

**Listening to Teachers' Needs:
Human-centred Design for Mobile
Technology in Higher Education**

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**Listening to Teachers' Needs:
Human-centred Design for Mobile
Technology in Higher Education**

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Abstract

Technology is developing fast. Especially mobile and wearable technology is on the rise. Educational technology has seen considerable developments in different technological areas recently. However, the vast development of everyday technology is not reflected in educational settings and the fast adaption of innovative technology is missing in the educational sector.

This thesis applies a Human-centred Design (HCD) process to analyze the context of teaching in higher education, to understand teachers' needs and requirements to design innovative and up-to-date technology. It was found that teachers lack motivation to integrate technology into their teaching processes.

Learning tasks were found to be a critical component in teaching and learning processes. Therefore, the support of teaching processes around learning tasks was chosen as the central problem in this thesis. The use case of alpine sport teaching was chosen for an in depth analysis of learning tasks.

To address the motivational problem, gamification was taken into consideration. Games are known for their motivational factors and effects. Due to the similarities between learning tasks and game tasks, an extensive analysis on how to design for motivating tasks based on lessons learned from game tasks was conducted. The findings include that certain game elements, structures and processes can be used to design for motivating learning tasks.

From the context of use analysis in teaching and the findings from the game analyses, the Dynamic Questing (DynQ) concept was developed. The DynQ concept consists of learning task creation, task triggering, context sensing and feedback generation. A proof-of-concept prototype was developed to test out the DynQ concept and to be used for user testing with alpine sports teachers. After that, the concept was also tested with teachers from different teaching contexts.

Further design and development of the system could help improve usability and user experience. This work forms a basis for the advancement of personalized and contextualized learning through mobile and wearable technology support.

Sammendrag

Teknologien er i rask utvikling. Spesielt mobil og "wearable" teknologi blir stadig mer populært. Læringsteknologi har i det siste hatt en betydelig utvikling på mange ulike områder. Paradoksalt nok, har ikke den store utviklingen innen hverdagsteknologi ført til tilsvarende økning i bruk av teknologi i undervisningssituasjoner. Denne nyskapingen og utviklingen av teknologi reflekteres altså i liten grad i utdanningssektoren.

Denne avhandlingen benytter seg av en brukersentrert designprosess ("Human-centred Design" - HCD) for å analysere undervisningskonteksten i høyere utdanning. Hovedsakelig for å forstå lærerens behov og krav, og for å bli i stand til å designe innovativ og moderne teknologi. Det viste seg at lærere manglet motivasjon for å integrere teknologi i undervisningsprosessen.

Et kritisk element i undervisnings- og læringsprosessen viste seg å være læringsoppgaver. Derfor ble støtte til undervisningsprosessen rundt læringsoppgaver valgt som hovedproblemet i avhandlingen. I denne avhandlingen ble undervisning i alpint benyttet som eksempel for dybdeanalyse av læringsoppgavene.

For å håndtere motivasjonsproblemet ble spillifisering brukt. Spill er kjent for sine motiverende faktorer og effekter. Siden læringsoppgaver og spilloppgaver har mange likhetstrekk, ble det gjort en utdypende analyse på design for motiverende oppgaver basert på oppgaver lært i spill. Funnene som ble gjort bestod av enkelte spill-elementer, strukturer og prosesser. Disse elementene kan bli brukt for å designe motiverende læringsoppgaver.

Basert på brukskontekstanalysen i læring, samt funnene fra spillanalysen, ble konseptet Dynamic Questing (DynQ) laget. DynQ-konseptet består av læringsoppgaveutvikling, triggering av oppgaver, kontekstanalyse, og generering av tilbakemeldinger. En prototype ble utviklet for å teste DynQ-konseptet og for å kunne brukes i brukertesting for alpintlærere. Etter dette ble konseptet også testet på lærere med varierende undervisningsbakgrunn.

Videre design og utvikling av DynQ vil kunne forbedre brukervennligheten og brukeropplevelsen. Dette arbeidet danner et grunnlag for utvikling av personalisert og kontekstualisert læring gjennom mobile og "wearable" teknologier.

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Renée Schulz
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List of Publications

All the papers listed below are an outcome of the research work carried out by the author of this dissertation.

Papers Included in the Dissertation

- Paper A:** R. Schulz, G. M. N. Isabwe, and F. Reichert, "Supporting Teachers' Needs within and through E-Learning Systems", *Proc. IEEE International Conference on Web and Open Access to Learning (ICWOAL)*, pp.1-4, 2014.
- Paper B:** R. Schulz, G. M. N. Isabwe, and F. Reichert, "Investigating Teachers Motivation to Use ICT Tools in Higher Education." *Proc. IEEE Conference on Internet Technologies and Applications (ITA)*, pp.62-67, 2015.
- Paper C:** R. Schulz, G. M. N. Isabwe, and F. Reichert, "Ethical Issues of Gamified ICT Tools for Higher Education." *Proc. IEEE Conference on e-Learning, e-Management and e-Services (IC3e)*, pp.27-31, 2015.
- Paper D:** R. Schulz, G. M. N. Isabwe, and A. Prinz, "Development of a Task-driven Mobile Teaching Tool for Enhancing Teachers' Motivation." *Proc. 8th International Conference on Computer Supported Education (CSEDU)*, Scitepress, vol.1, pp.251-258, 2016.
- Paper E:** R. Schulz, A. Prinz, and G. M. N. Isabwe, "The Use of Game World Tasks Concepts in Higher Education." *Joint International Conference on Serious Games (JCSG)*., Springer International Publishing, pp.67-72, 2016.
- Paper F:** R. Schulz, G. M. N. Isabwe, A. Prinz, and T. Hara "High-Level Context Information for Tasks in Teaching." *8th International Conference on Applied Human Factors and Ergonomics (AHFE)*., Springer International Publishing, pp.278-289, 2017.

Paper G: R. Schulz, G. M. N. Isabwe, and A. Prinz “Mobile Technology for Learning Tasks in Outdoor Education." *New Technologies for Teacher Support.*, Springer International Publishing, 2017. (submitted)

Paper H: R. Schulz, A. Lazareva, G. M. N. Isabwe, and A. Prinz, “Higher Education Teachers Meet Mobile Technology: Application and Acceptance." *Proc. 9th International Conference on Education and New Learning Technologies (ED-ULEARN)*, IATED, pp.9237-9246, 2017.

Other Publications Not Included in the Dissertation

Paper I: H. Øysæd, R. Andersen, A. Prinz, and R. P. Schulz, “Teaching Students to Learn." *Proc. 8th International Conference on Computer Supported Education (CSEDU)*, Scitepress, vol.2, pp.91-98, 2016.

Paper J: J. Sunday, G. M. N. Isabwe, M. U. Ali, and R. P. Schulz, “Towards Personalization of Peer Review in Learning Programming ." *Proc. International Symposium on Emerging Technologies for Education*, Springer, pp.270-277, 2016.

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List of Abbreviations

AASI	American Association of Snowboard Instructors
ADILA	Agder Digital Learning Arena
API	Application Programming Interface
DELP	Distance Education Leapfrogging Project
DOI	Digital Object Identifier
DynQ	Dynamic Questing (Application)
ELT	Experiential Learning Theory
E-learning	Electronic learning
GB	Gigabyte
GHz	Gigahertz (unit of frequency)
GPS	Global Positioning System
GUI	Graphical user interface
HCD	Human-centred Design
HCI	Human-computer Interaction
ICT	Information and Communication Technology
ID	Interaction Design
IP Rating	International Protection Rating or Ingress Protection Rating
ISO	International organization for standardization
LMS	Learning Management System
M-learning	Mobile learning
MB	Megabyte
MMORPG	Massive(ly) Multiplayer Online Role-Playing Game
NPC	Non-player Character
OS	Operating System
PC	Personal Computer
ppi	Pixels per inch/ Pixel density
PSIA	Professional Ski Instructors of America
PvP	Player versus Player
RAM	Random-access Memory

RPC	Remote Procedure Call
RPG	Role-Playing Game
SDK	Software Development Kit
TFT LCD	Thin-film-transistor Liquid-crystal Display
UCD	User-centred Design
UI	User Interface
UiA	Universitetet i Agder (University of Agder)
USB	Universal Serial Bus
UX	User Experience
U-learning	Ubiquitous Learning
Wi-Fi	wireless local area networking based on the IEEE 802.11 standards
WLAN	Wireless Local Area Network
xAPI	Experience API
ZPD	Zone of Proximal Development

PART I

Chapter 1

Introduction

1.1 Background and Motivation

Technology is currently developing rapidly [12]. In particular, mobile and wearable devices were on the rise the last years [13]. Advances in artificial intelligence and the availability of cheap sensors may even shift the need from human-machine interfaces to something that might be called human-machine teamwork where technology and humans work together [14]. In addition to that, a recent observation is that technology emerges in many fields of daily life, such as fitness [15], entertainment and health [16], [17]. Mobile sensor technology, such as smart devices and wearables, is increasingly emerging in sports and fitness [18]. In fact, technology develops so rapidly, that research is conducted on coping mechanisms for dealing with the ever-changing technologies, for example, those within IT project management [19].

Having been a university student for the last nine years, I have always wondered why technology moves so fast everywhere but in the classrooms. Usage of digital support technology beyond the regular presentation and organization tools is limited in higher education settings [20]. In my case, no university and no individual teacher seemed to really have a technological breakthrough; in some cases, it was not even allowed to use laptops in computer science courses. That caused the gap between technology usage within versus outside of an educational environment to become more visible, and even though this seemed to be this way, I have always wondered why.

University of Agder (UiA), however, has made strengthening the links among education, research, and artistic development work as well as developing and enhancing future-oriented management of education its strategy¹. This includes the

¹<https://www.uia.no/en/about-uia/organization/strategy-2016-2020>

fact that technology usage in education should be implemented for a future-oriented learning and teaching experience and keep up with the technological pace within the working and entertainment environments. Innovation is another important part of UiA's strategy and includes considering recent technological achievements when striving for an innovative educational support concept. Educational opportunities that come with innovative devices include the mobility of devices, the possibility to measure context through sensors and improvements in automated processes to interpret data. That prepares learning and teaching for future challenges. In a world with more and more emerging computer systems, mobile devices and ubiquitous computing, it is important to create the opportunity for teaching methods that make the best use of technology. The Agder Digital Learning Arena project (ADILA) at UiA specializes in research to implement future-oriented learning and teaching strategies as well as technologies. That is why my PhD project is located within the ADILA project.

The importance of this research area lies in the strong connection and influence between integrated learning materials and tools and learning and teaching quality [21]. Materials and tools have a direct influence on students and teachers, and ICT tools are increasingly seen as useful in education [22], [23]. This means that ICT tools have the potential to positively support the teaching and learning process, if designed correctly. It is widely discussed whether and under what circumstances technology improves the quality of teaching [24] or even affects learning [25]. However, in the sector of sports education, where technology for personal training, healthcare and fitness is on the rise, there is lack of extensive research in the field of educational technology usage and integration [26]. Digital technologies can offer new possibilities for the educational sector, as it can be seen in the growth of online and distance learning technologies [24], where the availability of the Internet and web technology made new forms of learning and teaching possible. Typical technologies discussed to be integrated into teaching are tools for administering students, tools for presentation purposes, tools to help facilitate course work or tools that are subject of the course being taught. In this context it is often overseen that technology could not only support common practices but also lead to innovative pedagogical approaches. Innovative use of technology can help to bring education to a next level, because of the complex relation between content, pedagogy and technology, which is central to ensuring successful integration of technology into education on the basis of understanding effective teaching with technology [27]. Despite the lack of research on how to shape and develop future technology solutions that offer pathways to progress, there is a lot of research that focuses on

educating teachers about technology usage, i.e. how to train them for the digital age and how technology can be infused into teaching [28]. Research on teacher education for technology usage underlines the importance of technology in education and shows that teachers play an important role in technology integration.

It is clear that technology must be carefully designed to support teaching and learning. It has to be useful, contextualized, fitting to the situation as well as supporting the teaching and learning approach. This can only happen if the technology is designed for the actual needs that arise in education, from the teachers' and students' points of view. How technology can be best used in education is still under research. The basic idea is that there are many important variables within education, where technology support could be beneficial. Technology can help to improve or even shape new aspects of teaching and learning, but which aspects can be supported has to be analyzed carefully. Teaching that incorporates technology has the potential to enrich and enhance the quality of teaching. To enhance the quality of education, there is a need to investigate the educational environment, the educational context, including the people responsible for shaping learning, and teaching at the course level. Although it is known that technology integration must be supported by an entire institution by providing resources and support, it comes back to the teacher to make use of provided resources.

Many teachers already use ICT tools in teaching and learning [29]. The use of mobile devices in educational settings increases [30], but the usefulness of the tools currently available varies a lot and many studies investigate why teachers decide to integrate certain tools into their teaching while they ignore others [31], [32], [33], [34]. There are indications that it is especially important to pay more attention to teachers' needs as key stakeholders alongside the students when it comes to using new technologies in class. Therefore, the main focus of this PhD project is on teachers' needs, requirements and motivation to use technology. The objective is to investigate what is missing and could be developed in terms of digital technology support for teachers. In particular, it was found that there is a lack of motivation among teachers to integrate new technologies. However, the lack of motivation is a complex phenomenon. It is a result of a variety of factors, including the usefulness and usability of such systems. The problem is how to design a supportive solution that motivates teachers to use it because it is beneficial to their teaching approach and is a great addition for the students' learning process.

In addition to missing supporting technology, most existing technology is developed for a traditional classroom situation or self-study at home, which is at a fixed location. That, however, despite of being the case for many students, is not

the only existing learning situation. There are students who are actively involved in contextualized learning, which involves approaches such as situated learning [35]. Technology for teaching was developed for the classic fixed-location approaches. However, there are different learning situations (with changing locations and other flexible conditions) that are in need of technology support.

To sum it up, technology is developing rapidly and is not taken advantage of to its maximum capacity in education. The gap between technology usage in education and that in other industries has to be closed. This is the case for traditional classroom settings as well as courses without a fixed teaching and learning environment. Learning and teaching should incorporate recent findings as well as developments in pedagogy and in digital technology to be up to date and thus ensure its sustainability and innovativeness.

