Abstract
The current educational system will change fundamentally due to arising challenges. Increasing migration rates and the demand for inclusive education will extend the already existing diversity among the learners. At the same time, modern learning theories demand new educational concepts. Learning should be motivated by the elements of the Self-Determination Theory (autonomy, awareness of competence, and social relatedness) and learners should construct their knowledge actively in a situated and social context. Facing these challenges, we propose a learning scenario based on learning tasks. The teachers should assign collaborative tasks that are individually designed and tailored to the needs and abilities of the students. The learning processes should be supported by a Personal Learning Environment (PLE), which supports the learning scenario by providing and managing learning materials and tasks and enables the collaboration among learners. The universal (system) design has to provide accessibility for various groups of users, in particular people with disabilities.

Keywords
Learning scenario, personal learning environment, social networks.

INTRODUCTION
Presumably, learning scenarios in European schools will change dramatically during the next decades, enforced by the increasing diversity of students, in compliance with the modern understanding of human learning as situated, socially embedded, active construction of knowledge, motivated by autonomy, awareness of competence and social relatedness. It seems obvious that efficient learning cannot be restricted to closed classrooms and by fixed time-tables any more. Instead, the learning process will be promoted by comprehensive, contextualized tasks that are individually tailored to the students’ individual abilities and prerequisite knowledge. The students will process these tasks in close collaboration with peers. In accordance with (OECD, 2004), we suppose that progressive learning scenarios will not be become prevalent without substantial support by specific ICT systems, called Personal Learning Environments (PLEs). One reason for this assumption is the tremendous workload of teachers that will be caused by such scenarios, another is the need for peer discussion that is inherently postulated by modern pedagogic approaches. Both problems could be alleviated by ICT systems that make use of technologies that have made the breakthrough during the last couple of years. First, nearly every student has permanently access to a very powerful computing, information and communication device in form of his/her smartphone. Second, social networks are connecting millions of people all over the world. The problem for learning is that students mostly have to seek other learners with similar interests laboriously. Third, the increasing number of MOOCs is offering more and more information and tasks, developed by specialists and often professionally presented. Forth, cloud computing allows to exchange data
easily between electronic devices all over the world, provided that they have access to internet.

In this article we describe the presumed typical learning scenario of the future as well as the design outline and the development process of our PLE proposal MyLearnSpace. The requirement analysis of MyLearnSpace was explained in detail in (Böttcher, 15.11.2014). The basic ideas of the assumed future learning scenario was sketched in (Hubwieser & Böttcher, 2014) already.

PEDAGOGICAL BACKGROUND

Already at the beginning of the last century, Maria Montessori (1870–1952) developed an educational approach, with the key elements independence, freedom within limits and respect (Montessori, 1993). The focus was set on individual learning, because learning would happen only intrinsically and thus cannot be prescribed externally (Montessori, 1993). Montessori postulated prepared learning environments to stimulate learning. Further, she introduced the use of adaptive learning material to stimulate autonomy (Montessori, 1993). Her approach preferred learning from working with materials, instead of direct instruction.

Célestin Freinet (1896–1966) and his wife, Élise Freinet (1898- 1983) postulated that students should learn by collaboratively working through provided learning materials that have been partly constructed by the students themselves (Freinet, 1964). Further, the learning process should be self-determined by the students rather than teacher-driven. As far as possible, the students should decide what they want to learn, with whom they want to collaborate and how much time they need for it.

