

Chapter 2

Emerging Dimensions of Learning

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Abstract Within the current global financial crisis, education has seemingly conflictive expectations as a producer of experts that can bring the globe back on track. One of the tensions lies between the formality and informality of education. While the formal approach emphasizes strict goal settings, accreditation and quality management, the proponents for informal learning call for flexibility and organic competence creation. Cases from K12 technology education with robots, contextual Information and Communication Technology education in developing countries and context-aware mobile learning games help to take the two approaches into real contexts. These examples open a scheme where technology can serve as a vehicle to combine the assets of formal and informal learning into a creative tension towards transformational learning.

2.1 Introduction

Learning and education are generally understood as the main drivers for wealth creation and poverty reduction—the problems that the developing countries need to solve in order to progress. The motivation for developing functional education is to reach the next one billion of particularly young, illiterate, unemployed people. Ordinary methods or conventional education do not suffice for the effort. At the same time, developed countries are struggling with the aging population. With a fast changing society, the elderly need to learn to cope with the surrounding

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changes and new digital services that they are dependent on, and the rare young people need to get education that matches almost one-to-one with their future jobs.

Much too often, the solutions for educational challenges have been hunted for using the dimensions of formal and informal learning. Formalists have believed in multiplying what they call “the best practices”. They are a synonym to introducing quality management systems to follow up their implementations devising national tests based on standards for school achievements and using technologies for streamlining learning outcomes and even processes. An informalist develops solutions that match authentic problems, and an extremist in their field could not care less about how the students can apply their skills in foreign settings. Standardization of qualifications is not an issue.

The problem is that informal and formal perspectives are not independent dimensions but represent the extremes of one dimension. In fact, the dichotomy maps the landscape of education in terms of forms. Even the contents or the spirit of learning are understood in terms of forms. From the viewpoint of integrating technology into education, the formal/informal division calls for technologies that manage a formal learning process or facilitate an informal one.

For the emerging grand challenges of learning, earlier recipes do not seem to work, including the dichotomy of formal and informal learning. The reasons are in the low number of teachers, their poor competences, lacking schooling infrastructure, too narrow or irrelevant competence spectrum of school graduates, among many others. Technology has been expected to answer to the presented problems. However, the technology used has been mainly developed with other application areas in mind, and in contexts that do not suffer from the problems described above. Therefore, it is important to identify fresh dimensions for learning that would release the imagination of educators to open the world of learning—knowledge, skills, and attitudes—to those not yet accessing it.

But how to identify the fresh dimensions? I would argue that the learning research community needs to go back to the ground and the grassroots. The explorations need to take place within the challenges, together with the learning communities. This requires risk-taking that has not really been in the focus of learning research. On the contrary, various ethical committees have made it sure that research happens in almost a vacuum, or clinical environments, and does not intervene with the learner or the learning process. Instead it observes a given, controlled learning situation, and, certainly, does not take risks. From the viewpoint of educational technology, the use of experimental methodology has meant that much of the research focuses on evaluating the use of existing technologies, or toy solutions only designed for the purpose of research. Too small a part of educational technology research aims at designing advanced technologies for real-life challenges. However, in science, it is always true that we are learning when we cross the frontiers of the current wisdom, and this involves risks.

Although money is usually one of the bottlenecks that prevent learning, it cannot solve the problem entirely. A recent article by Jansen (2011) analyzes the South African situation. Even within massive investments in education, the level of skills in mathematics and science has decreased among pupils coming from

disadvantaged communities or families. Jansen requires shifting the focus from money onto educators and their professional pride. Part of this pride is openness to cross the borders by exploring new ways to tackle the challenge, and then be proud of what had been found out.

Within an action research oriented study in learning Java programming to solve a problem, the researcher got negative feedback from their teacher students. The conventional approach to learn Java per se seems to lie deep in teachers' understanding of quality teaching.

One of the key principles of the world-renown Finnish teacher education is to empower teachers. A teacher's professional pride lies in their deep understanding that they are the best teacher for their class. To a major extent, the current article is based on this foundation. The dimensions of learning have been derived from individual cases that have taken the teacher researchers to various boundaries of learning.

2.2 In the Quest for Ideal Learning

Throughout history, the quest for ideal learning has had diverse drivers. This section identifies examples of these drivers. They are characterized by varying agenda: political, economical, psychological, philosophical, and finally, technological.

An example of how *politics* can influence pedagogy is the well-known Sputnik crisis in the 1950s. During the cold war era, American pedagogy needed to back to basics from more exploratory movements. The change was based on the interpretation that the Soviet science and mathematics education had outperformed the American one: it had brought up skillful scientists that took the cold war competitor to the outer space before the U.S. The outcome of the emphasis on the basics was the orientation towards formal education.

Economical interests have a significant role on new pattern of learning, but interestingly, they might not always lead to a formal or standardized focus. The Bauhaus school (Droste 1990) that flourished in Germany in the 1920s had roots in, among others, economics. It was expected to preserve the German competitiveness with England. The school was supposed to be a barrier-breaking, interdisciplinary learning environment for novel design.

The role of *psychological* research for education is apparent. The emphasis on informal versus formal learning has a parallel in the concepts of the unconscious and the conscious. In the 1970s, the psychologist Bettelheim stated that children can elaborate their unconscious fears within conscious stories, making the traditional tales enchanting (Bettelheim 1976). The tales help the children to prepare for their future. Thus, stories can be an informal learning milieu that enriches the learning process by emotional aspects.

Especially in science and mathematics education, it is possible to identify the barrier between a formal and an informal approach. From the *philosophical*

viewpoint, radical empiricism calls for an approach where learning needs to be based on immediate observation, and therefore, it cannot follow a formal process driven by theory or a given curriculum. A theory-based education squeezes down the empirical reality, informed by accepted or authorized theories (Beynon 2007). Pólya (1957) follows the empirical approach by encouraging teachers to teach mathematics in the way that it is done: by experimentation.

Technological developments have had diverse influences on pedagogy, supporting either the formal or the informal approach. An example of the formal interest is adaptive hypermedia (Brusilovsky 2001) that could basically orchestrate the learning process through a hyperspace. Papert's ideas on constructionism (Papert 1980) show how technology can open a learner in an informal setting. In his ideas of how technology can join science and art, Steve Jobs has echoed the agenda of the Bauhaus movement.