1.2 Problem Description

As described earlier, a gap exists between recent technology development and technology usage within teaching in higher education [25]. They are almost like two different worlds. Therefore, the first layer for the problem definition is teaching with technology or technology in education (Figure 1.1). Within the overlap, where technology is developed for education, not much diversity exists. Different technologies are used in education, but those directly designed to enhance teaching processes are rare. However, the discussion about how technology can be integrated into and beneficial for student-centered learning grows [36]. In some cases, the education sector tries to keep up with the pace of technology development, combining recent pedagogical approaches, such as student-centered learning, and technology usage in teaching [37]. There are such teaching approaches with few technologies to support the teachers, but there are even teaching and learning approaches with missing digital technology support. Of course, not having appropriate technology to choose from influences teachers' motivation to integrate technology.

If there is no digital support for a concrete used learning and teaching approach, teachers feel forced to change something about their teaching instead of feeling supported. There has to be added value to at least some aspects of teaching for the teachers to be positive about integrating any technologies. Analyzing the learning and teaching approaches as well as the teachers' needs and requirements is central to understanding if a technology is beneficial in teaching situations and if it can be integrated successfully.

One aspect of that problem is that a lot of research is centered on students'

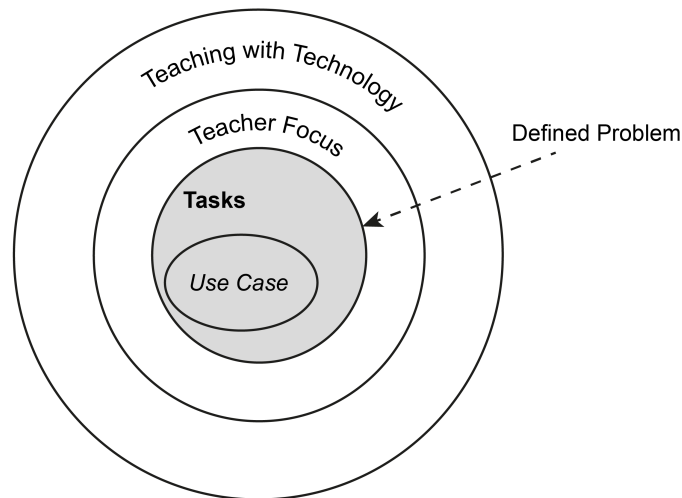


Figure 1.1: Different steps of problem definition and specialization towards teaching-supporting technology with a focus on learning tasks that include a specific use case.

needs and requirements towards technology. Not as much research regards the main stakeholder who is responsible for technology integration into the learning process - the teachers [38]. There are three different types of objectives for the use of ICT in education [39], [40]. ICT tools can be an object of a study (how to use ICT tools), a subject of study (ICT is part of the studies), or a medium for teaching and learning. In this thesis, the aim is on the latter.

One of the most important challenges is how to motivate teachers to use technology in their teaching approach to support their teaching models. Most teachers are not motivated to integrate technology into their teaching, especially if it is not fitting for their teaching circumstances and pedagogy. Therefore, the second layer of defining our problem is teacher focus (Figure 1.1). Teachers expressed (Paper B) that there are not many tools that suit their needs and teaching approaches. For most teachers interviewed in this study, quality teaching means following a student-centered learning approach. The students and their learning are in focus, and learning does not mean that a teacher only provides knowledge and the students absorb it. Learning, as described by the teachers, needs interaction and engagement with as well as reflection on topics. Seeing the students learn and grow was described by the teachers as a core motivation to teach. Students often learn through and engage with learning tasks that are created by either the teachers (homework, laboratory work and practice sheets) or the students themselves to practice. Observing and being part of the learning process involving and surrounding those tasks was described as a motivating factor to teach and found to be a central factor of creating a support-

ive digital teaching tool that teachers might actually want to use, since it reflects their needs as well as requirements and inherits their intrinsic motivation to teach. Therefore, the third and central layer of the problem definition (Figure 1.1) is concerned with the teaching and learning processes around learning tasks and how to develop supportive digital technology for these processes. This involves processes around tasks, such as designing, distributing and providing feedback. These processes are highly interactive and involve much communication, in which a potential to integrate recent information and communication technology can be seen.

Developing teaching-support technologies and adapting recent pedagogical strategies to different courses can be challenging. It is even more challenging for courses that do not match the traditional classroom style. Technologies that support pedagogic approaches often do not exist, especially for courses that are not taught at a fixed location as well as cognitively and physically challenging at the same time, such as sports education [41]. That is why outdoor education with a specialization into alpine sports was chosen as a challenging use case (Figure 1.1) that brings forth a number of challenging and special requirements towards location-flexible and teaching-supporting tools. In this use case, the gap between existing pedagogical models and available teaching-supporting technology is clearly visible, since there is no use of digital technology during teaching on slopes.

To know how to adapt and support the pedagogical models when learning does not take place in a fixed location, the courses have to be analyzed and understood to restructure them for new learning models as well as to design location-flexible, teaching-supporting technology for them, with the assumption that approaches and solutions deriving from that can also benefit traditional classroom settings or other courses in return.

How can these important teaching approaches including learning tasks and learning-task processes be digitally supported in a manner that also incorporates the potential of more recent technological developments? Attention has to be paid on how such a digital support concept can be designed so that teachers are motivated to integrate it into their teaching. In summary, this thesis aims to solve the following problem.

Teachers frequently integrate learning tasks into their teaching, but they lack sufficient digital technology support for this central teaching approach.

1.3 Research Questions

From the problem statement, two main research questions arise. The first main research question (1) is concerned with the processes needed to design a usable ICT solution. This can be split into three areas: (1a) analysis and development processes, (1b) technology integration processes and (1c) teacher motivation processes. First, a process is needed to ensure that a technology solution is usable from a pedagogical perspective and that it supports the teachers. Because of the need for a design process working closely with the users, the first part (1a) is about how a Human-centred Design (HCD) process that ensures development for the users' needs can be used. The second part investigates processes that are needed to identify how recent available technology can be integrated into education, to close the technology gap between education and industry. In addition to the pedagogical needs and the technological gap that has to be closed, teachers must be motivated to integrate the technology that is developed for their teaching processes (1c). The analysis of teachers' needs and motivations in depth as well as possibilities to integrate digital technology that is rarely seen in educational contexts are brought together.

The second main research question (2) is about how to design technology for the specific pedagogic approach of learning tasks in educational settings. This question can be further split into three detailed questions: (2a) concerning the analysis of task concepts, (2b) concerning designing for motivating tasks and (2c) what can be learned from the use case chosen in this thesis. The first part (2a) is concerned with the context of use analysis, specifically about which concepts of learning tasks need to be investigated, to be able to design a learning-task-supportive solution. Learning task concepts consist of task structures and the learning and teaching processes around tasks. Such processes can include planning, creating, distributing and collecting feedback. The second detailed question (2b) is about how to design technology-supported learning tasks that are motivating and engaging. The last detailed question (2c) involves the outcomes of the user testing and is concerned with what can be learned from challenging courses that do not follow the typical design of a classroom setting for learning tasks.

RQ1) Which processes are needed to design a usable digital ICT solution that supports teachers in their teaching processes?

RQ 1a) How can the HCD be used to address teachers' needs in depth?

RQ 1b) How can recent technology be integrated as useful and supportive teaching technology?

RQ 1c) How to motivate teachers to integrate recent digital technology into their teaching processes?

RQ 2) How can learning tasks be supported through digital technology?

RQ 2a) Which concepts are needed to support tasks in a digital technology solution?

RQ 2a) part 1 Which task structures need to be analyzed and integrated into a digital solution?

RQ 2a) part 2 Which task processes can be supported?

RQ 2b) How to design engaging and motivating learning tasks?

RQ 2c) What can be learned from challenging courses that do not follow the typical classroom setting about how to design learning task processes?

To answer these research questions, a mixed-methods approach, mainly composed of qualitative research methods was used in my PhD project. Because teachers are the main stakeholders, they are included in all research phases that follow the HCD process from the beginning, including the context of use analysis of the concrete problem space, to iterative testing with prototypes.

To answer research question 1, the context of use had to be analyzed. Conducting a literature review was particularly important in the beginning but was continuously used until the end. In the beginning, teachers from various fields were integrated into the analysis. Mainly mixed methods were used, including interviews and surveys to capture individual problems and their relation to the participants' teaching circumstances. The findings of the initial context of use analyses brought learning tasks forth as an important teaching process that needs technology support. To understand teachers in more depth, a use case was chosen based on what was found previously.

Refining the context of use analysis based on the use case adds to knowledge for research question 1. However, the use case was mainly chosen to go into more depth to design and develop a learning-task-supportive system, to answer research question 2. For getting more in-depth knowledge, field observations, focus groups and field testing were used. Interviews and surveys were used in addition. To answer research question 2, including 2a and 2b, it was beneficial to test concepts and ideas with the help of a prototype. This made it easier for the participating teachers to understand the concepts and refinements could be made. Being able to include teachers and having a prototype to test showed the importance of an HCD approach in addressing teachers' needs. To answer 2c, teachers outside of the alpine

sports courses were involved. Focus groups were found to be effective in evaluating the concept understanding and technology acceptance as well as possibilities for prototypical implementation in different teaching fields.

Details of the used methods are explained in Chapter 2.

1.4 Research Contributions

Contributions are made in the following areas: new possibilities for teachers to make tasks, to engage students in learning tasks and to open up new channels for feedback as well as communication of learning tasks and processes. Combining technological possibilities with pedagogic approaches, possibilities to enhance personalized learning and student engagement in learning tasks can be achieved, even without direct supervision.

To connect education and technology, it has to be understood how technology can support and contribute to educational settings as well as how education can make appropriate use of recent technology and thus enhance educational possibilities.

RQ 1a) The HCD was found to be a useful tool for developing technology for teachers' needs. Based on the continuous integration of teachers and through surveys, interviews, focus groups as well as observation of real teaching and user testing, the HCD process was beneficial to gaining insight into and gathering teachers' needs as well as requirements towards supportive digital technology.

RQ 1b) Teachers integrate technology that improves their teaching options. Everyday technology that includes sensors (smart devices such as smartphones and smartwatches) was found to be motivating for teachers to integrate it, because the technology can sense the student's learning context and provides possibilities for creating personalized learning tasks.

RQ 1c) It was found that technology that is perceived as supportive and matching the teachers' needs is intrinsically motivating for teachers to use. Based on the expressed motivations to teach in general, one of the core factors is that if the technology can motivate students to engage in learning tasks, the technology is at the same time motivating to use for the teachers.

Through the analysis of the current teaching situation and approaches, learning tasks were identified as a central teaching concept.

RQ 2a) The concepts needed to support learning tasks are combined in the Dynamic Questing concept (DynQ), which incorporates traditional learning task structures with game task structures and enriches the traditional learning task process with game task processes. The core of DynQ is a combination of task content, user context triggers, and feedback. In total a context-sensitive and personalized learning task concept was created.

RQ 2b) Motivating tasks from games were analyzed to find structures and processes to design motivating learning tasks in an educational context. The DynQ learning task concept is motivating not only for the students to use due to the use of game elements but also for teachers because it provides possibilities for creating personalized learning experiences and offers possibilities for improved learner-teacher feedback.

RQ 2c) The prototype based on recent technology (smartphone and smartwatch) was developed for a specific use case. The concept, however, was designed without a specific technology in mind, making technology and other specific parts in the prototype exchangeable. The concrete use case offered in-depth analysis with technology fitting to its requirements.

1.5 Structure of the Thesis

This thesis is structured as a paper collection with two parts. Part I provides an overview and a summary of the research project and processes within the project. The collection of papers is presented in Part II. The order of the papers is the same as the one in which they were published.

Part I

The first part of the thesis provides its summary and overview. Chapter 1 is the introduction, which describes the problem statement and the derived research questions, followed by the structure of the thesis. Chapter 2 describes the research methodology and how HCD is used in this project. Chapter 3 is devoted to the learning task aspect of the research problem. It analyses learning tasks in general as well as within the use case, describes how the analysis of game tasks is beneficial and applies the analyzed new task concepts from games to the learning tasks of the use case. Chapter 4 concentrates on the design and development of the DynQ prototype and describes several user testing as well as evaluation steps. Chapter 5 discusses

the outcome and answers to the research questions as well as the influence of a task-supporting digital technology solution on existing teaching processes that are relevant in this context. The final chapter summarizes the results, including the main contributions structured by research questions, and proposes future directions.

Part II

In the second part of the thesis, all papers of the paper collection can be found. Eight papers are attached (A-H), and two more papers (I and J) are mentioned but not part of this thesis. The papers are not altered in content but are formatted to fit the style of this thesis. This includes figures that are shifted from their original position due to formatting and page size. The citation style of the published papers was kept as it is. The original papers can be found through the provided ISBN and DOI numbers. Figure 1.2 gives an overview of parts of the research and papers in which they are presented. It shows the papers located in the phases of the HCD.

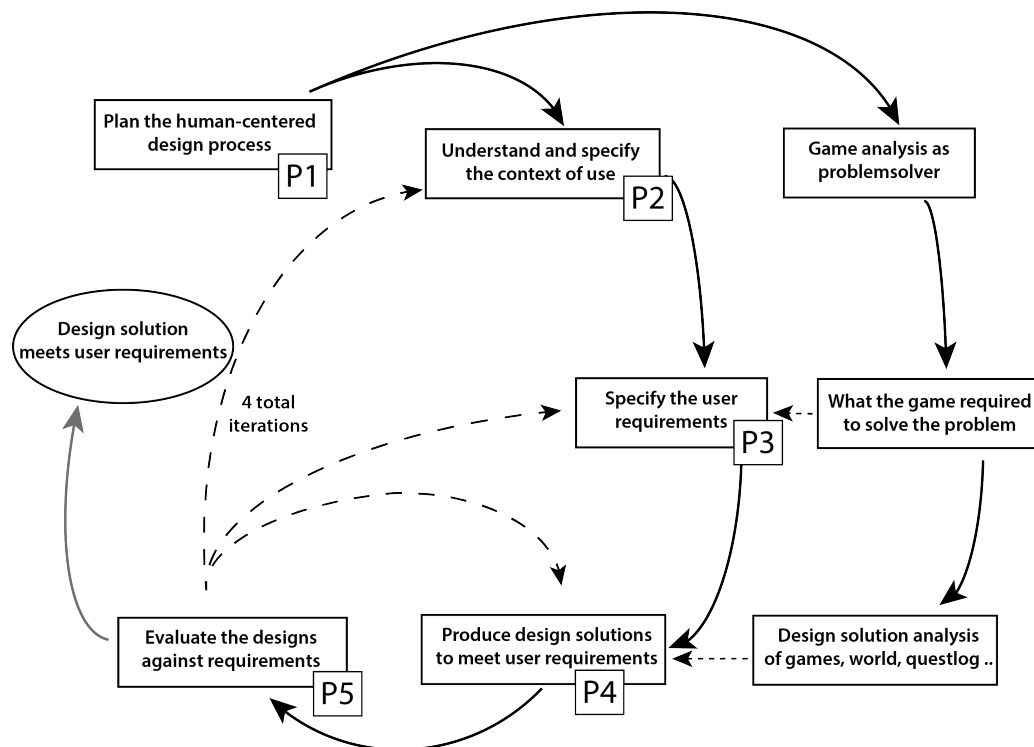


Figure 1.2: The HCD process with marked phases and highlighted additional phases for game analysis.

