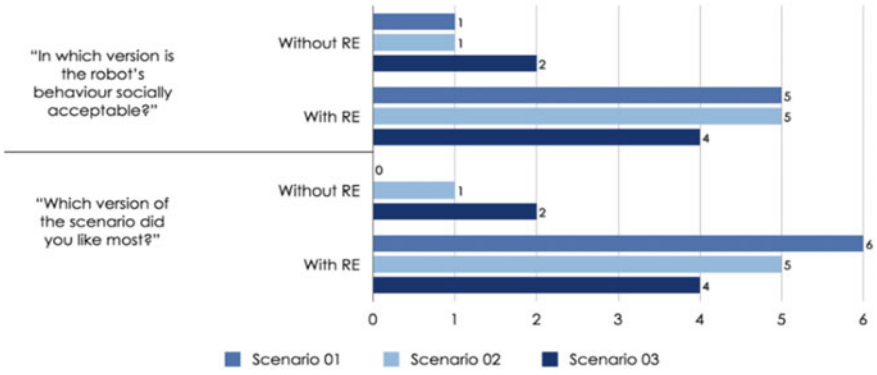

Fig. 25.5 Results of the comparison questionnaire

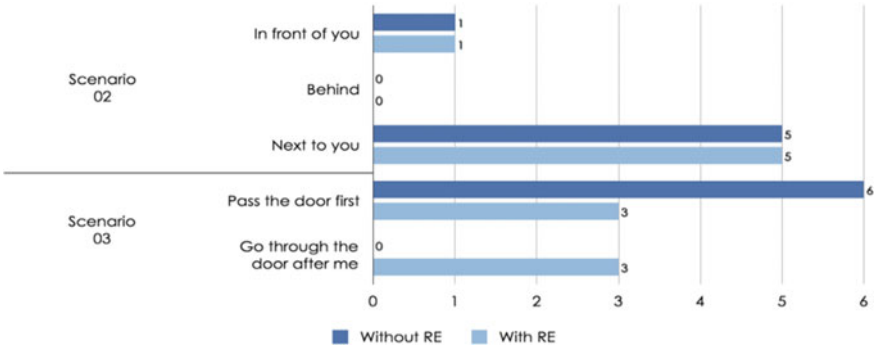

Fig. 25.6 Frequency of answers to the question: "where should the robot drive?" related to the scenario 2 "walking together" and scenario 3 "let's-cross-paths"

Figure 25.6 shows the total responses to the question "*Where should the robot drive?*" contained in the scenario evaluation questionnaire for Scenario 2 and Scenario 3.

The results reveal a preference for the response "Next to you" (Scenario 2—"Walking together") under both conditions, and for the response "Pass the door first" (Scenario 3—"Let's cross-paths") in the condition without reciprocal engagement. As we have said, the situation described in Scenario 3 is highly subject to interpretation depending on the context and the subject's physical abilities.

Figure 25.7 shows the average values obtained for the question, "*The robot appears to me…*" for the three Scenarios.

As the graph reveals, the differences in the figures are significant in Scenarios 1 and 2, but not in Scenario 3. The data confirm the findings of the assessment using video scenarios.

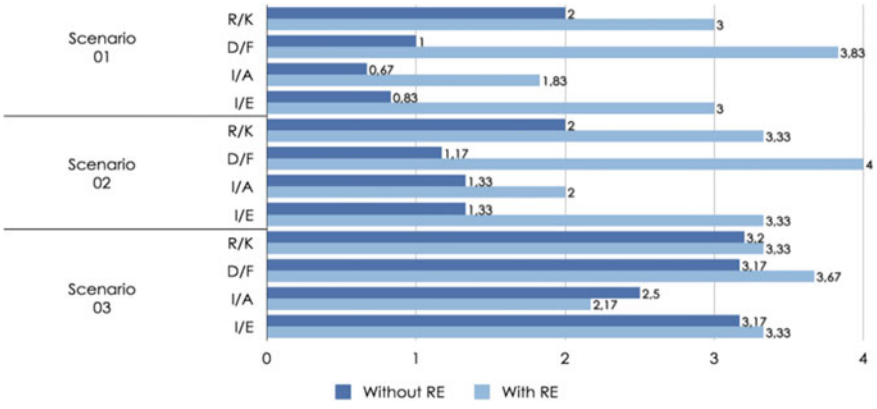

Fig. 25.7 Mean value for the robot attitude scale: "the robot appears to me": rude/kind; distracted/focused; individualist/altruist; indifferent/emphatic

25.6 Discussion and Conclusions

The findings from this second evaluation confirm the initial insights gathered through videos presenting behaviours of reciprocal engagement. From a designer's perspective, this is a valuable insight as it indicates that a cost-effective method such as "scenario building" can confirm an "educated hunch" or design proposal. However, we warn to be cautious and draw conclusions too easily. We depart from the idea that design concerns itself with the creation of opportunities rather than focusing on solving problems. In that respect, a recorded scenario of a novel (and working) interaction paradigm is a useful way to get quantities of appreciation for a proposed idea.

The reciprocal engagement of Scenario 3 was assessed to be the least convincing improvement. This scenario aimed at negotiating in the interaction who is to go first when there is an obstruction on the way. What did not help, as shown by the results, is that we did not contextualize or script the scenario enough. Who is to go first depends on a variety of aspects including cultural habits, which were obviously unknown for the video referees. These aspects were not communicated and even neglected in the experimental design. In Scenario 3 where user and robot had to go through a door, it was not clear why the person and the robot would need to go together. We foresee that better "scripting" the situation would benefit the results, as we strongly believe in the "negotiating in context" aspect of our reciprocal engagement. On the other hand, it also does highlight the importance of contextuality and that by merely perceiving (and acting upon) the movement of the person the robot could benefit from more contextual information such as the reason why a person goes somewhere.

Yet, even though the evaluation was not conclusive, it also was not dismissive towards the reciprocal engagement in Scenario 3. Pertinent was the qualitative insight that the designed behaviour in the negotiation is somewhat sturdy and thereby experienced as awkward. Our expectations for the actual reciprocal engagement were high, in a sense that we aimed to make the movements so natural that they might even go unnoticed. Unfortunately, this was not the case. Once again this points to the need for implementing subtleties in the movement design. Movements should be "smooth" (not chicken-like), in a sense that they are predictable and anticipative. They have to be intentional, expressive, and context-dependent. Furthermore, for movement-based reciprocal engagement, there is no room for delay. We urge to overcome the pre-programmed and planning paradigm of the system architecture, so the direct feedback loop could allow for people to have a sense of direct experience (needed to make valuable judgements of the robot's intentions), the interaction should occur in real time on the sense/actuate and system architecture levels. Pre-programmed computing does not fully allow for the interactions we achieved in the present experiment.

In our designed scenarios, reciprocal engagement occurs in interaction based on shared or conflicting objectives (e.g. going through the same opening that does not allow both to pass at the same time). It is an emergent and dynamic product of

cross-perception leading to an implicit way of learning how to coordinate interaction in a social context.

Studies on the perceptual crossing are attention-grabbing and have provoked a lot of resonance in different areas of research including experimental and clinical psychology, computer/robot modelling, philosophy, engineering, and design.

Our experimental results show that designing for reciprocal engagement can lead to natural and expressive forms of resonant movement-based behaviour in human–robot interaction, and this opens new potential areas of application including robot-mediated education and rehabilitation.

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