Based on the examples above, we use the attribute *formal* to refer to education that emphasizes structure, discipline, and expected outcomes, whereas *informal* learning gives a learner a foundation that she or he can play in, and learn as a side-effect.

In the following, we will see how experiences at the grassroots level can shape education in a *bottom-up* way. This approach is complementary to a more *top-down* principle of designing education based on international standards, like PISA for basic education or Shanghai lists for ranking universities. In a way, our approach takes the human rights into the centre of educational reform. It is the human situation with its all ambivalence and change in the surrounding society that maintains creative tension between formal and informal learning.

2.3 Four Seasons of Exploring Learning Approaches in Diverse Settings

The section describes four approaches that have successfully mixed formal and informal flavors of learning in real contexts. The approaches all share contexts that have been atypical platforms for learning, thus been the borderland for exploring new dimensions for learning. They cover the years 2002–2011, and the projects were located worldwide. The contexts have been arranged by seasons, indicating the stage within the overall research process and the role of the approach.

2.3.1 *Spring: Preparing the ground—Kids' Club*

“Kids' Club” is a technology laboratory where children between 10 and 16 years work with university students and researchers as co-designers of new technologies. The first Kids' Club following the agenda was established in 2002 at the



Fig. 2.1 Children ideating and learning in Kids' club

University of Joensuu (part of University of Eastern Finland as of 2010). Unlike a conventional afterhours technology club, the laboratory emphasizes research and an active collaboration with companies. Usually, an instance of Kids' Club has gathered twice a month throughout one school year with an overarching theme, like designing a miniature copper mine, or devising a smart door. The Kids' Clubs have had around ten children and two to three students or researchers per annum. Robots, like LEGO Mindstorms, have had a key role in shaping of the Kids' Club (Fig. 2.1) (Virnes et al. 2008).

The Kids' Club concept has been used in particularly challenging learning settings, with outstanding results. Learner groups consisted of both special education pupils with ADHD, Asperger's syndrome and autism, and an SOS children's village in Lusaka, Zambia. It has also been modified into a Seniors' Club where elderly citizens, with no prior skills in information and communication technology (ICT), have been able to design and implement digital games. The learning environments have allowed us to explore and devise novel technologies as well as pedagogical approaches to the learning process. The diverse settings have opened a novel field of study, and contributed to a set of research papers and theses.

Kids' Clubs have featured formal aspects, like curriculum and explicit learning goals. However, informal aspects of learning have dominated the concept. Children have solved authentic problems, and their work has not been formally assessed. Creativity and wide collaboration with local communities have

characterized the approach. The university students, most of whom are completing a Computer Science degree, that have been involved in the Kids' Club activities have not only got course credits but, more importantly, learned valuable competences from working with particularly demanding and knowledgeable customers. Thus, the mix between formal and informal aspects has not only shaped the children's learning process, but also that of the university students.

From the viewpoint of our overall research agenda, Kids' Club prepared the ground for understanding how co-design of technology can break the conventional separation of formal and informal learning. As a concept, it generated the dimensions describing the participation of the members of the learning community. Access, ownership and commitment cannot be classified as formal or informal aspects of learning. Besides the level of participation, Kids' Club focused our attention to the drivers of the learning process: invention, authenticity, diversity, and technology.

2.3.2 Summer: Growth by Cross-Fertilizing Formal and Informal Education—Contextualized ICT Education in Developing Countries

One of the challenges of ICT education in developing countries is that it does not match the realities of where graduates are supposed to work (Bass and Heeks 2011). Our work in Tanzania, at Tumaini University, Iringa University College, started with explorations on how ICT can be learned without the conventional approach of learning programming in the ABC style, starting from variables. Since 2002 we started the work by applying the Kids' Club approach of learning programming by building robots. Later we abstracted the approach from hands-on technologies towards context-in learning. The contextual undergraduate program in ICT started at Tumaini in 2007, and the first cohort of the three-year program consisted of 27 students. The program was built on the idea that the students, from the very first day of their studies, are working with local people that set requirements for the technology that the students, therefore, need to learn. In addition, the students get the topic for their thesis in their first year, which helps them to integrate their courses around a topic of interest (Tedre et al. 2009).

The frontier that allowed us to identify a dimension for learning at the Tumaini curriculum development process was that of courage. Most universities in developing countries have low academic self-esteem to design their own curricula that would match the surroundings. Also, private universities like Tumaini need to fund their operations by study fees. Introducing a novel program to its curriculum would present a fiscal risk by possibly resulting in a decreasing number of enrolled students.

Aiming at a university degree, the Tumaini ICT program is based on a formal approach: it follows a curriculum that has contents from the universal Computing curriculum. However, the formal aspects are balanced by informal ones.

Community outreach is a basis for problem-based theses that motivate students to explore on their own. The students also break the barriers of conventional undergraduate education by being exposed to and doing research within the user communities and novel pedagogical approaches.

Within the overall research agenda, the contextual ICT education forms the growing period which allowed us to cross-fertilize formal and informal education. The summer period of our research generated the dimensions of transformational and transactional university education. The dimension indicates the societal expectations of university education. The traditional transactional education emphasizes the values of formal education, like efficiency and standards, but does not reduce to it. Transformational education is an agent for change: education should not only serve as a wish list for future employers, but change the reality itself.