Figure 1.2 visualizes the HCD process according to [42] with numbered phases for an overview (P1-P5). Phase 1 (P1) is the planning phase, in which the PhD project

description originated. For a better overview, the mapping of papers in phases, iterations, methods and context can be found in Table 1.1.

Paper A is mainly located in the planning phase, describing the initial project plan with preliminary results that shaped the direction of research. It connects to an early understanding of the context of use, the second phase according to the HCD.

Paper B describes the fundamental understanding of the original context of use, in which the problem space is explored. It describes different aspects of motivation regarding why teachers integrate or refuse to integrate ICT tools into their teaching. The different tools that are used were explored and categorized to determine requirements for successful integration. The influencing factors were grouped into four categories, of which the three main categories that are directly connected to the system and its design were intrinsic values, human factors and general requirements towards the system.

Paper C discusses ethical issues regarding the use of the HCD process as well as the integration of game elements/ gamification into higher education.

Paper D discusses the first iteration of testing of the initial design solution. It explores and refines the requirements that were found based on previous research. The paper explores how teachers' motivation can be supported to use such a system. For this purpose, it describes learning task structures and how to design a system that supports learning tasks.

Paper E emerged from the idea of designing a motivating system, including initial thoughts of making use of gamification to boost the motivation of the users. Having defined a concrete problem on how to design motivating tasks, the researcher analyzed how games deal with tasks as well as why they are so motivating and entertaining for most players (gamers/users). The main focus was on how tasks are structured in games, how they occur and how their occurrence is connected to the players' world. Finally, the paper describes how these structures and concepts could be beneficial in an educational task-supportive system. This led to new insights into how recent technology, namely mobile, wearable and sensor technology, can help in getting rid of location boundaries and bring flexibility into such a system, that can in return be motivating for both teachers and students to use.

Paper F expands the view of task dependencies beyond measurable context information. It explores factors, so-called high-level context information, that influence students' learning process but cannot be sensed directly by a mobile or wearable device. It discusses a suggestion of how high-level context information can be gathered using intrinsic motivation, a low-level gamified application version, or an additional mini-game within the task-supporting teaching application.

Paper G is a central paper to understand the context of use. Information presented in this paper was gathered over a period of two rounds of field testing, to explicitly describe the use case in detail, and user testing outcomes. The main stakeholders here are the teachers who test the system and provide insight into their teaching, ideas, planning and how they can make tasks and thus support the students in their individual learning process by using an application that supports learning tasks.

Paper H presents a round of user testing designed to challenge the concept and idea. The focus group in this round of testing was not previously involved in testing and is from a different context from that of the skiing and snowboarding teachers in Norway, who were the primary stakeholders. Sports teachers from Uganda discussed the concept and possible use cases and gave insights into additional requirements to expand the usefulness of such a system into their fields of teaching (for example swimming, basketball, aerobics, fitness and nutrition).

Table 1.1: Papers according to their phases, iterations, methods and context.

Paper	Main Phases	Iteration	Methods	Content, Outcome
A	1-2	1	<ul style="list-style-type: none"> - literature review - semi-structured preliminary interviews 	<ul style="list-style-type: none"> - outline of the problem space - research approach - context of use
B	2	1	<ul style="list-style-type: none"> - online survey questionnaire - qualitative and quantitative methods 	<ul style="list-style-type: none"> - problem exploration - i.e. what teachers use, why or why not
C	1-2	1	<ul style="list-style-type: none"> - literature and experience based - mixed methods approach - qualitative and quantitative methods 	<ul style="list-style-type: none"> - ethical considerations - teachers perceptions about a task-supportive tool - requirements gathering - conceptualizing mobile teaching
D	3-5	1-2	<ul style="list-style-type: none"> - online survey about the teaching situation - interviews, including user testing - prototyping / wireframing - structured analysis of: - task structure, dependencies and - how they are distributed to the gamer (by analyzing 17 games from different genres) 	<ul style="list-style-type: none"> - analysis of how tasks work in games - applying those concepts to higher education
E	2-4	2	<ul style="list-style-type: none"> - task structure, dependencies and - how they are distributed to the gamer (by analyzing 17 games from different genres) 	<ul style="list-style-type: none"> - analysis of how tasks work in games - applying those concepts to higher education
F	2-5	3	<ul style="list-style-type: none"> - online questionnaire - sketching/ prototyping 	<ul style="list-style-type: none"> - high-level context information gathering as added value within sports education and how it could be done - three different conceptual approaches on how to motivate users to provide high-level context information
G	2-5	2-4	<ul style="list-style-type: none"> - field observation and field testing - user testing and interviews - demographic questionnaire - additional information questionnaire - open student questionnaire about their task experiences - prototyping 	<ul style="list-style-type: none"> - understanding of the context of use for alpine sports - deep understanding of teaching structures - designing a task-supporting application - testing especially the teacher task design options with teachers in their real teaching environment (skiing region) - two rounds of testing and refining
H	5	3	<ul style="list-style-type: none"> - focus group - scenario-based interview approach - prototype as conversation material - qualitative content analysis 	<ul style="list-style-type: none"> - challenging the concept that was mainly shaped with teachers from alpine sports from Norway - gaining new insights and updated requirements for inclusion of other subjects

Chapter 2

Research Methodology

2.1 Human-centred Design

User- or Human-centred Design (UCD/HCD) incorporates ideas and concepts from many different disciplines, such as engineering, psychology, computer science, and design. Over the years, HCD developed from only focusing on what the user directly expresses as needs to understanding that context, stakeholders, tools, interactions and environment factors that are crucial to understanding the real user needs and for successful design and development [42], [43]. The HCD following ISO 9241 - Part 210 [42] (a combination of the former, ISO 13407:1999 Human-centred design processes for interactive systems and the associated ISO TR 18529:2000 Human-centred lifecycle process descriptions [44]) does not further specify the research or design methods. Many different methods can be selected for the different steps and phases within the HCD [45].

HCD differs from other approaches by its focus on understanding the users' needs, experiences and desires [46]. It was argued that HCD can be applied to model educational user interfaces [47] because they have requirements that are tightly tied to the teaching context and identified stakeholders. The prototype served as a subject matter and basis for user testing and discussions as well as further research and testing, meaning that research and development are interwoven in this project.

The HCD steps were followed during the development process of the prototype. The highly iterative HCD process provides frequently updated prototypes, on the basis of user testing and evaluation. This also leads to frequent new insights into research matters. It is particularly noteworthy for this approach that not only the interface part of the design is important but also the way people interact, the cultural challenges, and the stimulation of people [46].

The context of use in this thesis includes technical, physical and organizational

environment factors, as mentioned by [45], together with the theoretical background of learning and teaching, which is extremely important in education. It is critical to know what the teachers use as their theoretical background for teaching, to support their teaching approaches. The following sections describe methods used within the HCD in this PhD project, for research as well as for the design and development of the prototypes.

2.1.1 Literature Review

A solid literature review is the foundation of research and can help uncover unsolved problems, important directions as well as problem-solving concepts. For this interdisciplinary work, the literature has to cover many different subjects. Literature in the direction of ICT-supported learning and teaching has to be covered, including teaching and students context in sports education as well as the usage of mobile technology and wearables in (sports/alpine) education. To understand the context of use and get immersed into the use case of teaching skiing and snowboarding, literature was essential. The main sources for that were the books and materials used in the use-case courses. These are "Den alpine lærevei - Alpin skiteknikk" (The alpine learning route - Alpine skiing technique) [2], snowboarding material covering the basics [48], as well as freely available snowboard education materials (<http://www.snowboardforbundet.no>) and the book "Alpine Technical Manual: Skiing and Teaching Skills, Second Edition" [6] from PSIA AASI (Professional Ski Instructors of America & American Association of Snowboard Instructors), which cover the topics of alpine skiing, telemark skiing, snowboarding like the course in Hemsedal, but also cross-country skiing, and adaptive skiing/snowboarding and how to teach these. In addition, to understand the context in terms of what affects the learning process, sports literature regarding situations and variables that can have an impact on sports performance and learning was consulted [49], [50].

Extensive literature review had to be conducted on how to develop for human needs, how to shape the research design within an HCD approach [51] and how to develop the prototype following the HCD process [42]. In addition to that, the course "User Testing and Evaluation" and its literature (including [52], [53], and [54]) gave further insight into the crucial topic of testing and evaluation with participants within the HCD. Further, books such as *Interaction Design: beyond human-computer interaction* [55] were used. Keywords for this search were *human-centred/centered design*, *human-computer interaction (HCI)*, *mobile design*, *user-centred/centered design*, *usable systems*, *usability*, *user experience design* combined with more specific topics such as *wearables*, *mobile learning*, *ubiquitous*

learning, e-learning, mobile teaching, learning tasks in higher education, situated teaching, experiential learning, zone of proximal development, computer-supported collaborative learning, sports teaching and learning, sports and wearables, alpine sports, snowboarding, skiing, gamification, as well as game elements with varying additions and in different combinations.

Tackling the problem of designing for increased motivation, an extensive literature search was done in the direction of common issues and problems related to why teachers do not integrate technology into their teaching and gamification to find motivating aspects that can be used for the solution approach. The most important influence in the gamification literature was by Deterding et al. [56], [57]. His research helped to see concepts of games as a whole and underlined the importance of not using single, context-missing elements. These works inspired me to analyze the big picture of how tasks are used, designed and distributed in games, how the users are informed about new tasks and how they interact with them, which helped to shape a large part of the dynamic task concept used in this thesis.

For the prototype development, in addition to freely available android programming literature and sources, literature was used for the wearable (smartwatch) development part: "Step-by-Step Android™ Wear Application Development" [58].

2.1.2 Questionnaires

Questionnaires help to gather reliable information and are most often used to gather demographic data [55] and can use closed-ended questions, open-ended ones or a combination of both [59]. Questionnaires can be used as a stand-alone method for data gathering or in conjunction with other methods. In combination with interviews, questionnaires help to collect data that is not part of the main interview, such as demographics, which help in putting all other answers into context. Having participants' background information, such as demographics, helps in analyzing differences between answers based on relevant context information. Using scales such as the Likert scale can also be beneficial for data analysis [60]. Questionnaires on their own can be not motivating enough for participants to actually stick through and open-ended questions tire participants easily. Confusing or negative questions should be avoided. These types of questions can lead to false information, since the researcher is in most cases not present to explain or clarify.

Questionnaires were used in almost all user testing situations. For the most part, they were used to cover the demographics as well as answers to some basic questions as a prequel to following interviews or focus groups. However, in the beginning, a questionnaire was also used as a stand-alone research method to gain

insight into tools used by teachers around the world. The outcome of this questionnaire is described in Paper B. In demographics sections (in Papers B, D, F, G, and H; in the first, second and third iteration of the HCD), the questionnaires were used mostly quantitatively, using multiple-choice or short free-answer fields in which the participants were not expected to write a lot. Some questionnaires featured more qualitative questions, which required the users to write more. Depending on the user testing context, questionnaires were given either in a printed paper format or online on tablets or PC devices. A context that required at least printed back-up questionnaires is a context with insufficient or unstable Internet/WLAN/Wi-Fi connection. This context was, for example, encountered during the user testing and evaluation sessions at Makerere University, Uganda. Another user testing context that needed printed questionnaire versions was during the field testing in Hemsedal, Norway. Here, the students were asked to answer an open questionnaire about their task experiences; enabling them to quickly take a sheet of paper and note some sentences helped to get more answers. The user testing with the teachers, however, could be supported through online questionnaires, since the teachers are a responsible group of self-interested users who reliably answered the questionnaires during or after the stay in Hemsedal, as soon as their time schedule allowed.

2.1.3 Interviews

The goal of interviews is to gain structured insights into specific information. The possibility of diving deep into a topic is what makes interviews really important in HCD [51]. It helps an interviewer to capture the real problems, and because of the interview situation, follow-up questions can be asked and answered to understand given answers better and more detailed. Interviews can include material for discussion, especially when conducted face to face. A prototype can easily be used during an interview as an additional subject for discussion, especially when users are made familiar beforehand, so that they can express their ideas and thoughts based on the prototype more precisely.

Before all interviews, during all iterations of the HCD, the goals were formulated and guides for the interviews were written, to make sure the interviews follow the same core thoughts to be comparable and to see where users add ideas. Interviews can be unstructured, semi-structured or fully structured [59]. In this research, different types were used, but most interviews were semi-structured. Semi-structured interviews were used so that data remained comparable to an extent but left the freedom for the individuals to express important thoughts without a structure that is too restraining. Also, the number of interviewees can vary. The number of

people interviewed at the same time ranged from one to eight, and one-to-one interviews were the most used form. For analysis, most interviews were recorded either on video or pure audio. Notes were always taken, and participants were encouraged to take notes themselves, especially in group interview situations, to give every participant the chance to be heard, even in more hectic situations. Interviews were transcribed from the recordings for post-analysis. In situations where the prototype was used as basis for discussion, interactions with the prototype were also recorded on video. A range of recording technology was used: a webcam attached to a laptop, different types of smartphone cameras, professional video cameras, hand-held regular cameras and action cameras (GoPro). For audio recordings, either an audio-recording application on a smartphone was used, or a camera, where either the lens was blocked from the beginning or the video material was deleted afterwards according to participants wishes. Content was recorded in English and Norwegian, and Norwegian interviews were translated into English for analysis.