The Self-Determination Theory (SDT) (Deci & Ryan Richard M., 1985), (Ryan & Deci, 2000) emphasizes that classroom practices that support students’ satisfaction of autonomy, competence, and relatedness would be associated with both greater intrinsic and autonomous types of extrinsic motivation. Autonomy means that the learner has to decide what he or she wants to learn at a certain point of time. To experience one’s own competence needs to work active on problems and tasks. The need of social relatedness demands to learn together with other students that are similarly motivated to do work on the same topics and problems. Further, the SDT postulates three central innate psychology needs, with all of them relating to the intrinsic and extrinsic motivation (Deci & Ryan Richard M., 1985), (Ryan & Deci, 2000), (Niemiec & Ryan, 2009): (1) competence, (2) social relatedness, and (3) autonomy.
The learning theory of Constructivism, based on the work of Jean Piaget, Lev Vygotsky, and Jerome Bruner, claims that knowledge is actively constructed by the learners rather than "transferred" from any source of instruction. It is based on the assumption that "we generate knowledge and meaning through experience" and that "knowledge is both individual and social" (Muise & Wakkary, 2010). Learning environments should support a maximum of self-control by the learner, since learning is considered as a self-driven process (Gräsel, Bruhn, Mandl, Fischer, & others, 1997). (Reinmann-Rothmeier & Mandl, 1996) remark that learners would need support in case of arising problems, which cannot be solved by the learners themselves. (Cobb, 1994) argues that knowledge is both constructed through social interaction and in the individual’s mind.

According to (Caine & Caine, 1990), the "objective of brain-based learning is to move from memorizing information to meaningful learning". Therefore, learning has to be contextual and teachers must take student interests into account: (Caine & Caine, 1991) demands that the sources of information should be quite complex, including social interactions, group discovery, individual search and reflection. Additionally, the classroom organization should support the collaborative construction of subject matter knowledge, using workstations and working on individualized projects. Many responsibilities are delegated to students, while the teachers are only monitoring.

Butler and Winne provide an analysis of cognitive processes involved in self-regulation (Butler & Winne, 1995). They review several interesting areas of research, including affect and its relation to persistence during self-regulation. Further, the role of self-generated feedback in decision making and the influence of students’ belief systems on learning are investigated. They state: “For all selfregulated activities, feedback is an inherent catalyst. As learners monitor their engagement with tasks, internal feedback is generated that describes the nature of outcomes and the qualities of the cognitive processing that led to those states.” For our purpose, their model of self-regulated learning could serve as blueprint for our learning scenario, see figure 2.

![Figure 2. Model of self-regulated learning according to (Butler & Winne, 1995).](image)

The learning strategy of peer instruction was developed by Eric Mazur at the Harvard University (Crouch & Mazur, September 2001). He is working with specific content related conceptual questions, "which probe students’ understanding of the ideas just presented. [...] Students then discuss their answers with others sitting around them; the instructor urges students to try to convince each other of the correctness of their own answer by explaining the underlying reasoning" (Crouch & Mazur, September 2001). Several surveys have demonstrated that this method works quite well. It seems able to enhance the learning success dramatically in some cases (Crouch & Mazur, September 2001), (Porter, Bailey Lee, & Simon, 2013).
In 2006, the General Assembly of the United Nations adopted the Convention on the Rights of Persons with Disabilities (United Nations, 2006). It demands that all countries have to ensure inclusive education at all levels. Separate schooling for disabled students should be cancelled and all students should be integrated into common mainstream education. Obviously, specific assistive technologies will be one of the key factors for the success of this educational inclusion (Douglas, Corcoran, & Pavey, 2007).

**TECHNOLOGICAL PREREQUISITES**

Social networks connect people. This can be done in two different ways, which can be combined. For one thing, users can add each other to their friends list (Werdmuller, Tosh, Files, & Free, 2005). Like in the "real world", friends on on-line platforms are more likely to collaborate than users who do not know each other (Dillenbourg, 1999). (Werdmuller et al., 2005) mention that (virtual) friendships are created by shared fields of interest. Besides bilateral friendships, communities are connecting users with shared interests. (Liccardi et al., 2007) describe communities as "informal groups of people that develop a shared way of working together to accomplish some activity". They emphasize that the membership of a community is "usually self-selected and self-organized". Typical components of communities supporting collaboration are forum, file management and wiki (Werdmuller et al., 2005).

Massive Open Online Courses (MOOCs) became an educational buzzword in 2012 and have enjoyed wide media coverage in the popular press (Marshall, 2013). The first course presented under the name MOOC took place in 2008. In contrast to traditional ways of teaching, where the size of participants is restricted, MOOCs have to be easily scalable, which causes a need for different technologies to provide or support this scalability (Wulf, Blohm, Leimeister, & Brenner, 2014): peersupport, gamification, learning-analytics, (peer-)grading, verification of identity, validation and plagiarism control. Up to now, three prominent technical platforms for MOOCs have been established: Coursera, edX and Udacity, which have their origins at American elite universities.