2.3.3 Autumn: Processing the Harvested Ideas—Context-Aware Mobile Learning Environments in Authentic Settings

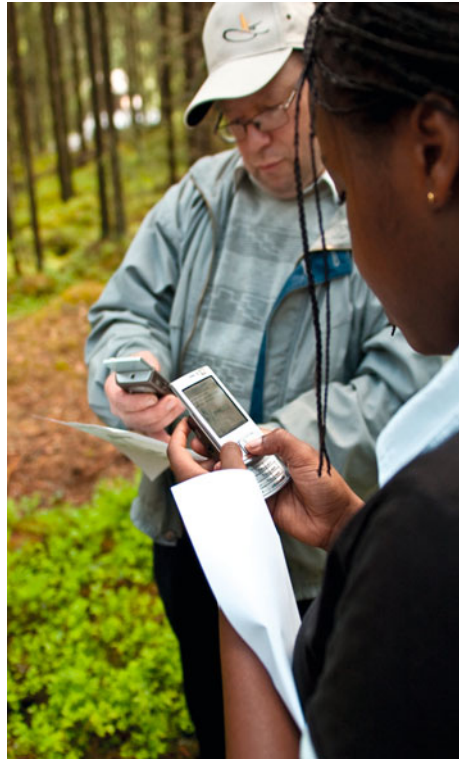
Idea-wise, our work in context-aware mobile learning games is an application of the contextual approach in education to technology itself. Since 2006, we have created mobile games for a science festival, an open-air museum, a forest located in a biosphere region, and the Museum of Technology in Helsinki (Fig. 2.2). All of these games have shared the context-aware approach that allows the mobile game to follow the user in the environment where they are. The games are based on interactive stories that require the users to carry out tasks or solve puzzles in the surrounding environment. For example, an interactive story takes an open-air museum visitor into the 19th century where they need to locate various objects within the museum premises in order to solve the puzzle (Islas Sedano et al. 2010).

The frontier that challenged the designers of the games was in game developers' interaction with the content experts. Museums, science festivals and biosphere regions are predominantly places for informal and explorative learning. Museum curators are not usually familiar with technology. Applying technology into these settings might easily flatten the experience and narrow an otherwise free exploration into a linear path. The linearization of a path has happened for example with interactive museum guides that mostly take the visitors the fastest way from one place of interest to the next one.

Formal aspects of context-aware learning games are shown in the rules of the games that enforce the visitor to experience the context as an organized setting. Informal aspects of the games are based on the authenticity of the learning experience in an out-of-classroom surrounding.

The period with context-aware learning games allowed us to process the harvest of our earlier intervention: the observations on the importance of context in the ICT curriculum design. The approach generated the dimension of context awareness. Context awareness is an integral perspective of the design process,

Fig. 2.2 Context-aware games are designed in their user environment in close collaboration with content experts



and it applies to the availability of local resources. In addition, context awareness can be intensified in the learning experience by technical implementation.

2.3.4 Winter: Consuming the Lessons Learned for the Next Rounds—Design Milieux

Inspired by our research on using ICT for HIV and AIDS education, we have come up with a scheme of design milieux (Duveskog et al. 2012). The concept of a design milieu captures the features that promote successful design of learning environments in authentic settings. Although based on the analysis of approaches described here, the concept of a design milieu allows us to reflect upon and summarize the lessons learned from the seasons of Kids' Club, ICT education in context, and context-aware games.

Unlike most research in educational technology, the analysis of design milieux does not pay attention to how technology enhances the learning process or its outcomes. On the contrary, it concentrates on the characteristics of the environment where a given learning technology has been designed and implemented. This

is an important aspect, because technology functions more and more as a tool to enhance the learning process, whereby the learning community becomes the design community rather than a user community of a set of digital learning materials. Thus, this research aspect has taken us from limits of a conventional user scenario towards a more unknown design scenario.

A design process can follow a formal pattern from specifications until an end product, and the co-designers can be assessed on their contributions to this process. However, learning as a design endeavor can be more naturally understood from the viewpoint of informal learning.

The outcome of the analysis of design milieux generated a dimension that describes a given milieu by the following characteristics:

1. Creative engagement of student designers.
2. Support from leadership.
3. Sense of ownership in process and product.
4. Freedom of expression.
5. The development of new expected and unexpected skills.
6. The variety of technical equipment and resources.
7. The appearance and quality of the intervention.
8. The achievement of goals.
9. Spin-offs.
10. The openness to outsiders and new ideas.

The exciting outcome was that a given characteristic can indicate a creative tension or conflict within the milieu. For example, the leadership can support part of the process but be overly critical of some aspects of it.

2.3.5 Synopsis of Complementary Dimensions Emerging from Explorations on the Ground

Table 2.1 summarizes the dimensions identified in the approaches presented in Sect. 2.3. It shows how different foci of the research have helped us to identify dimensions that complement each other. The different points of interest are linked to the four seasons. The preparation stage collects the aspects of what a learning process consists of: the participating learning community and the forces that drive them to learn. When informal and formal aspects of learning interact with each other in a real curriculum, the question is shifted to what outsiders expect from a (university-level) learning: should learning happen at a factory-like entity with standardized procedures or should it rather take place in an experimental unit that promotes change.

The third phase gathers the harvest as products, exemplified in our research as learning games. These games are quite logically based on the context-aware technology, because of the ground that emphasized the participation of the context

Table 2.1 Dimensions for learning generated by the four approaches

	Focus	Dimensions
Kids' club	Spring: preparing the ground	Participation: access, ownership, commitment Dynamics/drivers: invention, authenticity, diversity, technology
ICT education in context	Summer: growth by cross-fertilizing formal and informal university education	Societal expectation: transformational or transactional
Context-aware learning games	Autumn: processing the harvested ideas	Context awareness: design, resources, implementation
Design milieux	Winter: consuming the lessons learned for the next rounds	Creative tensions

and the cross-fertilization of the streams of informal and formal learning for transforming a given context. Therefore, the identified dimension focuses on various aspects of context. Finally, creative tensions identified by the study of design milieux illustrate the inherently conflictive qualities of any learning setting.

In the next section, we will analyze the dimensions more carefully, to be able to show how the educators can enrich their teaching by taking advantage of these dimensions.

2.4 Dimensions of Learning

2.4.1 *Level of Participation*

Our research on the Kids' Club as an open platform for technology learning has observed the importance that participation has for successful learning results. Participation can be analyzed by using the categories of access and ownership. Access means technical, attitudinal or other possibility to participate, ownership measures the level that access is relevant for self-expression. In particular, access to education or technology does not guarantee its ownership, and maximum ownership materializes as commitment, i.e., the allocation of resources to what is understood, or owned, as a relevant technology or education.

The observation is in sharp contrast to various programs that are based on the idea of delivery of technology to schools, to maximize its penetration. The delivery of technology has to be based on the demand of the learning community.