2.1.4 Field Research

Field Research is a mostly qualitative method in which the researcher emerges into an everyday life setting of the participants with the goal of collecting data. This approach was formed in the professionalization of anthropology and sociology and was later formalized in human studies fields [61]. Methods of field research are participant observation, interviews and conversations as well as the use of personal documents [62]. What is observed has to be noted, recorded or logged. To this end, the researcher gathers information through note taking or video and audio recording. Even sensor-based logs can be part of a field observation [63].

In this research, the method of participant observation and field interviews was chosen to analyze and understand the context of use and to understand the structure and interactions within the given problem scenario within the use case. The specific use case of outdoor education, specifically skiing and snowboarding, made it mandatory for the researcher to observe and analyze the current teaching situation out in the field, where the teaching is done. This type of observation study differs much from observations in classroom education. Teaching and learning does not only happen at a fixed location, it even specially requires a frequent change of location and terrain, which has an effect on the course structure, group dynamics and the interactions between students and teachers. Observation was used as a qualitative method to analyze the current context of use and allowed the researcher to immerse into the users' situation. This information can be used to enhance scenario-based design approaches [64] for the phases for which the course is not held. The

more precise the knowledge about the real-world scenario is, the more precise and near to the observed real-world problems and teaching approaches the scenarios can be. From an extensive user context analysis, user needs and requirements can be derived, which leads to improved design solutions and further user testing and evaluation (according to [42]). The main focus was on how the teaching works at the moment; how the student-teacher interaction works; how teachers design, decide on, and distribute tasks; and how students learn during the lessons and during the self-practice phases. This analysis of the overall context and situation lead to improved insights based on which technology can help to bridge gaps within the teacher-student communication and lack of further guidance by the teachers during the self-practice period of the students. To support the teacher, it is important to find out where sensor-based task triggering could lead to innovative educational solutions. For this, we had to observe the connection between context variables (such as location, weather, as well as students' skills and performance) and the task decisions the teacher makes. From that point, we could analyze the requirements to support task design, distribution, and feedback with technology for enhanced teaching and learning. The extensive description of the use case of skiing and snowboarding can be found in Section 2.2 and in the appendix, in Paper G "Mobile Technology for Learning Tasks in Outdoor Education".

The field research was conducted two times, in May 2016 and May 2017 in Hemsedal, Norway. It was conducted from two perspectives. First, teachers were observed during teaching from an outsider perspective. Second, the observing researcher was part of the student group. In both cases, the lessons were video recorded using multiple cameras (GoPro) on the slope. Video recording was done free hand, or the camera was attached to either the helmet or the chest of the recording person. In some cases, the teacher recorded from his perspective (helmetcamera or free hand) during the lesson. In addition to the user context analysis, user testing was conducted during the field observations. Teachers were interviewed (alone or in groups) and asked to test the prototype in the actual teaching conditions on or near the slope.

2.1.5 Focus Group

Focus groups can be used to find out how and why participants think in a particular manner and to explore their attitudes and needs concerning a particular topic [65]. Group dynamics take the direction to new and unexpected ideas and help to uncover unforeseen challenges and issues. Another benefit from focus groups is that a group might be able to build on each other's knowledge within the discussion, so that a

certain state of creativity can be reached, even if the general background knowledge about the topic of research might be little. The group can be encouraged by the possibility to discuss among themselves and build on their applicable ideas, which can help to discover new aspects of the research topic [66].

Focus groups were used during the field observation trips to discuss the concept and general teaching practices as well as to analyze potential supportable tasks. Another focus group interview was used to evaluate the DynQ concept from an outside perspective. The concept itself should not be teaching subject specific; however, our use case is specifically anchored within alpine sports. To avoid too specific fixations during the development process, a focus group interview with teachers from a different context was conducted. Teachers from Uganda were invited to participate during the Distance Education Leapfrogging Project (DELP) workshop at Makerere University in 2016. To stay in the context of sports education, participating teachers were selected randomly from the sports department.

2.2 Use Case Outdoor Sports Education: Skiing and Snowboarding

2.2.1 Considerations for Defining a Use Case

In the HCD process it is highly encouraged to work closely with the users throughout as many stages and iterations as possible. Having a clearly defined and stable use case with a core set of users who are able to stay through several iterations can be beneficial. In single-user testing sessions, the depth of insight into user needs is limited and through varying users, the outcomes can be diffused. It is important to have a common ground of communication between users and the designer, so that the concrete use case helps to talk about issues and to illustrate concepts from both sides. Generally, use cases are picked to identify real user needs and requirements with a specific group of stakeholders.

The identified problem includes that teachers' needs are not addressed enough in current existing teaching and learning tools. To analyze specific issues, a real use case is one method of getting access to situations in which actual teachers' needs can be analyzed. Even though including a variety of users for testing is highly encouraged in HCD, the HCD can be too broad and diffusing for a project of this size. Instead of trying to include all sorts of teachers from many different courses, the concept was built on initial diverse user input and then further user evaluation on a specialized course: Alpine sports (skiing and snowboarding), which is part of

the outdoor education studies at UiA. A reason to choose this course was that tasks are central within the teaching of alpine sports and that the learning process highly relies on individual tasks.

More specifically, alpine sports features tasks beyond the usual classroom routines (sitting, reading, and writing tasks) and can challenge the concept and maximize the potential to use possibilities given by existing technology. Tasks in outdoor environments feature variables that cannot be found in classroom environments but match the DynQ concept and are supported by technology. Those explicit variables are, for example physical location, weather, time and speed. Almost every mobile device, phone or watch can measure such variables easily, but they are not considered to be meaningful teaching support. This means the course features innovative variables that can be supported by almost every commonly used mobile device, which is not done yet, thus making it a useful and meaningful combination to showcase and challenge the task-based concept.

Deciding for a specific use case means that the variety of involved users was knowingly reduced and specialized so that a stable concept could be developed. From having a stable concept, generalizations can be made and tested with an increased variety of teachers. The use case helps in analyzing the problem that was stated on a more general level using a more specified concrete topic to draw conclusions from what has been found back to the general level, if applicable. Having a concrete use case also deepens the insight into problems faced. Prototypes can be tested within an actual real teaching environment and being able to be part and take part in the teaching that should be supported by technology is very beneficial. Having a real use case confronts the researcher with users having an actual opinion and possibly a strong interest in what is being researched on.

Working with such a specific use case certainly has drawbacks. Even if certain generalizations can be made, it can be difficult to not lose sight of the overall goal to support many different courses instead of developing a specialized tool that only one type of courses can use.

2.2.2 Alpine Sports: Skiing and Snowboarding

In this subsection, the use case course is described. This course is the basis of user needs, prototype design steps and user evaluation for the final concept; therefore it is important to get insight into the course structure. For better context understanding, it is important to describe the course used for user testing as well as shaping and influencing our research and system design. In addition, the course analysis underlines the necessity of individualized tasks and helps to understand why teach-

ers can be especially supported to design and distribute tasks as well as how much individual tasks and task feedback is needed.

From the broad field of outdoor education, the alpine sports course was chosen. The course comprises of three sub-disciplines. Those disciplines (Alpine Skiing, Telemark Skiing, and Snowboarding) are taught in Hemsedal, Norway, over five days. Students are grouped by discipline and skill level (beginner or advanced) with different teachers to complete all three disciplines. The five days are structured as follows:

- Each discipline has to be done by each group for one whole training day.
- Every group goes through all three different disciplines within the first three days.
- Students are divided into three different discipline groups every day, so that all courses run in parallel.
- Every discipline group is split into beginners and advanced students, which totals to six groups in parallel.
- After three days, each group must have completed every discipline on a basic level. On the fourth day, they choose one discipline in which to specialize and be trained further.
- The last day is open for training in all disciplines. The students are expected to acquire a minimum of basic skills about the disciplines and about how to teach those disciplines to other students.

As can be seen in Figure 2.1, the teaching involves iterations of theoretical lectures, practical training and self-practice phases. It is centered around active and experiential learning with a high involvement of teachers (and peer) feedback. Self-practice phases are important to deepening the theoretical understanding and the acquisition of motor skills, since they often require repetition of certain actions and movements to manifest.

Including a use case like this makes it possible to address specific parts of the problem statement, specialized for this case. Through the specialized and thus stable group of stakeholders, it is more likely to address all research questions more precisely.

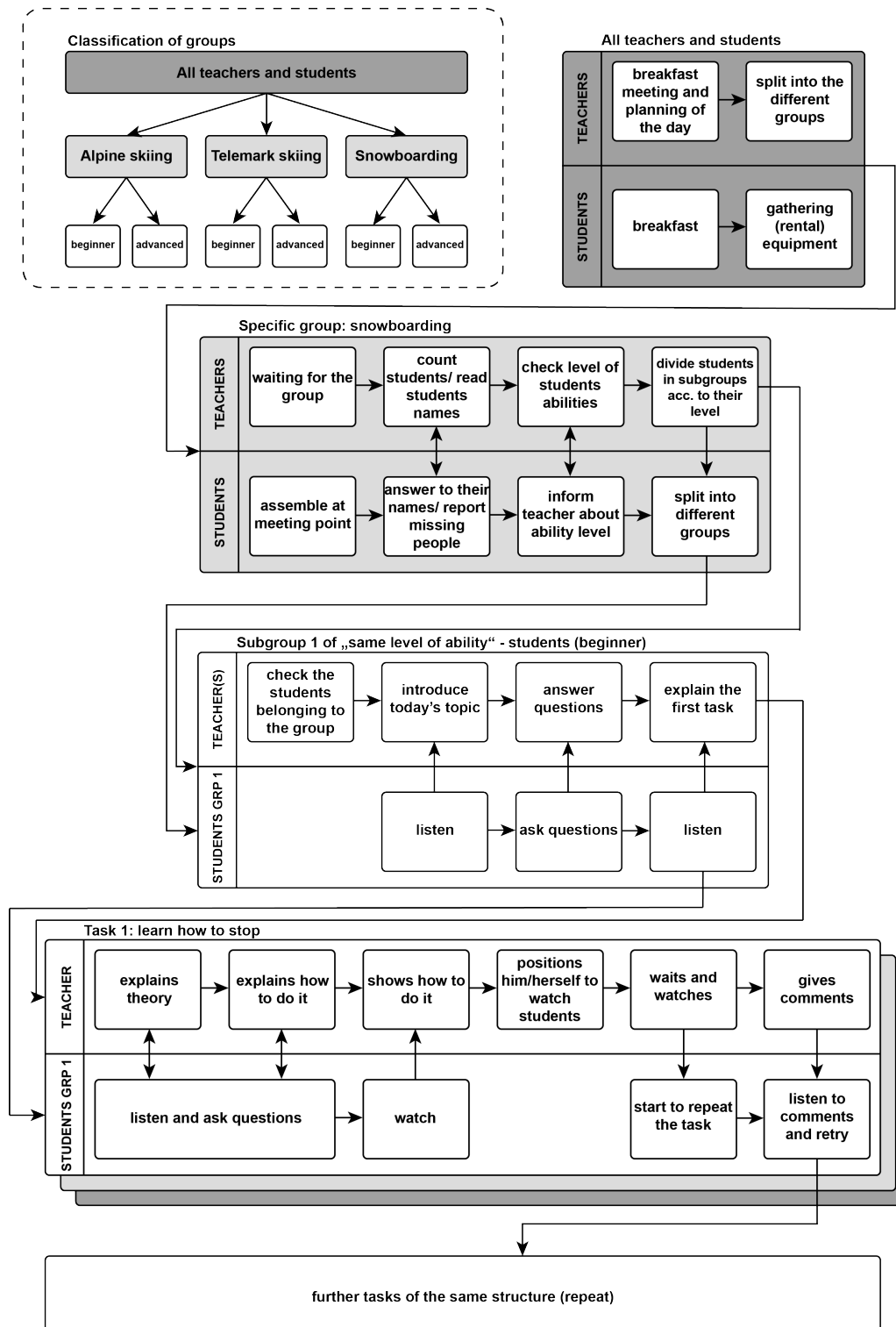


Figure 2.1: Structure of the course taught at University of Agder (UiA) in Hemsedal, Norway (Paper G).

2.3 Ethical Considerations

Research using the HCD process naturally involves humans in testing and evaluation processes. The Norwegian Centre for Research Data (Norsk senter for forskningsdata (NSD)) was informed about this research and gave the researcher clearance to proceed. All participants were informed about the study, study goals and how their data were being handled, according to the rules of NSD. No personal data were stored; only anonymous data was stored and published. Participants gave their consent in the cases where pictures were used for publication, even if the pictures only showed parts of the body.

In this thesis, gamification was used. In short, gamification describes the use of game design elements in a non-game context (here: education) [56], [57]. This method prompts one to look at ethical implications that could come with game elements. Those game elements taken from games were developed with different requirements to ethical correctness than systems in education require. Paper C describes the ethical implications that need to be taken care of while developing a gamified system, including design issues and the teacher's role in a gamified system within higher education. When designing a gamified system, the following design aspects should be considered: balance between gaming and learning experience, system usage with a defined end, no exploitable bugs, not turning the students against each other in a negative way, students not getting a disproportionate advantage by helping each other or by getting help from more advanced students, not being addictive, having an appropriate level of difficulty and being accessible for every participating student.

Teachers' roles may vary in a gamified system, depending on the design and which game elements were used. Typical roles from games can be opponent, supporting character, storyteller, hero character or group leader.

It has to be kept in mind that the purpose of (gamified) e-learning systems is to conduct ethically correct teaching to help students get a deeper understanding of the learning content and to support the teachers in the best way possible. The use of gamification within an educational system must not violate any ethical principles.

Chapter 3

Dynamic Learning Task Concept

This chapter is concerned with analyzing learning tasks in educational settings, especially alpine sports, and tasks in game settings. The first section explains the reasoning behind focusing on tasks and task processes. Then, learning tasks as part of the context of use analysis are explained. After having explored the problem space more accurately, the perspective of computer game tasks comes in. Starting with an idea on how to design a motivating solution for students as well as teachers, the computer game task analysis revealed how tasks can be tackled from another perspective and added insight into how learning tasks in an educational context could be shaped. In both areas, education and games, task structures as well as task processes were analyzed (Figure 3.1).