The term Ubiquitous Computing was created by (Weiser, 1991), where he predicted: “Specialized elements of hardware and software, connected by wires, radio waves and infrared will be so ubiquitous that no one will notice their presence” and “Ubiquitous computers will also come in different sizes, each suited to a particular task. My colleagues and I have built what we call tabs, pads and boards: inch-scale machines that approximate active Post-It notes, foot-scale ones that behave something like a sheet of paper (or a book or a magazine), and yard-scale displays that are the equivalent of a blackboard or bulletin board”. In (Krumm, 2010), the editors present an overview of the rapidly progressing field of ubiquitous computing. It covers the major fundamentals and research in the key areas that shape the field. Eleven of the most prominent ubiquitous computing researchers contributed chapters to this book. According to (Krumm, 2010), ubiquitous computing research can be categorized into three distinct areas where the research is focused: systems, experience, and sensors.

In 2011, the US National Institute of Standards and Technology (NIST) has published its commonly well-accepted definition of Cloud Computing (Mell & Grance, 2011): “Cloud computing is a model for enabling ubiquitous, convenient, ondemand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.” Furthermore, the publication lists three Service Models (Software, Platform or Infrastructure as a Service). For MyLearnSpace, the first one is relevant (Mell & Grance, 2011). Among
the described deployment models described in (Mell & Grance, 2011), the Hybrid cloud. meets our demands: "The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds)."

**RELATED WORK**

In 2004, the International Schooling for Tomorrow Forum organized by the OECD developed a set of six scenarios for schooling in the future up to 2020, categorized according the overall role of schools in the society: On the summarizing website (OECD). The scenarios are classified in three categories: (1) Attempting to maintain the status quo (2) Re-schooling – major reform and renewal of schools and (3) Deschooling – widespread disestablishment of school systems. According to the original publication document of the scenarios (OECD, 2004), the crucial role of ICT is explained in detail. Additionally, the learning scenarios are detailed. From our point of view, our vision is a combination of the scenarios 2b and 3a.

In 2006, Microsoft has published a vision for the future of education that reflects the impact technology can have on policy and practice (Rasmus, 2008). Microsoft used its Future of Work scenarios to explore possible scenarios for learning in the future. Based on a scenario-planning process education was explored “through the lens of work, examining educators, learners, and administrators in the context of creating, synthesizing, absorbing, sharing, and managing information”.

In principle, a PLE is composed of all tools that a person uses to support learning (Attwell, 2007) Typically PLEs support learning in three main fields: (1) the learners are supported in setting and achieving their own learning goals, (2) learners can use PLEs to manage learning content and their own learning process (Cooper, Grover, & Simon, 2014), and (3) PLEs are based on the paradigm of social construction (Kreijns, Kirschner, & Jochems, 2003). Hence the communication with other learners should be facilitated. In consequence, a PLE has to be related to social network systems (Attwell, 2007).

According to (Cooper et al., 2014), PLEs have the following goals: “facilitate easy sharing, search, and retrieval of relevant knowledge and resources, help connecting people and provide easy-to-use tools for collaboration, especially around curriculum design, leverage social tools and data visualization techniques to highlight popular content as well as address burning issues and questions; provide members visibility into the relevant activities and projects, and avenues for active participation, support curation of content and facilitation of the many activities the vCoP supports, afford low barriers to sign-up and participation, and provide materials to help newcomers to get started, and incorporate features to allow busy educators to keep up with – and participate in – ongoing discussions and activity on the site”.

**THE LEARNING SCENARIO**

A comparison of the learning theories presented in section 2 shows that most of them recommend the following essential elements of successful learning processes: (1) activation and autonomous working of students, (2) collaboration among students, and (3) contextualization of learning tasks. Based on these elements and in respect of the increasing diversity, we suggest the following “learning scenario of the future”.