If access and ownership are dimensions independent of each other, following scenarios can be considered:

1. Minor access, minor ownership: Technology or education is rare or not available, and there is no demand for it either.
2. Minor access, major ownership: Technology or education is hard to access or difficult to use, but the few opportunities are fully used. This is usually the case for early adopters of technology. Their passion allows them to break the barriers from learning technologies and expressing themselves with it.
3. Major access, minor ownership: Technology is understood as transferred from outside and alien for the user communities. Technology might be used, because it is enforced, but it does not have a positive impact to the users' lives or they remain only users, not designers that can express themselves with it for their own purposes.
4. Major access, major ownership: Technology is available and in full use: the ideal scenario.

Even in countries where the ICT penetration at school is high, the educators might not use it, due to their low ownership (scenario 3). However, even a poor technology and low bandwidth do not prevent its functional use, if the learning community see how they can express themselves with it (scenario 2). The Kids' Club experience shows the importance for the drivers that support the ownership of the technology. They are described in the next section.

2.4.2 Drivers of the Learning Process

Another dimension identified in the Kids' Club concerns the drivers that motivate, initiate or foster a learning process. The dimension answers the questions of *what* drives, *why* learners get interested, *who* are maintaining the interest, and *how* the process is facilitated.

Invention means the outcomes of learning. Learning should always satisfy the learner's curiosity and will to find new observations, problems, solutions and insights. Therefore, invention answers the question of *what* to learn.

Authenticity tells what drives the learner to new inventions. Authentic learning is based on genuine interest and motivation that is rooted in the learner's immediate context or surrounding. Authenticity is the *why* of learning.

Diversity of the learning community is a prerequisite for innovations that solve authentic problems. A heterogeneous group of learners, the *who*, guarantee the representativeness and distribution of expertise that develops along with the learning process.

Technology is a vehicle that allows for diverse participants of the learner community to combine their skill and knowledge profiles to transform authentic problems into working inventions. It is the *how* of the learning community.

2.4.3 Societal Expectations from an Educational Institution

The five preparatory years before the launch of the contextualized ICT curriculum forced us to analyze the societal expectations of a university curriculum that both uses and teaches information and communication technology. From the early stages of development, it was required that the curriculum needs to differentiate from its many competitors that have been transferred to Tanzania without much rethinking. The university, by its rector, expressed the wish that the graduates became doers.

The design process of the contextualized ICT curriculum aimed at transformation that changes the surrounding society. The change process was to be conducted not only by competent ICT graduates, but even by students that were still taking classes, enabled by the openness of the curriculum itself. On the contrary, a conventional, transactional education serves the purposes given to the institutions from outside and beforehand.

Table 2.2 summarizes how transactional expectations from education, particularly that of a university, distinguish from transformational expectations. The aspects can be divided by three main categories. First, from the *relations*' point of view, a transactional institution follows the trends of the surrounding society, and its dependency is seen not only in its finances but also its values. It avoids risks when cooperating with its partners, and its teaching is based on textbooks rather than its own research.

Secondly, *organizational* issues distinguish institutions. A transformational university arranges teaching according to dynamic, open and flexible curricula where also its research partners can have their say. Academically, a transformational

Table 2.2 Transactional and transformational expectations from university education

		Transactional (effective within status quo)	Transformational (change)
Relations	To the trends in society	Passive to reactive follower	Active to proactive leader
	Of research to teaching	Teaching is based on repeating, presenting, performing research	Teaching is based on doing research
	To funders with respect to finances and values	Dependent	Autonomous
	To real life	Risk avoidance	Risk taking
Organization	Studies	Closed (Lehrplan)	Open (Curriculum)
	Academic	Discipline-based	Interdisciplinary
	Administrational	Hierarchy	Learning community
Students	Graduates	Qualifications	Competences
	Incoming students	Restrictive—entrance tests	Attractive—recruitment

institute favors interdisciplinary approaches where degree programs and research units cross the traditional borders of disciplines. Overall, the administration supports the institution's identity as a networked learning community.

Thirdly, the attitude towards *students* is most clearly seen in how the institution recruits new applicants and how it equips the graduates. A transactional university is superficial and formal in its selection process, whereas a transformational university is consumer-oriented and understands that it is primarily the students that choose a university, no more the other way round. Therefore, it takes risks in its student recruitment, and its flexibility in relations and organization guarantee that an excited incoming student can grow and graduate with competences that help them to outperform those with qualifications that do not measure the graduate's passion but superficial mastery of examinations.

In general, an emphasis on structures and formalities characterize a transactional educational institution. Its main task is to carry out the services to the society, according to predefined agreements. A transformational educational institution lives by its contents and spirit.

2.4.4 Aspects of Context-Awareness

The explorations with context-aware games exposed us to yet another dimension of learning, that of context-awareness. It can be measured by at least the following three aspects:

1. The design aspect describes the extent to which the design process has taken into account contextualization and participation.
2. The resources aspect indicates how well the learning environment makes use of local resources and copes with limited budgets available for small or poor user groups. In this way, it measures the sustainability of the learning intervention.
3. The technical or implementation aspect indicates the use of mobile and context-aware technologies in the intervention.

The previously identified dimensions—participatory, motivational and societal—orient towards the *people* of the learning community: their internal collaboration, their dynamics and their interrelations within the larger society. The context-aware dimension complements these dimensions, since it pays attention to how *technology* allows the learning experience to grow its roots in the surroundings where it takes place.

Like the other dimensions, the context-awareness of learning cannot be reduced to or measured by the dichotomy of formal and informal learning. Interestingly, the concept of awareness has conscious and unconscious connotations. The first connotation is used for example in issues like HIV and AIDS awareness, to refer to explicated and internalized understanding. The second one applies to the sensory use of the term: one can be aware of a sound without consciously paying attention to it.

The latent and manifest meanings of awareness are apparent also in the context-aware dimension of learning. Organic growth of learning within its surroundings, representing the aspect of resources, is often latent. However, it can be supported both formally and informally: allocating resources or making use of what is available, in improvised ways. The design aspect refers to an organized growth process of a learning intervention, and is thus manifest. Context-aware design benefits from formal and informal approaches: planned collaboration methods alongside with an open attitude and tolerance of diversity. The technical aspect shares latent and manifest viewpoints as the technologies enhance the aspects of both design and resources.