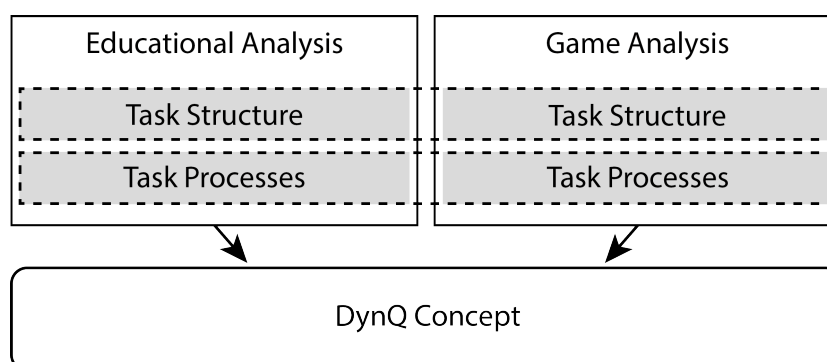


Figure 3.1: How educational and game analyses contribute to the Dynamic Questioning (DynQ) concept.

Task structures are concerned with how a task is constructed in itself and which elements a task inherits. *Task processes* are actions that concern or use those tasks. These can range from planning, creating, distributing, and embedding tasks in the teaching process to getting feedback from conducted tasks. Both sides, the learning task analysis and the game task analysis, contribute to the "Dynamic Questioning"

(DynQ) concept. This is the basis for the supportive teaching tool DynQ. Development and testing are described in Chapter 4.

3.1 Connection between Learning Tasks and Teachers' Motivation

As an important step within the context of use analysis, a particular interest lies upon the motivation of teachers to integrate digital technology into their teaching processes. Teachers' general motivation to teach is an important resource to understand what might be motivating to support with digital technology (Papers A and B). The topic of motivation to use ICT tools in education is complex. Earlier studies considered influencing variables towards teachers' motivation. Such variables include technology acceptance [67], attitudes towards technology systems, teachers' confidence to use such systems and their opinions about them [34], [68], [69]. Buabeng-Andoh categorized these factors into personal-level, school-level, technological-level and barriers, where one of the factors within the technological-level is that appropriate software is missing [68]. These categories are not far from the categories that were found in my PhD project: human factors (most often related to skills, attitudes, opinions and confidence), values connected to intrinsic motivation (including satisfaction, level of interest, joy and entertainment) and general requirements towards the tool (including usability, interactivity level, monitoring progress, specialization, adaptability, and learning requirements). The main difference is that our categories are compiled through the lenses of human-computer interaction research and therefore already specialize on possible requirements towards motivating (for teachers and students), as well as usable and pedagogically valuable tools.

Knowing what is in the center of teachers' interest helps to develop for motivating ICT tools. At this point, it was analyzed that interaction with the students is central to the teachers' motivation (Paper D). Looking at what can enhance interaction, we first have to define types of interaction that can be considered. According to Moore [70], there are three main types: learner-content interaction, learner-lecturer interaction and learner-learner interaction. Interaction is an important aspect of learning that was also identified as one of the most important factors to build effective digital learning solutions [71]. Hence, supporting interaction is central to this work, as it aligns with the needs teachers expressed (Paper D). Teachers expressed that they were motivated to use an ICT tool in the teaching process if the tool could help to make the student activities visible or observable for the teacher, thus enabling a form of digital student-teacher interaction. Student activities most often

involve a form of learning tasks.

One of the most important factors of what teachers described as motivating is the ability to follow students throughout the journey of learning. This leads to the assumption that motivated and engaged students are motivating and engaging for teachers and that technology that can support teachers with their teaching approaches and processes and is engaging for students is motivating for teachers to use since it helps them to visualize or get insight into the students learning progress. An approach that most teachers use to engage students in the learning process is learning tasks. Learning tasks can differ a lot in content from subject to subject but are used generally in all disciplines in one or another way. Students engage in learning tasks and the learning process can be observed during the task solving or training process.

3.2 Context of Use: Learning Task Analysis

An important aspect of the HCD is to understand the context of use. Having found that teachers are motivated to use technology if it can support teaching processes around learning tasks, these processes and task structures have to be analyzed carefully. From that, teachers' needs and requirements can be formulated and design solutions (prototypes) for user testing and evaluation can be developed.

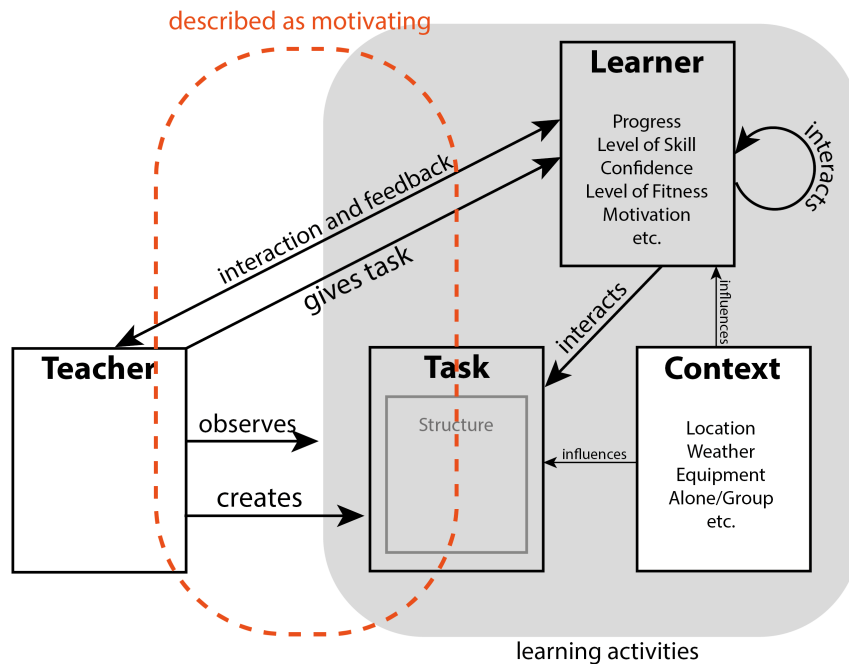


Figure 3.2: What the teachers see as motivating during the teaching process (Paper D).

The possibility to have increased access through technology to see the students interacting with the tasks, solving tasks, or interacting with one another mediated by the task is considered to be an important motivation factor for teachers (as shown in Figure 3.2 (Paper D)). As obtained from interviews and user testing, teachers mentioned learning tasks as one of the most interactive aspects of teaching including interacting and engaging in content, with one another or with the teachers. Teachers stated that they can see the students grow while solving tasks and students' interaction for problem solving and a high engagement in content can be seen during the interaction with learning tasks.

3.2.1 Learning Task Analysis

Learning tasks occur in different forms and situations. Teachers prepare and create learning tasks for the students to solve during lectures, lab work, as homework or in the field as training tasks. Some teachers use small tasks during lectures to interact with the audience [72] in the form of questions, discussions or other small activities. Complex learning tasks are most often created for lab work, student projects or homework and are either solved individually or in small groups of students. However, some courses have a large number of students, so that individual tasks or group work cannot be carried out in the same way as done in courses with smaller sizes. Outside of the direct teaching situation, teachers have little insight into the task-solving process. In most cases, learning tasks are planned, created and handed out and the result is handed in if required by the teachers. To support these learning task processes digitally (planning, creating, distributing, and collecting feedback), there is a need to know how tasks are structured and how they are distributed as well as how not only results but also solving or training steps can be made visible to the teachers. Based on the context of use analysis, using questionnaires, interviews and field observations in many different studies (such as Engineering, ICT, Social Sciences, and Natural Sciences) and the concrete use case of alpine sports (Papers D, E and G), the following aspects were found to be central structural aspects of tasks:

- task title,
- overview, short description,
- long or complete description,
- resources (links, books, pages, papers, material, equipment. . .),
- people connected to a task (if necessary),

- location (if necessary: laboratory, classroom, outdoors, etc.),
- time for task completion (if needed),
- level of difficulty (alpine specific: level of terrain difficulty), and
- rewards for completion (optional: credits, grade percentages, etc.).

The task title is needed as human-readable identifier for the students (the machine-readable identifier could also be generated from the title). Students should be able to grasp what the learning task is about at a glance. The short description should contain the task itself. Depending on the type of task, subject or context, a longer version or more explanations may be needed. The resources needed for the task should be stated as well. This can be crucial in contexts such as sports, in which special equipment is needed. In general, these resources can constitute virtual (directly linked material) resources or the requirement outline for physical resources. In some cases, it is necessary to know people who are connected to a task or a set of tasks. Connected people can be for example the teacher, teaching assistants, other professors interested in cross-course work, administrative personnel or team members. Designating a location can be necessary if the task comprises laboratory work, field work, or a specific terrain for sports or if certain rooms are booked for the students. Time for task completion can help to indicate how long a learning task should take or add another challenge to the task like "reaching a certain location in a certain amount of time". The level of difficulty helps the students to choose from a set of tasks (some might have a higher difficulty than others) and to know what they have to expect from a learning task. In alpine sports, slopes are often marked with a difficulty for the terrain that can directly be related to the task difficulty level. The reward section could include, for example, the number of credits earned for certain tasks or the percentage a given task contributes to the final grade. This can help students to know what they get out of undertaking the task. If stating rewards is inappropriate for the given context, the section should be left blank.

Learning tasks range from an easy to a complex difficulty and tasks can build on each other. Some tasks require acquiring prior knowledge or skills from previous tasks. A tool that supports such an aspect can help the teacher to use this information to improve the teaching and tailor it to the students' needs. Teachers expressed interest in certain types of feedback generated through the learning task activity. Feedback and statistics of the student activities could be presented to the teacher. A list of feedback possibilities can be found in Paper D.

3.2.2 The Role of Tasks in Teaching and Learning

This chapter describes learning theories connected to tasks in teaching and learning. After that, tasks within the use case of alpine sports are analyzed including how the zone of proximal development (ZPD) and flow theory influence teaching and learning in alpine sports.

3.2.2.1 Zone of Proximal Development

The Zone of Proximal Development is defined by Vygotsky as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers" ([73], p.86).

The original definition of the zone of proximal development (ZPD) is about the levels, not tasks, of development [74], but the ZPD has to be created with activities leading to development. Wells [75] defines that a ZPD applies to 'any situation in which, while participating in an activity, individuals are in the process of developing mastery of a practice or understanding a topic' [74]. It is also noted that the ZPD can be created for any kind of skill [76]. This means that, if a task is created as an activity as part of a process of development, the task can be created to be within or out of the ZPD of an individual student, including the individual student's (1) level of skill and (2) level of challenge. The key factor we are looking at within the ZPD is the notion of "under guidance", the difference between assisted versus unassisted performance [76]. The main claim is that students can develop further with the help of a more capable other than they would be able to alone. The ZPD is shown in Figure 3.3.

The observed use case showed many instances, which included "more knowledgeable/capable others". The more capable other can be a teacher or a more skilled student. In general, teachers expressed the concern of non-applicability of the ZPD in classrooms because of the number of students [77]. However, sports are often taught in non-classroom environments, including the exercises and activities of the particular sport subject. This form of teaching requires smaller group sizes, since teachers have to observe the students to give feedback and because of safety reasons. In addition, because of varying group sizes (between 5 and 20 in this use case), the teachers can only spend a limited amount of time per student. In this case, however, the feedback from the teachers (or other more knowledgeable peers) is crucial. As

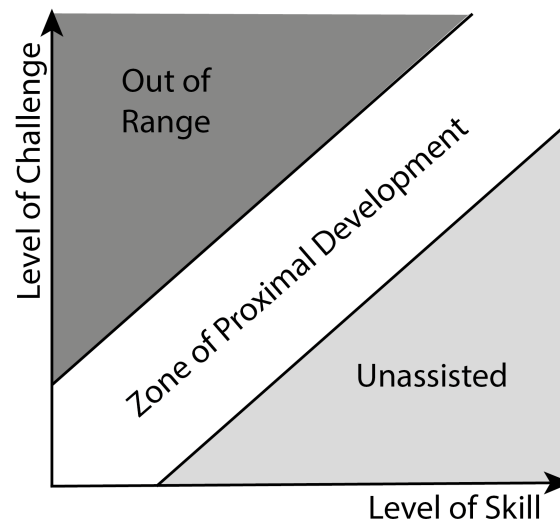


Figure 3.3: ZPD: the range of development including guidance (modeled after [1]).

stated by the teachers, there is an observed mismatch between what students think they do and what they actually do, and an observer is required to point out where the difference is. In fact, the course encourages the advanced students to actively help and teach the beginner students after their own lessons to learn how to teach the given subject. One of the course objectives is to prepare skilled students to teach skiing or snowboarding in the future. In the advanced classes, teachers teach the indicators of why certain learning steps and tasks can fail, thus giving the advanced students the skillset and tools to scaffold beginner students [78].

The concept of the ZPD in sports education was addressed in previous research work. In [79] the teacher (here the coach) is described as "more capable other". Using guided discovery and problem solving to teach technical and tactical aspects of sports performance, teachers can use questioning, prompts, and feedback to facilitate the appropriate amount of guidance to promote learning [79]. Of course, it is also important to consider how the teacher guides and formulates the feedback [80] to reduce anxiety in sports learning and performance, but the most important aspect is to have reachable goals in the first place.

Over the time, as the student gains an understanding of what is required to successfully perform a skill, the amount of guidance needed becomes less [79]. Snowboarding teachers often directly guide students through the movements while explaining how to perform a certain skill successfully. They take the students hands and perform for example curves with them on the slope, for them to get a feeling for the correct movement so that motor learning can take place. The correct amount of guidance in these early stages is important. Failing often results in getting hurt

which then can turn into frustration, fear and anxiety. This again can lead to refusal to train further [81]. The same risk exists when students get digital learning tasks. Therefore, also in a digital design solution, the teacher has to be able to make tasks in appropriate steps within the ZPD of the students, with as much (theoretical) guidance as needed to minimize frustration and the development of anxiety. This also means that tasks that are out of the ZPD of the students should not be pushed onto them prior to acquiring the needed skills.

Digital supportive technology has to match the teaching requirements, to design tasks so that they are close to the students' status of knowledge to stay in the ZPD of the individual student [73]. The best case would be if the tasks are designed in a way to guide the students so that the technology can function as a more capable/knowledgeable other.

3.2.2.2 Flow Theory

Flow is described as "a state of consciousness where one becomes totally absorbed in what one is doing, to the exclusion of all other thoughts and emotions" [3], meaning that flow is about focus and a harmonious experience.