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The overall organizational structure could still be quite traditional: a teacher is teaching 1-2 subjects and takes care of several classes or courses in these subjects. Every student attends classes in about 15 different subjects, depending from the grade and the type of the school.

The individual learning processes are promoted mainly by learning tasks, which are assigned to the students individually by the teachers. The students work on these tasks in small groups for 1-2 weeks, trying to solve problems on their own or by asking peers. They should ask the teacher only if this is absolutely necessary. The teachers are monitoring their progress and their motivation level. The individual learning tasks would be quite different from the simple “homework-assignments” that are currently assigned in most cases. They have to be put in a thrilling and motivating context that is related to the students' experiences. This context has to be tailored individually, for instance according gender or personal disabilities.

The basic goal for the students during the task is to acquire competencies in the sense of (Weinert, 1999), who defined competencies as “the cognitive abilities and skills possessed by or able to be learned by individuals that enable them to solve particular problems, as well as the motivational, volitional and social readiness and capacity to use the solutions successfully and responsibly in variable situations.” Furthermore, he stressed that competencies may be composed of several facets: ability, knowledge, understanding, skills, action, experience, and motivation.

Apparently, the learning tasks will have to be quite complex, yet separable in different completion stages, called milestones. The completion of a milestone has to be reported by the students to the teachers by submitting certain artefacts, for instance a text document, a drawing or a tangible device. Again, the nature of these artefacts may depend from individual attributes of the students. The nature of the learning tasks may vary broadly. From simple summaries of texts, books or websites over the conception of systems, solution of mathematical or physical tasks to the collection of a portfolio that consists of elements of different nature. Regarding the collaborative work on projects, this could be subdivided into different learning tasks for each of the participating working groups.

The timetable of a certain class is only rudimentary. In each subject the students have to attend about one introductory lesson and one presentation meeting per 2 weeks. Assuming that these meetings take about one hour each, it results in about 15 hours per week in a traditional classroom. The rest of weekly working time (about 25 hours in all-day-schools) would be freely disposable for teamwork on individual tasks. The resulting workload of teachers according to this scenario was calculated in (Hubwieser & Böttcher, 2014).

In the terms of the model for self-regulated learning of (Butler & Winne, 1995) (see figure 2), the teacher assigns the tasks, trying to link it to the prerequisite knowledge of the students. The goals are negotiated with the students. Additionally, advice for tactics and strategies is given to the students. Their performance is assessed according to the quality of their products (representing milestones or final outcomes). The external feedback comes from the teacher and from peers.
In our opinion, the task processing should principally (not exclusively, but in most cases) take place in the following steps (see figure 3). The teacher organizes the introduction into a new learning topic. This should provide information about the topic and its relevance for the students, suitable contextualization and activation of students' prerequisite knowledge. Additionally, most intended competencies require certain knowledge that has to be provided by some kind of information input. All provided information has to be accessible (barrier-free) by all students of the course. This requires that the teacher has to provide suitable access for instance to students with visual or auditory disabilities. This activity might take place (at least partly) in a traditional classroom, which is no more necessary for the following steps until the presentation. According to the individual abilities of the students and the respective (also individual) learning objectives, the teacher assigns different suitable, comprehensive tasks to groups of 2-3 students and agrees with the students upon the working schedule and the intended outcome of the task (solution or product). To unburden the teacher from the production, this input should come mostly from suitable prebuilt information sources, which could be analogue, originating from haptic or printed media as well as digital, e.g. from MOOCs. Nevertheless, the teachers still will have to select, restructure, recombine or reprocess original information out of different sources for this purpose. The students work for 1-2 weeks on each task. Thus, each student has to work on many tasks during the school week. As this work is performed without prescribed timetable, students are free to choose on which task they will work at a certain time. Nevertheless, there will be some restrictions, because the team members have to meet or because some specific resources are needed. The tasks are subdivided in milestones. If a milestone is accomplished, the students report this to the teacher. The teacher inspects the working progress and gives feedback. If problems arise, the students try to solve these by themselves as far as possible. For this purpose, supported by a PLE, peers are contacted that are working on the same learning topic. Given that this assistance by PLE would not be restricted to the same school, age group and region, there would be plenty of people that could help. As soon as the students have completed a task, they approach the teacher and ask for acceptance of the solution. Depending on the outcomes of the work, the teacher will give feedback, demand further improvements or accept the product for presentation. In this case, the task outcome will be presented at the next presentation meeting of the whole class or course, aiming to communicate the results and seeking final
feedback from peers. From time to time, the class is given a summarizing task that aims to integrate the results that have been presented by all class members.