2.4.5 Creative Tensions

Our analysis of the process behind learning environments has identified a set of ten success factors for their design milieu (Sect. 2.3.4). Together, these factors define the fifth dimension of learning. It is related to the motivational or drivers dimension, because most of the identified factors measure the pull or push effects of designing successful learning environments. However, unlike the other dimension, the focus is on design, not learning.

The most interesting finding is the indication of simultaneous conflictive factors. For example, while it is important that creative designers enjoy a freedom of expression, a free context might feature conflictive characteristics of criticism and judgment. In this case, a factor that might sound counterproductive to a creative design process, might force the designer to redesign, reflect upon or re-assess their work, potentially improving the final product.

A creative tension is crucial for promoting out-of-box thinking. Our preliminary results indicate that the most exciting learning environments have been designed in milieu that have conflictive features. To some extent, this is contrary to the fairly common viewpoint that the learning environment should smoothen the learning process.

2.5 Role of Educators in Designing Technology for New Dimensions of Learning

2.5.1 The Educator's Four Agendas

Educators have a key role in reshaping education so that it meets with the challenges set for it. The dimensions analyzed in Sect. 2.4 translate to the educator's agendas that we call spring, summer, autumn, and winter.

Spring. Prepare your milieu as a living laboratory for learning. The milieu is where the learning happens, and it can also be called learning environment, context, setting, or surrounding. The term milieu emphasizes all different aspects of the place of learning, as part of the ecosystem it is embedded in. Preparing the milieu means that the educator familiarizes themselves to the milieu, to make full advantage of it. In that exercise, the educator makes use of the dimensions of participation and drivers.

The educator needs to ensure both the access (*laboratory*) and the ownership (*living*) of the technology that the learning milieu uses. Participation means that the learners feel comfortable in their environment and can express themselves so that learning becomes an activating design process for them. This requires two things: First, the teacher learns the talent profiles of the learning group, their interests, culture and background. Second, the teacher demands a technical environment that the users can learn to use for their self-expression.

The educator orchestrates the learning process by paying attention to its drivers. An ideal setting is built on a mix of formal and informal elements, like explicated principles and a creative atmosphere.

Summer. Cultivate the curriculum so that it transforms its environment. When the prerequisites of a successful learning process are guaranteed by participation and drivers, the educator starts growing the learning process so that it makes a difference in the learners' lives and their context. This requires open collaboration and negotiations with the surrounding community. The educator cannot isolate themselves within the school, but should proactively see the potential of the surroundings, which in some cases might exceed the geographical limits of the immediate neighborhood. Again, formal principles are handy to guide an informal, improvised interaction with the community.

Autumn. Harvest technologies by inviting skilled ICT professionals to co-design learning specific technological solutions within your real context. A technology-intensive learning setting is always a milieu that uses its local resources for designing new technological solutions. At this stage, a living laboratory that opened up to the rest of the community starts to produce new technologies. These solutions integrate the learning process to the surrounding, so to add authenticity, contextualization, and relevance. The educator with the rest of the learning community learns also technical skills. Like in earlier stages, part of this phase is formal with requirement analysis, specifications, and learning the technical environment, and the rest is informal exploration.

Winter. Incubate your own context as a creative design milieu, by making use of tensions. After the educator has managed to make the learning milieu a functional living laboratory that is actively involved with its wider context, also via the technologies that it has designed, the laboratory has changed into a creative design milieu. At that point, the educator starts to stimulate it by deliberately making use of the creative tensions within the milieu. This exercise can follow predefined, formal recipes, but also improvise.

To give an example of how these principles apply, let us consider a typical setting in the context of a developing country. A community multimedia center

(CMC) is a unit that is expected to serve a local community, like a village or a small town, and act as a hub for learning and using ICT. In many cases, it has reduced to a boring office with a decaying training room equipped with outdated technologies. The architecture of the building is based on traditional teaching scenario where the teacher makes the students to learn various features of software by heart. There is not only a question of what the learners benefit from the courses, but also what problems desktops solve in developing countries, in general.

To change the conventional, non-functional CMC scenario, we can follow the four principles. First, an existing CMC needs to re-position itself within the community that it serves. The CMC should not only be an access point for technology, but attract ownership and commitment among the user community. Secondly, the curricula—which does not need to restrict itself to ICT skills, but also design issues, business classes etc—needs to be rethought to transform the community as well as the CMC itself. A key issue is that the CMC needs to become proactive and take risks. Thirdly, the CMC can be a center that also designs relevant solutions to its surroundings. And last, the CMC should be a dynamic place that sparks innovation by admitting the tensions in its operations.

2.5.2 The Educator's Technical Toolbox

The educator needs the following technologies that are relevant for realizing new dimensions for learning. It is worthwhile observing that the selection contains very few mainstream educational technologies.

For participation that is more than access, the educator uses social media and tools that support dynamics and collaboration within the group, not just exchange of opinions. The collaboration can also be stimulated with hands-on technology exercise, such as designing and building robots. Technology can also intensify drivers, as tools for creativity (invention), context-aware technologies to integrate the technology to its surroundings (authenticity), or dialogue tools for understanding each other (diversity).

Whereas various database tools support the management and efficiency requirements of transactional learning, transformational learning requires information retrieval, including tools for text analysis, multiple representation, and digital stories. They also allow for analyzing and visualizing emotions.

Context awareness in design requires tools for contextualization and participation. To cope with limited resources of the context, either in poor settings or small groups, the educators can make use of various planning tools. But most importantly, for implementing tools that interact within the physical environment and integrate the learning process to it, educators need to master mobile and context-aware technologies, such as those using sensors.

2.5.3 Role of Data for Supporting New Dimensions of Learning

A general requirement for the successful use of technology relates to input and output data created in the learning process. An important aspect is data access and ownership. The latter refers to users' being proud of, protecting and taking care of their input data. This is an issue for all phases above, from creativity tools up to sensor technologies that require accurate input data. A crucial aspect of the output data is its appropriate and culturally meaningful representation; that is particularly important for learning.

It is also important to keep in mind that learning can be considered as a process that turns tacit or implicit data from the context into explicated information and knowledge that, again, can transform the very context. The learning milieu is a place or laboratory that supports this process of enhancing context awareness.