Closely connected to the ZPD in this case, task should be designed with an appropriate level of challenge within the student's skill-range, according to the flow theory [3], [82]. If the challenge versus skill level is in balance, tasks are more engaging for the students, hence a better learning experience can be achieved. Csikszentmihalyi [3] described characteristics and dimensions of flow. As early as 1992, flow was described in sports research [83], [84]. The difference compared to the ZPD is that there is no guidance within the flow; it is more about the level of challenge within the right difficulty level, neither too easy nor too difficult. Being able to distribute tasks according to the students skill levels can trigger such a flow state, in which students train on their own based on a task recommendation.

Creating a learning experience within the flow is exactly what teachers in the use case of skiing and snowboarding are trying to achieve. As seen in the skiing training literature, teachers have to be well aware of the students skill-set to create an optimal learning path within the flow zone. This requires different tasks for different students to learn certain skills [6].

3.2.3 Learning Tasks in Alpine Sports

Sports education highly depends on a task structure that starts with the simple basics and builds upon acquired skills over time. The learning path does not necessarily have to be the same for each student, but different tasks can focus on the same needed skills. This means that tasks have a hierarchical structure with more basic ones in the beginning and complex, specialized learning tasks afterwards.

3.2.3.1 Task Structures

The hierarchical structure of learning tasks used by teachers in alpine sports is equally represented in the skiing and snowboarding literature. Complex movements have to be broken down into smaller movement parts. One example is learning how to turn with a snowboard: 1. heel or toe side edging (without sliding), 2. diagonal side slips (keeping the board at 90°), 3. side edging into fall line and then 4. back to 90° [85].

The literature illustrates task structures according to skill levels: fewer in the beginning as well as more complex and higher variety in the higher skill regions (Figure 3.4). This means that the students follow tasks from the easier level to the more complex tasks with different directions of training in higher skill regions. Different foci of training require specialized and structured tasks. Skill level and tasks are also closely related when it comes to choosing a training location. That is determined by the type of lifts the student is able to take (not every beginner is comfortable using every type of lift, and snowboard beginners are particularly often not able to take dragging types of lifts in the beginning) and terrain that is needed. The terrain and difficulty of slopes is mostly indicated using colors (green, blue, red, and black (single black, double black and triple black)). For certain tasks, multiple possibilities for the specific terrain difficulties can be chosen. In many cases, it is not necessary to have a specific slope, rather a specific difficulty, meaning that learning tasks should indicate the terrain color or difficulty needed. For some specific tasks, a specific location, which cannot easily be replaced on other slopes, can be chosen. This can, for example, be a large flat area without many people passing by, where groups can find enough place for first steps, testing and exploring. Naturally, since alpine sports are mostly taught outside, the learning and teaching conditions can vary a lot. Even the same track or slope can be different depending on the time of the day and the weather. Teachers have to decide on tasks, depending on the students' skills, the location and terrain (as well as weather conditions). Every group needs to go through the basics, but every group is different and learns at a different pace. The teacher needs to adjust the tasks according to the groups' needs.

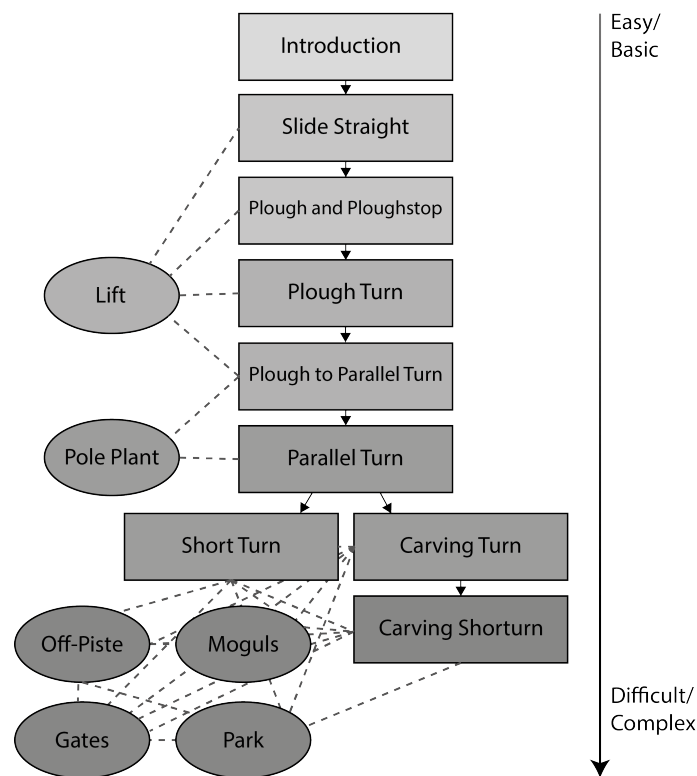


Figure 3.4: Hierarchical task progression concept within alpine skiing [2].

3.2.3.2 Task Processes

Learning tasks are assigned verbally for the most part. When the teacher is involved during the course, tasks are actively explained to the group of students, followed by a demonstration by the teacher. Students follow the teacher down the slope while performing the task, imitating the teacher's movements or following the teachers' instructions on how to move. The teacher observes and gives feedback. According to the students' progress and other environmental conditions, the teacher chooses the next tasks and decides on a difficulty level and terrain. As observed, most tasks are individual learning tasks but group tasks are important as well. Tasks such as "the human queue" require the involvement of multiple students, who build a long line with enough space between each other so that the first person can start to practice slalom in between them. As soon as the first student reaches the end of the queue and stands in line with the others, the next student starts from the top. Another learning task, "jumping over objects", requires one student (or teacher) to place an object (for example, a glove) ahead on the slope while the other students wait at a distance (uphill, to be able to gain speed). One by one, the students then start to accelerate and try to jump over the placed object.

3.2.4 ZPD and Flow in Alpine Sport Tasks

The ZPD and the flow theory originally talk about very different concepts, but in the context of learning tasks, both concepts can be seen as quite close to each other. The flow theory does not necessarily include assisted or unassisted learning or development, but from the theory it can be understood that most of the flow experiences are rather unassisted. However, flow can also be experienced with guidance. Both theories indicate that learning tasks out of the ZPD or flow can result in boredom, when they are too easy, or in anxiety, when they are too challenging [4]. The point of a new skill introduction can start within the flow of a student. It can then reach a point where teacher guidance is required for the student to develop further and is furthermore able to grasp the skill, returning back into her/his personal flow zone, not being bored or anxious (Figure 3.5). This requires personal learning tasks for the individual student. Based on the background, previous knowledge, skills and other variables such as equipment and location, students cannot learn optimally with the same learning tasks and cannot proceed with a fixed, linear set of learning tasks that are the same for all students. The ability to change learning tasks and introduce new tasks as well as jump over unnecessary tasks is what teachers do to keep the students at a stage where they can develop and learn and not fall out of the flow or ZPD zones.

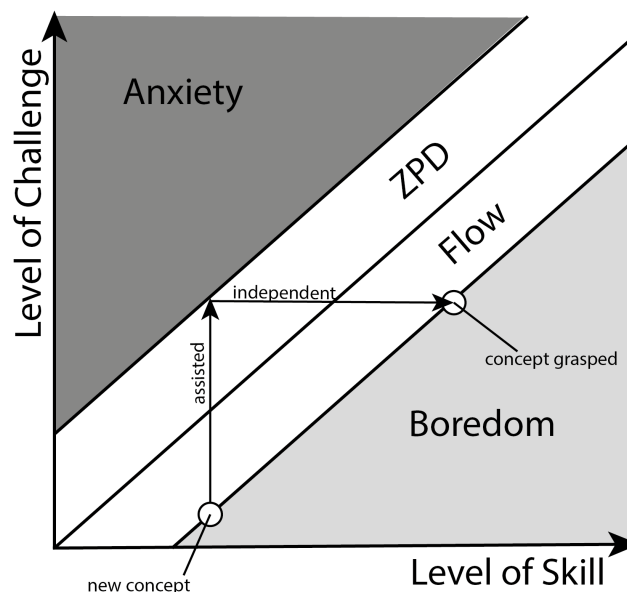


Figure 3.5: Connection between Flow and ZPD (modeled after [3], [4], and [5]).

An example is how the skill "parallel turn" (skiing) can be achieved. Depending on the student's abilities and available terrain, different steps or sub-tasks can be

followed to teach the student how to parallel turn (see Figure 3.6). An example for two different students taking different paths through learning how to parallel turn is shown in Figure 3.7. Student 1 is an example for an adult person who has no prior experience on skis and does not engage in much physical activity in general. Student 2 could be a path for a younger student who is generally very active, knows how to inline skate but also has no prior experience on skis. The teacher has to consider prior knowledge and activity level when deciding upon tasks for the students. Learning the same skill is different for each student. The learning process of different students can require different steps and a different amount of learning tasks that focus on different core elements to achieve the desired skill. Learning tasks should be challenging, but not too challenging, since too challenging tasks can result in frustration and anxiety. This thought is closely connected to the ZPD, as described earlier. However, flow is not only about performance or learning a new skill, but about the enjoyment of a special occurrence of a harmonious experience. Such an experience can also not be achieved by learning tasks that are too easy and boring or out of the student's development range.

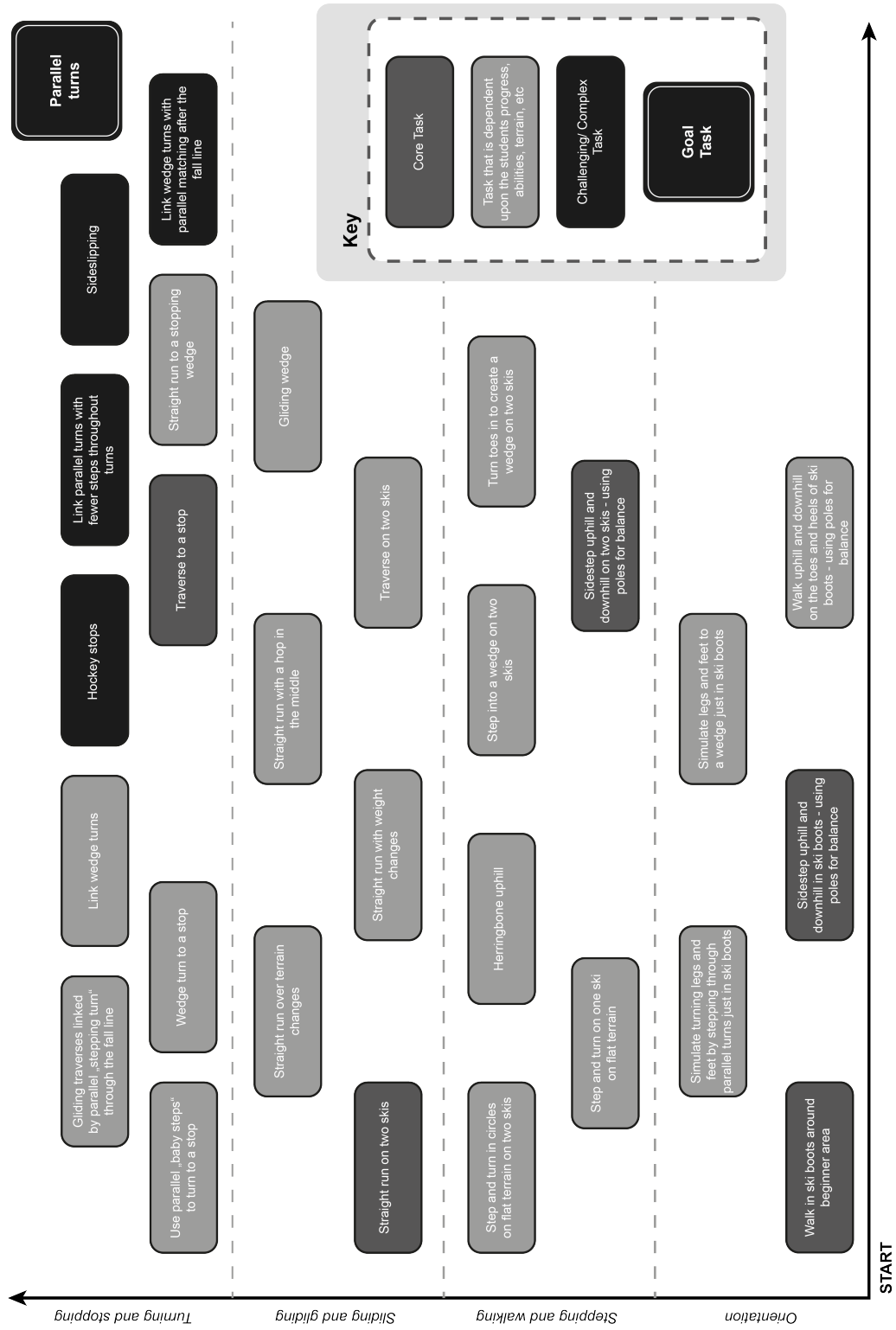


Figure 3.6: Different steps or task possibilities of learning how to parallel turn [6].