The outcomes of the tasks in combination with the quality of the presentation are certified and graded by the teacher. Potentially, the teacher might demand an additional oral examination about the task, e.g. to assure and test individual learning progress, verify originality, defend plagiarism or to decide different performance levels of the team members. At the end, the outcome of a school career of a certain students will consist of the collection of certifications of tasks. Depending on number, completeness, requirements, quality or performance of this collection, different graduations may be rewarded. By this way, the separation of students in different school types (as Gymnasium, Middle School or Main School in Germany) could become obsolete.

DESIGN OUTLINE

Being well aware of the performance capability of current E-Learning systems, we are not intending to reinvent all their accomplishments. We are regarding Moodle (www.moodle.org; recently ranked as the top E-Learning system among the “Top 100 Tools for Learning 2014”, see c4lpt.co.uk) as the reference system for E-Learning platforms and assume that our PLE should have at least the functionality and features of the current Moodle version 2.7. In consequence, the following requirement analysis will only address functionality that is not (or at least not in the desired extent) featured by Moodle.

In principle, according to the central elements of our learning scenario (see section 5), the PLE should provide the following basic functionality: (1) task management: support in finding, designing, assigning and managing learning tasks, their processing and their outcomes, (2) collaboration management: support in finding and managing peers for collaboration and (3) media management: support in finding and managing learning material, media and other artefacts.

MyLearnSpace should be accessible everywhere the students and teachers are able and willing to work on it. On the one hand, this requires the accessibility by desktop or laptop computers as well as by handheld devices as smartphones or tablets. On the other hand, the data have to be stored on a central server that is accessible by all these different devices. In general, the PLE should be accessed via a normal web-browser. Yet, for mobile devices, which are often restricted in the use of internet, an App would be more appropriate.

The need of inclusive education as prescribed by the UN Convention on the Rights of Persons with Disabilities (United Nations, 2006), raises the requirement of being barrier-free as far as any possible. In consequence, all material must be displayed (at least as far as possible) by all perception channels that are technically available (haptic, visual or auditory channels). For this purpose, modern assistive technology has to be integrated or properly interfaced, for instance screen readers or Braille displays. Auditory materials as sound recordings have to be transcribed as far as possible.

The role management has to distinguish the different types of users and their access permissions. Up to now, we have identified the following groups, each represented by a specific role, ordered by decreasing permission extent: Programmers, System Administrators, Curriculum Admins, Teachers, Parents, Students, External Contributors and Advertisers/Sponsors. The Teacher role has to be explicitly awarded by the supervised students respectively their parents in case of minority.

As any other ICT system, the design of a PLE has to consider issues of information security, privacy and data protection. Depending from the types of data, the demands
in this regard vary from “very low” to “high” on a 5-point Likert scale. The lowest value might be valid for the learning content, as long as it is strictly separated from user content, which has the highest demands on data protection. The latter could be eased by using pseudonyms (in agreement with the teachers) instead of the real names of the students. As it concerns the “engine” of the system the administrative content should be treated on the same security level as the most sensible other content.

Basically, the data (content) of the PLE could be subdivided into learning related content (tasks, learning materials and their metadata, communication elements like wiki entries, blog entries or forum threads), user related content (role, personal data, school context, grades etc.) and administrative data (list of tags, structure of metadata, information about the specific hard- and software environment, version control, permission lists of the user groups, etc.).