One of the key goals of learning is that it will have impact on behavior, a change in the learner or in their environment. Ideally, the learner's behavior changes from uninformed and heteronomic towards informed and autonomic. Technology should make the increasing levels of awareness transparent, from implicit and latent up to explicit and explicated; including the aspects of knowledge, attitudes and behavior.

An informal learning setting copes with uncertainty of the process, or even makes use of it. The data equivalent of uncertainty is rough data. Keeping this in mind, the information retrieval or other technologies used should not automate the refinement process of data (what happens, e.g., in Google Refine), but allow the learner to refine it by themselves, even at the cost of getting lost in the hyperspace.

The learner-controlled data refinement process should support positive filtering, *i.e.* to filter out the unnecessary extra data. Positive filtering does not mean building digital, negative filters, or barriers of prevention mechanisms blocking harmful information.

2.6 Application Areas in Developing Countries

The section shows how a few key areas, with high expectations in the developing countries, can benefit from the presented dimensions for learning. ICT is expected to penetrate throughout the society and as an overarching technology require well-trained ICT professionals. Various development projects, funded by governments from developed countries, are, after decades' of history with not only success stories, a standard tool for development.

Recently, the role of the poor, or the bottom of the pyramid (BoP), as technology users has attracted attention as a vehicle to reduce poverty. Apparently, the surprisingly high penetration of mobile technology among the poor has opened the eyes of the decision makers. The subjective power of the poor can be channeled by mobile technology in what is called crowd sourcing (Howe 2006): getting an

extended community of citizens to suggest or even design the ways how their living conditions can be improved. Companies are using crowd sourcing also to get ideas for their products or future services.

Microstudies is a theoretical, not yet realized example of how the new dimensions of learning could revolutionize learning in developing countries. Unlike the traditional, certificate or degree oriented formal education, micro-studying is based on learning module by module and building one's competence bottom-up.

The emphasis of the section is to show how the existing learning approaches can be significantly outperformed, by applying the dimensions seriously. The focus is on both multiplication and qualitative improvement.

2.6.1 ICT Education

As an integrating technology, ICT, in addition to biotechnology and nanotechnology, has been mentioned as one of the most potential areas that change the realities in developing countries. However, the level of ICT education in developing countries does not yet match the expectations from ICT graduates. Most ICT or Computer Science programs are still based on the international ACM/IEEE Computing Curriculum. Another problem is that ICT education is split up among institutions of varying academic levels, with only occasional interaction with each other.

For the dimension of participation, ICT education needs to emphasize ownership. The learners need to become master designers that can express themselves with whatever technology is available. This is in sharp contrast to enterprise-dependent, formal certificate programs that many ICT or Computing departments at, say, African universities arrange, on behalf of these companies. Currently, the programs focus on the accessibility of the given proprietary software.

As of the drivers, ICT education has to focus on the aspect of diversity. This is because the future graduates are expected to be able to work with diverse users, and understand their demands that might be expressed in most informal representations. Learning to make use of diversity helps also in designing ICT solutions that reflect new cultural settings, this far not exposed to ICT. These solutions might end up export products to the global community, for example, as adventure games or mobile weather forecasts based on oral stories.

ICT education, if any, needs to be transformational. In its relations to the society outside the educational institution, it needs to be proactive in initiatives, base its teaching on in-house R&D, and take whatever risks are required to cross the borders and work with companies, non-governmental organizations and individual, low-income user communities. It needs to be organized as a learning community that co-operates nationwide from the level of primary school up to the university. ICT education, rather than being predominantly a subject of its own, needs to be a central component in interdisciplinary programs. It could be implemented through

ICT4D (Unwin 2009), game design, or e-tourism. Students need to be recruited based on their interests and pragmatic orientation, and the competences of the graduate need to match the challenges of the region and the country.

Regarding context awareness, ICT education in developing countries is the most appropriate place to focus on context-aware mobile computing. This particular area can significantly benefit areas where mobile penetration is high and people are living in informal settings. Not only for natural disasters, but positively for surrounding market opportunities, context-aware applications are functional. Tourists can also benefit from mobile applications that help them to learn and understand an alien context.

ICT education has to take place in living laboratories on-site, rather than closed ones. Therefore, the aspects of design milieu can be used to nurture ICT education.

2.6.2 Development Projects

Development projects aim at enhancing a country's capacity for wealth creation. A typical example of development projects is STIFIMO, a science, technology, and innovation program between Finland and Mozambique. The Government of Finland is funding the program by 22 million euros in 2010–14. The purpose of the program is the following:

By the end of 2014, Ministry of Science and Technology of Mozambique with its strategic partners are running funding and support services for catalyzing and commercializing science and technology based innovations in Mozambique. Intensified and focused R&D and training activities in the areas of ICT and agriculture have turned these fields into role models on how to apply science and technology for innovations, within networks of diverse stakeholders. A few risk taking pilot initiatives have further transformed the Mozambican STI landscape.

2.6.2.1 STIFIMO Contributes to the Overall Objective

In 2025, Mozambique is fully using science and technology for innovations that contribute towards economic growth and poverty alleviation. This means that culture of innovation has emerged and expands selected sectors of the economy and strengthens its key clusters. The national STI system is effective and efficient and well-utilized due to its quality of service. Mozambique is known for its use of and contribution to international good practices. The country has managed to turn local human and material strengths into contextualized ST-based innovations, based on demand. Proactive collaboration between the private, public and academic sectors is constantly searching for synergies and cross-overs between the sectors.

Development projects and programs are in many ways intercultural learning processes, and therefore, it makes sense to apply the dimensions of learning to

them. Most of the current development projects, however, seem to follow quite simplistic patterns that leave little space for learning. This is seen in their lack of results that would benefit the developing country or region in question. A typical development project is based on a program document that formalizes, if not stagnates, the project to a set of consultancies, carried out by expatriates that almost literally follow the program document.

From the participation point of view, a development project requires commitment from the local stakeholders. From the viewpoint of a learning process, a development project is a school where all the stakeholders pay a study fee: this can be a formal prerequisite that can be acknowledged by ICT tools, in terms of used working hours, ideas, results or accomplished changes.

Development projects are driven by their authenticity. They require a bottom-up approach where problems are solved at the ground-level and functional innovations are promoted outside their sources by mobile technologies.