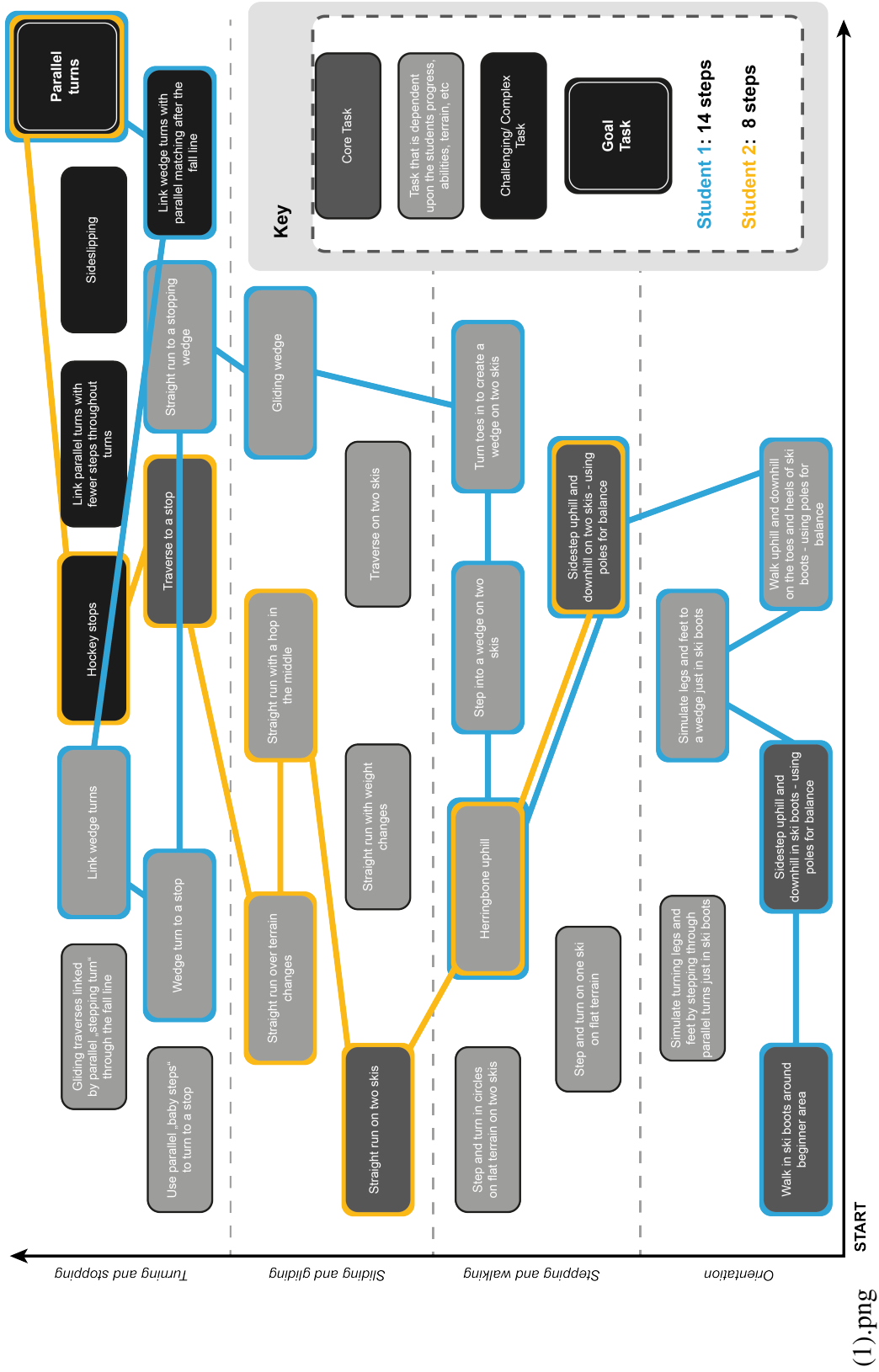


Figure 3.7: Two students' paths of learning to parallel turn [6].

3.3 Game Task Analysis

In this project, the term "gamification" is expanded from "game-design elements in non-game contexts" [56], [57], to include game concepts, mechanics and complex interactions between the player (user) and the game world (environment).

As described previously, teachers want to have a supportive tool that enhances task design and distribution as well as communication between teachers and students. Games are an area in which tasks work well and are known to be engaging and motivating [86]. That is why I looked into games, specifically game task structures and game task processes, that can help to design a motivating digital teaching solution. This chapter first describes the background of gamification and thereafter the analysis of game task structures and game task processes to then use them as elements of gamification.

When the researcher looked into how to design motivating and engaging systems, gamification came up in the literature. "Gamification", the procedure of bringing game elements into a non-game context, has been a subject of many studies in various fields lately and many claim it works or does not work [87]. The term "gamification" was coined around 2002/2003 by Nick Pelling, as part of his consultancy company as stated on his website¹. At this time, he defined gamification as 'we help manufacturers evolve their electronic devices into entertainment platforms', hence making them into games. The most cited definition of gamification today is, however, 'the use of game elements in non-game context' [56], not defining the outcome of this process and not saying that the outcome of this process is a game. There are many studies in which a gamified system becomes a game. In some research, the three terms "gamification", "serious game", and "game" are used interchangeably [88], [89]. There are attempts to define the difference between them [57], [90], [91], [92], but this is not the focus of this thesis.

In this thesis, the goal is to build a motivating system around tasks, including task processes such as planning, creating, distributing and getting feedback from learning tasks. This means that our motivation to look at games is to find a solution for designing motivating processes around tasks based on the idea that games work with tasks all the time as well, and players often cannot get enough of following the tasks a game provides.

Before any elements can be integrated into a non-game context (education in

¹<http://www.nanodome.com/conundra.co.uk/>

this case), one has to find out which elements can contribute to the specific goal of the non-game context (designing a learning-task-supportive digital technology solution). Considering the definition of gamification by Deterding [56], [57], the term “elements” is not precisely defined. Moreover, it was analyzed that not every simple “game element” is beneficial for educational or other contexts. Our approach is to analyze games with respect to a specific problem and how the problem is represented and solved in the game context to adapt game task structures and task processes to the educational setting. This should bring new and different perspectives into solution approaches for educational challenges, to possibly find motivational solutions. However, most gamification frameworks try to analyze all possible game elements, mechanics or concepts at the same time for all possible non-game contexts [93]. That leads to the lack of details for concrete design solutions, since in general approaches no specific mechanics or concepts can be analyzed in detail. Previous research already notes that underlying game dynamics and concepts (Freedom to Fail, Rapid Feedback, Progression, Storytelling) are crucial, not only achievements, badges and game-like graphics [94]. Therefore, we argue that not only visible, easily distinguishable elements such as badges and points are gamification, but also more complex game concepts and cognitive elements. Hamari and Koivisto [95] identified nine dimensions of a gamified environment beyond the typical points and badges: challenge-skill balance, clear goals, control, (immediate) feedback, autotelic experience, loss of self-consciousness, time transformation, concentration, and merging action-awareness. These nine dimensions represent outcomes of gamification, but Hamari and Koivisto [95] do not state how they are achieved. More research in the area of gamification looks at game structures, which is useful for gamifying non-game contexts. According to Prensky [96], six elements of game structure exist: rules, goals and objectives, outcomes and feedback, conflict/ competition/ challenge/ opposition, interaction, representation or story. In addition, some research combines HCD with gamification, clearly stating that an extensive context analysis is needed to understand what type of gamification is needed, by referring to core principles of how to choose effective gamification elements [97].

Looking at tasks in educational settings, we found that they have a similarity to game tasks. Both rely heavily on all six dimensions stated in [96]. Educational tasks follow rules, have goals, produce outcome and in the best cases, allow for feedback. In addition, learning tasks can and should be challenging for the students on a correct level (referring to ZPD and flow). They can offer competition, conflict or opposition either on purpose or indirectly. A contextualized task design can lead

to personalized learning and teaching. It is interesting to see how games handle the aspects of personalized tasks and how the interaction between tasks, gamers (users), environment and goals is structured.

Many different games showed similar mechanics of handling tasks and presenting them to the gamers/players. The combination of the quest/task parts of structure and processes from games are collected under the umbrella-term "quest-log concept". First, the structural aspects are described in the next section. After that, the interaction and task assigning concepts behind tasks are analyzed. These aspects, structural and procedural, are analyzed so that they can be transferred into the design of a digital task-supportive system for an educational setting and enhance the motivation to engage in task-supporting technology for both students and teachers. The following sections attempt to answer mainly the research questions 2a (parts 1 and 2) and 2b about what can be learned from game task design to be used to create motivating and contextualized task structures and task processes in higher education.

3.3.1 Game Task Structure Analysis

Tasks and their visual representation in quest-logs were analyzed from 17 games. These games were selected due to their different genres, to cover different game design elements and their different publication times, to cover eventual differences in game design over the last 15 years. The list of these 17 games includes: Planet Explorers [7], Saints Row IV [8], The Elder Scrolls Online [9], ArmA3 [10], Borderlands 2 [98], Company of Heroes [99], Dungeon Siege [100], Fallout 3 [101], Far Cry 4 [102], Hitman Absolution [103], Mass Effect [104], Middle Earth: Shadow of Mordor [105], The Elder Scrolls IV: Skyrim [106], Thief [107], Tom Clancy's Splinter Cell: Blacklist [108], Warhammer 40k Dawn of War II [109] and World of Warcraft: Warlords of Draenor [11]. Examples are shown in Figure 3.8. The quest log is a widely used concept to get, store, collect and view new and old tasks in the game: the quest-log [8], [106] (other names can be: "missions" [7], "journal" [9], [100], [107], "tasks" [101], "diary" [104], "objectives" [103] and others). This quest-log visualizes tasks the player gets in one way or another, for example game world encounters, exploration or a conversation with a Non-Player-Character (NPC). A visualized quest-log is the central accumulation of tasks and is therefore, often perceived as a "to-do list". This makes sense, since it shows tasks that are available. Depending on the different quest-log approaches, it may show a description, context of the task, requirements, location (map), objectives, pictures and rewards.

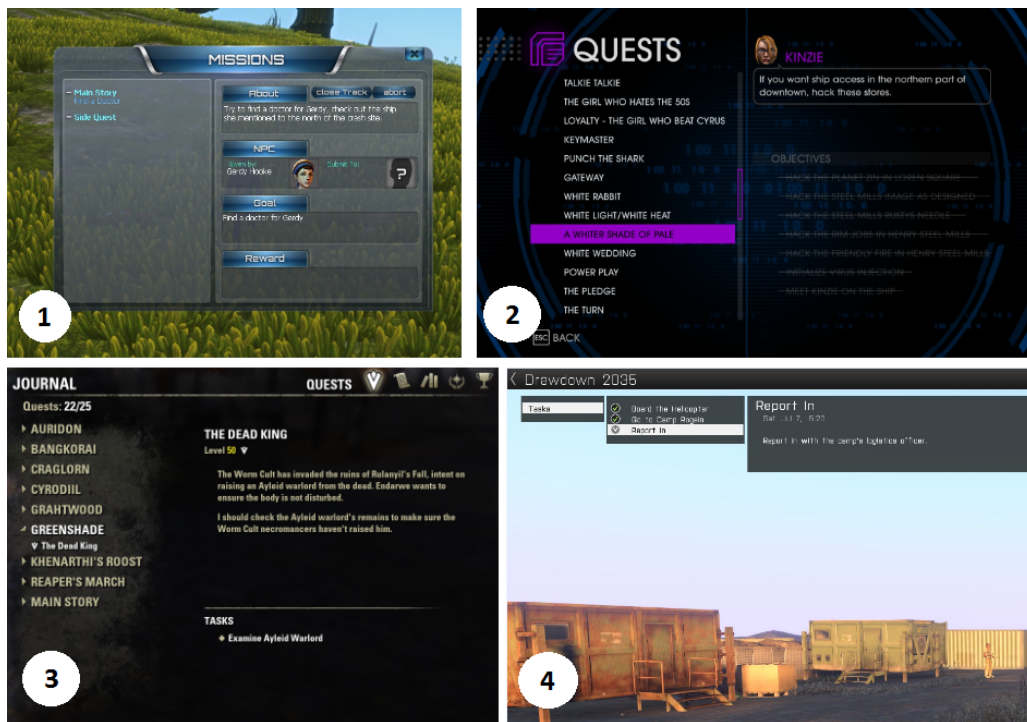


Figure 3.8: Different Quest-Log Structures: (1) Planet Explorers [7], (2) Saints Row IV [8], (3) The Elder Scrolls Online [9], and (4) ArmA3 [10].

There are rather simple quest-logs, such as in ArmA3 [10], that show only a list of tasks and more details in a drop-down menu. This quest-log is located directly in the game world. Quest-logs can also be shown without a connection to the direct game world (upon opening the quest-log screen, the game world cannot be seen and the interaction with the game world is interrupted). In addition, those quest-logs can contain game-type graphics as well as a very rough description and detailed objectives. However, both quest-log types (in the game world or disconnected from the game world) have the same structure: a list of quests and details of a selected quest. The details in quest-logs from Planet Explorers [7] are, for example, clearly assigned to “About”, “NPC”, “Goals” and “Reward”.

The summary of the analysis of game task structures from the 17 games mentioned above contains the following structural elements, which can be found in Tables 3.1 - 3.4:

List: A collection of quests/tasks is shown. Some lists have more detailed structures, whereas others only show the names of tasks. There are games in which no apparent list can be found in the quest-log, since for example only one quest can be conducted at a time. In some cases, tasks are specifically bound to locations or other factors, so that there is no list view or other written overview and tasks have to be encountered through finding and triggering them.

Information/Info: Shows more detailed information about one selected single instance of a quest/task, often mentioning task reasons, goals, objectives, steps to reach goals, involved people and a description of where to go. Most information texts are written in a story context and, are not always easy to understand.

Goals/Objectives: Objectives are structured sub-tasks or sub-goals. They can be seen as structure on how to fulfill the overall goal of a quest. In contrast to "Info", the objectives are mostly structured, without unnecessary information and easy to understand.

Map: A map of the location can show either multiple tasks on a map covering a larger area or where a selected task can be conducted, giving either in-depth details or only hints. The map can be connected to multiple tasks or to a single task. Maps can have larger and smaller instances, too. In some games, maps can be zoomed in or out and switched between zones through which a player can travel. Maps can also show very detailed locations such as caves, dungeons or the indoor environment of larger houses.

Picture: A picture is most often related to a single task, showing a target objective or anything related to the task, e.g., task history or task reason. In some cases, the picture does not cover any additional valuable information to engage or solve a task but immerses the player into the situation by giving visual context to written details.

Rewards: In some quest-logs, rewards are shown. These can come in the forms of currency, reputation, items, certain types of resources, achievements or experience points. Rewards are shown for a single task upon selection.

Type: A task type can refer to a kind of task-solving process that is needed. Types such as escort, mission with a time limit, rescue mission, kill-the-target, collection, race, capture-the-flag and many more can be found. Tasks can be made for single players or groups, ranging from small groups to large groups, often called raids.

Navigation for the quest-log: Navigation boxes refer to interaction possibilities not directly related to the tasks. Some of them have a relation to a task, such as starting or canceling/declining a task.

Task title: The title of a task is often highlighted. In some cases the title appears in large letters on the screen while a game is in progress, whereas in others, the title is highlighted in the task list and upon selection of an individual task.

Character: In some games, the game character (played by the gamer) is shown next to the quest-log. Characters have been found to be full-body figures as well as head- or bust-only figures.

However, the quest-log concept is more than that. It combines the task structures (in which one part is the visualization of task structures) with task processes, which

creates a good overview over dynamically changing tasks. Depending on a player's progress, situation and context, tasks can change, or new ones can appear while the progress of other tasks can be lost (by, for example, getting out of range of the task requirements).