To support the basic functionality, the learning content of MyLearnSpace is organized around the “main topics” of the relevant curricula, corresponding more or less with the main chapters of typical curricula or schoolbooks. In the curricula of our home state, we estimated about 10 main topics per subject and year, for instance “irrational numbers and square roots” or “prism and cylinder” in an exemplary curriculum of mathematics. If we assume that the set of main topics is similar for each school subject over all states and countries, we would have to set up about 15*10 = 150 topic rooms over all grades per school subject. The internal knowledge structure of these topics will be represented by a collaborative concept map, see (Hubwieser & Mühling, 2011). The integration of new curricula and topics or of changes in the already integrated ones will be taken over by certain distinguished teachers in the role of Curriculum Admins.

Apparently, this structuring principle is helpful regarding the management of learning material. For the task management this seem natural also, because all the tasks are related to learning objectives which are closely related to those “main topics” of the curricula, representing the knowledge part of the learning objectives (see Anderson & Krathwohl, 2001). Finally, the collaboration management will be much easier if the peers would be gathered around the curriculum topics they are seeking help for. Due to the diversity of existing curricula in different countries or school types, the same topic may appear in different grades. Therefore, each topic will be represented technically by a topic tag, which can be assigned to all learning content elements by the users. In consequence, searching content by giving a certain topic tag, the user will find content elements regardless of the country or the school type of its origin. By this way a student of grade 8 in Gymnasium could collaborate with a peer that attends grade 9 of Middle School in a different state.

To organize the learning and task content, we will apply our Educational Ontology (Hubwieser & Bitzl, 2010) in a slightly adopted form. Its core part is displayed in figure 4.
As the students are working on topics of (about 15) different subjects simultaneously, we propose to organize the student’s view on the learning and collaboration content in *Topic Rooms*, one per “main topic” of each curriculum. At the end, all relevant (according to rating systems) learning content elements that are available for the student will be displayed at the respective Topic Room, arranged by their access functions, see figure 5.

The preferable view on the task content will be the Task Room, both for teachers and students. Basically, the task view will present the individual progress in the task processing, reporting and displaying the status of milestones and referring to submitted artefacts and feedback documents. While the student’s view is (naturally) restricted to his/her own tasks, the teacher has access to an overview of the task processes of all his students (see figure 6).
According to the accessibility requirements, 3-tier architecture seems appropriate. The presentation layer will be represented by ordinary Web-Browsers, eventually supported with some local logic, implemented e.g. by JavaScript. Alternatively, we will design specific Apps for the most popular platforms of handheld devices (e.g. iOS and Android). The functionality of the PLE will be located on central servers, similar to the data management.
Basically, *MyLearnSpace* comprises the following modules, which are partly implemented in the prototypes already: (1) *administration*, managing users, roles, access permissions, communities, (2) *content*, managing curricula, topics, tasks, documents and artefacts, (3) *representation*, comprising editors for specific content as formula or concept maps, and (4) *communication*, comprising subsystems for wikis, rating, blogs and forums.

**CONCLUSION AND FUTURE WORK**

Although the anticipated learning scenario may already exist in some very progressive schools, it will definitely take substantial time, resources and efforts to put it into practice in mainstream schools. Yet, we are convinced that all these changes will take place, finally forced by the prescribed inclusion of all students in regular classes. Therefore we are convinced that it is high time to start the development of an ICT system that supports future learning scenarios out of several reasons. The most important one is that these scenarios will not make the breakthrough without supporting software, due to the increased workload of teachers or because of missing support for collaboration with peers. Another reason is that it offers great research perspectives in empirical pedagogics as well as in computer science, even if our learning scenario is only realized in some avantgarde-classes.

At the time this article is written, another group of students is just finishing its practical work on integrating the already existing prototype modules of MyLearnSpace. Subsequently another Bachelors’ Thesis will implement this integrated prototype at an exemplary grammar school in Bavaria. Based on the evaluation of this experiment, we will proceed in the development of our Personal Learning Environment for self-determined, active and social learning.

**REFERENCES**


Peter Hubwieser was teaching Mathematics, Physics and Informatics at Bavarian Gymnasiums from 1985 to 2002. In 1995 he received his doctorate in Theoretical Physics at the Ludwig-Maximilians-Universität München. From 1994 to 2002 he was working on the implementation of Informatics as a mandatory subject at secondary schools in Bavaria. Since June 2002 he is associate professor at the Faculty of Informatics of the Technical University of Munich.