A transformational development project requires a learning community approach that is very far away from the conventional hierarchical administration followed in most developing countries. Stakeholders—the active student body of a development project—needs to be recruited based on their merits rather than formal statuses.

From the viewpoint of context-awareness, a development project require participatory and contextualized design, and building upon local strengths.

2.6.3 Crowd School: BoP Sourcing as a Global Learning Exercise

Kenya's becoming the world leader in mobile banking is a success story that is based on the BoP thinking (Hughes and Lonie 2007). The demand among ordinary, often poor, citizens paved the way for an industry that has in many ways reshaped the financial landscape of Kenya and other developing countries. Not only the transfer of money has become independent of one's ability to go physically to a bank, but m-banking has also revolutionized the way the products and services are marketed and paid for. This has fundamentally changed the opportunities for small-scale entrepreneurs.

Crowd sourcing means solving complex problems in parallel. In a way, a problem—whether open or closed—can be given to a global user community that start contributing to its solution(s), making use of the computing power that they have available. This means that both the individuals and their computing powers are used in parallel. As mentioned earlier, an interesting observation is the amount of the people with mobile phones in developing countries. The mobile phone users can have a substantial role in solving global problems in an orchestrated—yes, partly formal—way, participating in a global, authentic—yes, understood traditionally as an informal—learning process.

When thinking of learning from the viewpoint of a learning community, crowd sourcing can enhance learning by making a truly distributed effort where people with

different talents solve problems. For example, one way to use computers for HIV and AIDS education is based on students' real life stories that they craft into a digital form. Sharing these stories on a distributed platform that possibly automatically interlaces the stories contributes to getting a bigger picture of the complexity of the HIV and AIDS phenomenon. This requires that an individual teacher works closely with the particular context, to collect the stories, but at the same time ensures that the community shares their stories within a global community.

A *crowd school* is a learning approach where a global BoP learning community combines forces to solve a given, complex problem. How could a global crowd school look like? An example that makes use of diverse schools around the globe is the Environment Online (<http://www.enoprogramme.org/>). It is organized around thematic assignments on environmental issues. The virtual school features concrete assignments, like tree planting and various other campaigns. A challenge is to use technology to orchestrate the tasks into massively parallel assignments within the BoP communities that use mobile technologies, and to support these assignments automatically.

Going back to our example of m-banking, we can build an analogue between money transfer and knowledge transfer. In the same way as real money is transferred in m-banking, a crowd school revolutionizes the distribution of knowledge and ideas within its network. Whereas m-banking transforms individual entrepreneurship into profits, the transfer of information and knowledge materializes into solutions and new insights in a crowd school.

Using the presented dimensions, a crowd school calls for the ownership of given problems and is driven by a hunger for invention. An outside society expects it to come up with radical openings, so it is transformational. From the context-awareness point of view, it emphasizes the use of available resources.

2.6.4 Microstudies: An Application of Microloans to Education

The concept of microstudies applies the success of microloans into education and training. Microloans have transformed the lives of masses of small-scale entrepreneurs. According to the concept, the bank is not asking for major and long-term business plan for a major loan, but the customer starts from very small amounts of a few euros. Based on the success of the entrepreneur's portfolio, they can apply for bigger loans and develop the business accordingly.

Following the microloan concept, microstudies are a sequence of modules that develop a learner's competence in a given area. The learner is expected to have a mobile phone into which they can order the required module. The building competence profile is stored digitally on a server. The learner can use the profile and history at job interviews. The learning process is not based on distant learning objectives, like those of certificates or degrees. On the contrary, the goals are

simple upgrades on his or her current skills. The modules can be paid by airtime. Over the years, the learning path that consists of the sequence of modules can be transformed to a certificate or degree.

Microstudies are more individual than a crowd school, and also more formal. This can be seen in the dimensions relevant for microstudies. Reliable access is prioritized at the cost of ownership. An efficient and inspiring technical implementation can also work as the driver of a successful learning process. This is also seen in the transactional emphasis of microstudies that make the best out of available resources. This said, it is important to observe that microstudies are a cross of formal and informal education, and their requirements emphasize practical competences rather than knowledge.

2.6.5 Mapping Educational Challenges in Developing Countries onto the Dimensions of Learning

The examples presented in this section show that the dimensions can be applied in versatile ways for most diverse application areas. Table 2.3 summarizes the dimension profiles for the presented application areas. It is important to note that the creative tensions of design milieux apply to any application area, and have therefore been omitted from the analysis.

Table 2.3 shows that the identified dimensions of learning help to focus the design and teaching efforts onto the critical aspects of learning. The analysis shows that there is no one best practice or approach for improving learning. The analysis also indicates that the introduced dimensions are independent of each other, and only dependent on the requirements and demands from the intended learning context.

Once again, the idea of characterizing learning based on its formality loses meaning when brought into a context. For example, for tackling the massive challenge of inappropriate or completely lacking ICT education in developing countries, a much more fine-tuned approach is needed than organizing adaptive online courses matching the formal learning requirements.

Table 2.3 Dimensions of learning applied to a few relevant application areas in developing countries

	Participation	Drivers	Transactional versus transformational	Dimensions of context
ICT education	Ownership	Diversity	Transformational	Implementation
Development projects	Commitment	Authenticity	Transformational	Design, resources
Crowd sourcing from BoP	Ownership	Invention	Transformational	Resources
Microstudies	Access	Technology	Transactional	Resources

It is interesting to note that in a set limited to only four different scenarios, all the aspects of the presented dimensions were required. The observation means that the presented dimensions are expressive and sensitive to the differences of the environments.

2.7 Discussion

Juxtaposed with the traditional dichotomy of formal and informal learning, we have identified a set of new dimensions that an educator can make use of to intensify and diversify his or her teaching setting.

The dimensions were identified from various real life settings where new technologies were applied in living laboratories that had features from both formal and informal learning. All the interventions covered several years of research. The research agenda was, together with the learning community, to create new pedagogical approaches and related technologies and analyze their feasibility. Unlike a typical study in educational technology, we were not interested in the effect of a particular technology to learning outcomes, but diverse aspects on how the learning changes together with new technologies. One of these results is the identification of the dimensions of learning.

Retrospectively, the four different interventions and their results have been arranged with the metaphor of seasons. The four seasons focused on the roles and dynamics of a learning community (spring), how the learning community answers the expectations of its surroundings and possibly changes it (summer), how to the community co-designs new technologies that integrate learning to its physical context (autumn), and finally, how the learning community survives as a design milieu with diverse creative tensions (winter).

Rather than organized or planned beforehand, the research process was explorative and organic. It identified the dimensions of participation, drivers of learning, focus of societal expectations, context-awareness and creative tensions in the learning environment as a design milieu. These dimensions are not aligned with the dichotomy of formal and informal learning. Rather, they help to cross the boundary between formal and informal learning. This is an important finding, because the boundary easily stagnates the reforms in education. For example, ownership can be encouraged in both formal and informal settings, and authenticity is a useful driver for all learning. The derived dimensions show that the boundary is artificial, and the dimensions encourage, for example, educators to use and design versatile technologies for their particular learning settings, independently of their being formal or informal.

There are three main target groups that can benefit from the dimensions: educators, designers of educational technology and researchers.

Regarding educators, the findings emphasize the design orientation of learning and teaching. The future of education is in its functionality: the learning community learns by designing artifacts that increase their awareness of their context. The educator facilitates this process that exceeds any physical, disciplinary, maturity or other limits that traditional schooling is based on; the context is not restricted to the immediate physical surroundings. This far, various limits have usually determined the forms of education: classes, age groups, subjects, degree contents, objectives and so on. The design orientation emphasizes the roles of improvisation and inspiration. It also has an impact on the professional identity of an educator.

For a designer of technology for education, the study reminds of the need for novel technologies for learning. Basically, the learning technologies should allow the learner to elaborate their awareness of the surrounding reality. This requires advanced features for context-awareness and tools that they can use for representing the learning process, transforming raw data or tacit knowledge into more explicated forms of information. Moreover, the technologies should allow sharing this forming knowledge within the most heterogeneous and distributed learning communities, i.e., people speaking different languages, representing different world views, using the same expressions for different meanings or emotions, or the other way round. In other words, we can use the term *hermeneutic* technologies, to emphasize the importance of interpretation of observations in the learning process.

In terms of researchers, the dimensions call for more context-oriented an approach to learning. Much more than this far, the learning requires relevance, at the cost of structures. Context-orientation is a cross-disciplinary challenge where the new technical solutions go side by side with the advancing understanding of learning. Moreover, the context is a multilayered concept: an individual learner belongs to multiple contexts simultaneously that vary within the community. Technologies are required to help the learner to manage the learning process through the overlapping contexts.

Much of the article is based on contexts outside the mainstream of technology-intensive learning settings. The reason for the discrepancy lies in the research agenda of the author. For a fresh understanding of learning and the role of technology therein, researchers need to take a way outside their camp and be exposed to realities outside their comfort zones. We cannot find answers to the challenges of teaching the next billion by sitting in our well-equipped classrooms and in closed technology laboratories. The more challenging a learning context is, the more it requires a researcher to focus to find an out-of-box solution to these challenges.

The dimensions of learning were derived from a few concrete learning settings. This raises the question of the validity and generalizability of these dimensions outside these living laboratory settings. To some extent, this is a fair question, but the diversity of the settings and the length of each intervention compensates for the lack of representative sampling. Rather than a statistically oriented survey, the

derivation process has been, deliberately, explorative and focused on a deep analysis of the settings in the review. To show the validity of the results, the derived dimensions of the selective study have been tested in other selected learning scenarios.

Richard Branson has challenged educators with his idea of a tented university in Africa. To think of a learning milieu as a caravan, or educators as nomads, is aligned with the dimensions identified in this study. A functional design should bend modern technology towards tools that incorporate the dimension of learning to whatever learners need to accomplish, by their minds or hands. Becoming competent in knowledge, skills, attitudes, values or behavior should not be an artificially isolated island from the rest of life, but an integral part of it. Like a tent that can be set up anywhere, the future learning milieu is as ubiquitous as a campfire in the African night. The difference is that it breaks the boundaries of what, where and how the traditions allow one to learn.

2.8 Conclusion

We have presented a set of new dimensions for learning. The dimensions are based on a few analyzed research-based learning interventions. They all took place in the borderland between formal and informal learning: in K12 after-hours technology laboratories, explorative university education in a developing country or in places where people are supposed to learn on their own, like a museum or a national park.

The set of identified dimensions emphasize different aspects of learning: the degree of the participation within the learning community, the drivers that motivate a learning process, the societal task expected from an educational institution, and the role of the surrounding context. The creative tensions as indicators of productive design milieux show that learning always takes place in a dynamic field.

Examples for the context of developing countries showed that the dimensions have potential to significantly change the traditional educational settings and cross their conventional boundaries. The role of the educators in the effort is crucial. The teachers need to rethink their roles and tasks as educators, towards the direction of becoming conductors of highly distributed learning processes.

The transformation in the educators' role requires technology. For example, technologies used in crowd-sourcing can make the world into a global think-tank that solves problems at hand. This kind of learning makes use of advanced text mining techniques for information retrieval.

But future educators do not only orchestrate global learning processes from within their immediate contexts. They turn these contexts into design milieux that produce digital and artifacts and context-aware tools for learning. A learning community for functional design reminds of the Bauhaus movement in the 1920s.

All in all, the use of the dimensions helps educators to assume varying roles, improvise, and even act globally, if needed. The flexibility is necessary for the

reform of education. The reform is required by the challenges caused by reasons that look quite different from each other: fast and unexpectedly changing competence requirements of working life, the minimal or lacking educational infrastructure or missing teachers in developing countries, or the aging populations in the countries of high income.

The study shows the need of further research in the area of context-aware learning. Most of the current technologies for education are supposed to ease the administrative or pedagogical management of learning processes or provide learning and teaching resources available where and when needed. Context-aware learning technologies offer instruments that root the learning into its surroundings.

A key question is how technology can provide a cozy, homely learning environment for the masses that do not have a privilege of schooling. Social media can provide a stimulating, even addictive environment with supportive peers. However, it is a significantly harder challenge to make sure that the members of these communities get competences that match the requirements of the job markets for the lifetime of the members.

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