3.3.2 Game Task Processes Analysis

The 17 games mentioned above were analyzed. First, there were three different layers of interaction possibilities found in most games (Figure 3.9, Paper E). The first layer is the game world, being the world where the player character (e.g. Massive(ly) Multiplayer Online Role-Playing Games (MMORPGs)) or player entities (e.g. tactic games) move and act. The second layer is the interface for the real player to interact with the game world, showing interaction possibilities such as skills, bags with items, maps, the quest-log and information about the self or other characters (e.g., names, health bars, and level), game statistics such as team points, death, and reviving time (e.g., multiplayer ego-shooter) and chat possibilities. Unlike the real world, a game world needs an interface between the game world and the user (gamer) to make interactions possible. In most cases, a graphical user interface (GUI) guides the interaction possibilities for users. The third layer refers to settings and may not have a direct impact on the game. However, through simple changes in the settings layer, the game experience can change. Such a setting might be "automatic follow-up on quests if available". In addition, some games allow the creation of macros (defined input sequence of available game interactions) in the settings layer, which enables players to enhance and personalize their game flow.

The game world and interface are the most important layers for analyzing the task flow.

Tasks can be picked up by interacting with NPCs, due to events happening, because of the time or because of the completion of previous tasks and more. All sorts of game-world interaction can lead to further tasks, and those task-chains can differ from player to player. The advantage of the game world is that it has all the data needed to do so, since the characters of the players in the game are technically part of the game world and every action can be tracked. This means that tasks are influenced by the environmental variables, the player's behavior or other occurring events. For example, when entering a new area, new tasks can appear and old tasks can disappear if an important NPC dies. We call these actions, events and happenings that lead to task changes "triggers". In most games it is not necessary to complete all tasks, it is rather important to follow a main task-chain with an option to choose side-quests to complete. Since the game world knows "all" about

Table 3.1: Quest-log visual task structures by games (1).

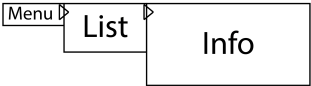
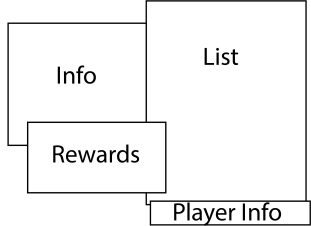

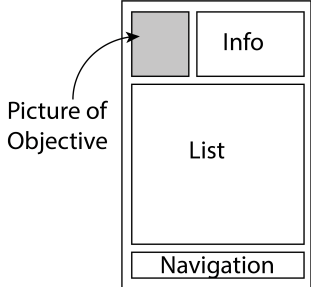
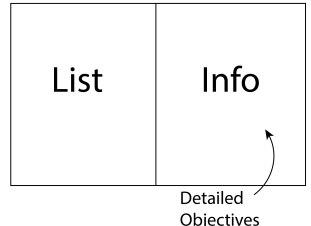
Name (Genre, Year)	Notable Attributes	Visual Structure
ArmA3 (open-world tactical shooter 2013)	in-game dropdown, rather simple, no rewards or extra, information	
Borderlands 2 (action RPG first-person-shooter, 2012)	3D graphics, slightly unstructured and confusing, matching the game graphics, symbol to show quest type, shows difficulty	
Company of Heroes (real-time-strategy, 2006)	simple, in-game view of quest	
Dungeon Siege (RPG, 2002)	simple, picture of target/goal	
Fallout 3 (open-world action RPG, 2008)	quest-log graphic aligned, to the game graphics, messy and chaotic (on purpose), shows quests on a map, shows steps to reach the objective	

Table 3.2: Quest-log visual task structures by games (2).

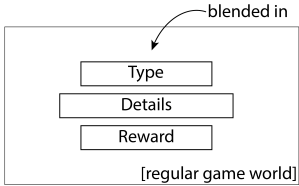
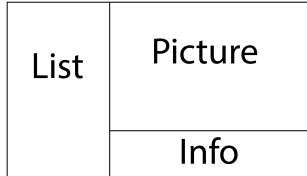
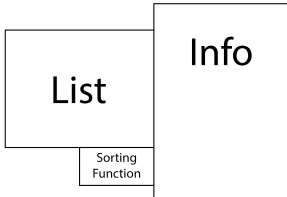
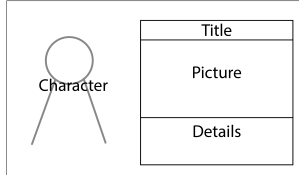
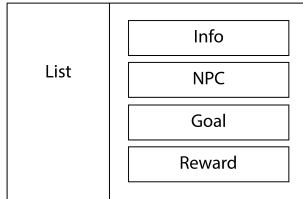
Name (Genre, Year)	Notable Attributes	Visual Structure
<p>Far Cry 3 (open-world action-adventure first-person shooter, 2014)</p>	<p>shows only one quest at a time, shows quest on map, blends in environment</p>	
<p>Hitman Absolution (stealth game, 2012)</p>	<p>short and simple, descriptive text, shows related picture of objective</p>	
<p>Mass Effect (science-fiction action RPG, third-person shooter, 2007)</p>	<p>"diary", rather simple, less information and few details, the biggest screen is rather empty, there is no quest-sorting function</p>	
<p>Middle-Earth Shadow of Mordor (action RPG, 2014)</p>	<p>blends in next to the character, immersive feeling, big picture to show what should be done</p>	
<p>Planet Explorers (adventure RPG, 2015)</p>	<p>very structured, simple, information categorized into: about, NPC, goal, reward</p>	

Table 3.3: Quest-log visual task structures by games (3).

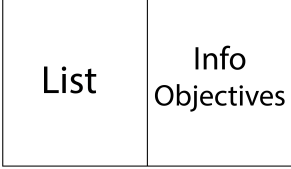
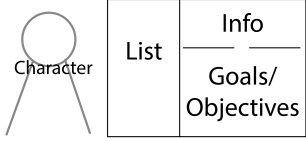
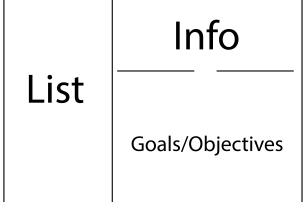
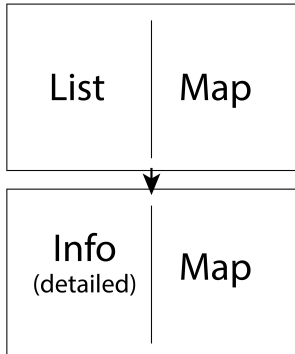
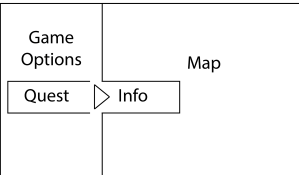
Name (Genre, Year)	Notable Attributes	Visual Structure
Saints Row IV (open-world action adventure, 2013)	simple, but structured objectives	
The Elder Scrolls Online (MMORPG, 2014)	description, short tasks (objectives), shows character, shows difficulty level	
The Elder Scrolls Skyrim (open-world action RPG, 2011)	same structure as in Elder Scrolls Online, transparent window: game world can be seen behind	
Thief (stealth, 2014)	quest details hidden in full text, no direct link to map, upon selection of tracking a quest -> a marker is shown on the map	
Tom Clancy's Splinter Cell Blacklist (action-adventure stealth, 2013)	dropdown, more details, including map, no rewards shown	

Table 3.4: Quest-log visual task structures by games (4).

Name (Genre, Year)	Notable Attributes	Visual Structure
Warhammer 40k Dawn of War II (real-time strategy tactical RPG, 2009)	bad overview, less information, shows rewards, shows map, "mission briefing", then in-game list view	
World of Warcraft: Warlords of Draenor (MMORPG, 2014)	very detailed, story explained, short overview, direct relation to map, sort quests by location, shows rewards	

the interacting character, it is easy to tailor tasks to the area, speed and skill of the individual gamer. Therefore, many games provide a specific gaming experience through personalized tasks.

To visualize a possible task flow, please look at the example in Figure 3.10. The player encounters a situated task by reaching a specific location. Here, the player finds a cave and gets a task to do inside (1). The task triggered by location is automatically stored in the quest-log, shown on the right (2). It visually moves from the top position to the right, so the player knows where to find it. It shows the title, objectives and the reward. In (3), the progress of the task is visually tracked to give the player feedback about every step. In the middle of the screen, the progress of what is done currently pops up as soon as the player adds to that goal, and on the right the overall progress is shown. On the top right, the map visualizes the area in which the task has to be completed in yellow. In (4), the final step of the quest and the completion is shown. The reward is highlighted and the tasks are checked. In this case, the player also earned an achievement alongside the task (5) to highlight an extraordinary completion within the task or multiple tasks that were completed.

As observed and analyzed from several games, tasks are highly context sensitive and player specific. Tasks can be distributed or get to the player in multiple ways. Ways in which tasks are given to the player include:

- tasks can be given, guiding the player/user to do something,
- tasks can be spontaneously encountered,
- side tasks can be chosen to be followed,

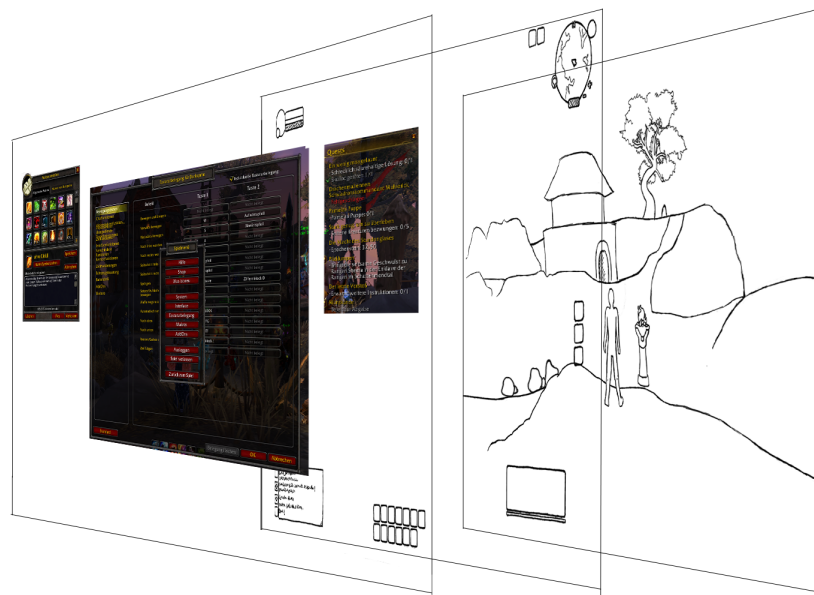


Figure 3.9: Game interaction layers on the example of World of Warcraft, Warlords of Drenor [11]: Game world, interface and setting (Paper E).

- depending on the character and game-flow-tasks/story-line-tasks can vary,
- achievements can have an influence on the availability of tasks,
- decisions can shape tasks,
- tasks can be available only for a certain time, they can change or disappear, and
- tasks can be found through exploration.

Task feedback to the player is mostly shown directly. It includes feedback about the progress, in numbers, by highlighting certain areas in maps as well as through progress bars, steps or phases shown and achievements upon completion. Task attributes that are shown to the player as feedback can include the following:

- the tasks' progress (e.g., "collected 1 out of 4")
- a task attribute: pass/fail
- tasks repeatable by choice, restricted possibility for repetition (for example, only once a day/week) or never repeatable (shown to the player)
- information and objectives visible during the task (sometimes directly and sometimes upon opening the quest-log)
- showing nearby players doing the same tasks or grouping up function
- highlighted necessary items in the world or in the bag/inventory of the player



Figure 3.10: Task processes in World of Warcraft: Warlords of Draenor [11].

- shown task duration or time left for completion
- completion time (or other aspects that show how successful the completion of the task was, e.g. number of items collected in time, monsters killed or people rescued).

What can be seen is that tasks in games are highly context sensitive. There is a connection between the players' context including progress, situation, skill level or specialization and the availability of tasks.

3.4 Dynamic Learning Task Concept: DynQ

In this chapter, the outcomes of both analyses are brought together. The learning tasks as analyzed are used in the current teaching processes. The analysis features important core structures and processes that have to be maintained in a digital supportive solution. However, the game task analysis revealed how different types of game processes and even structure parts can help to design for more situated and contextualized tasks. These insights help to design learning task structures and processes that are motivating for the teacher to integrate, because they add new teaching possibilities and new channels for feedback and communication to the current teaching processes.

In the current teaching scenario, the teachers create learning tasks and hand them to the students either verbally, in writing, on paper or digitally. After engaging

with a task, students either give feedback to the teacher, or they do not deliver any feedback, because it may not have been required. This means that a teacher often has one point of interaction with the students about their learning tasks. In the case of alpine sports, the teachers are in fact heavily involved as long as they are with the students during the training sessions. The teacher is highly important especially for beginners, since movement and understanding the concepts of skiing or snowboarding is hard to grasp without being shown and given feedback about body stance and movement (expected versus reality, i.e. "what they think they do versus what they actually do"). From the game analysis, it was found that in games, tasks often have different sources, whereas in teaching situations, tasks often only come from the teacher or teachers. It was also seen that learning tasks as of now can only be adapted to the learners' situation in the teacher's presence. The teacher evaluates the students' situation and knows how to adapt tasks according to the skill level, progress, problems, equipment, weather and location.

In the DynQ concept that was created from both the educational analysis and the game element analysis, two main aspects are targeted:

1. The DynQ concept offers new possibilities for teachers create tasks, and it offers new channels for feedback and communication over learning progress between teachers and students.
2. Student engagement is created through personalized learning tasks; therefore, where the focus of my PhD work is on the teachers' needs and requirements to create those personalized learning tasks.

The DynQ concept is an interaction between context, tasks and triggers, in which the triggers are the defined causes for tasks to appear based on certain context variables (Figure 3.11).

To use the DynQ concept in teaching, teachers must understand or know about conditional tasks, to understand the concept of task triggering (that an event or a change of learning context can lead to a new task) and what triggers could be used in their specific field of teaching.

The digital ICT solution must support the creation of learning tasks according to their original educational structure and the enhanced functionalities from the DynQ concept. These include the direct sending of tasks from teachers to students (like the common method) and task triggering through context-triggers. The ICT solution must include means to provide information that can be used for those context-triggers.

The system should be able to provide feedback to the teacher, based on accomplished tasks and achievements (Paper D and G). The exact form and content of

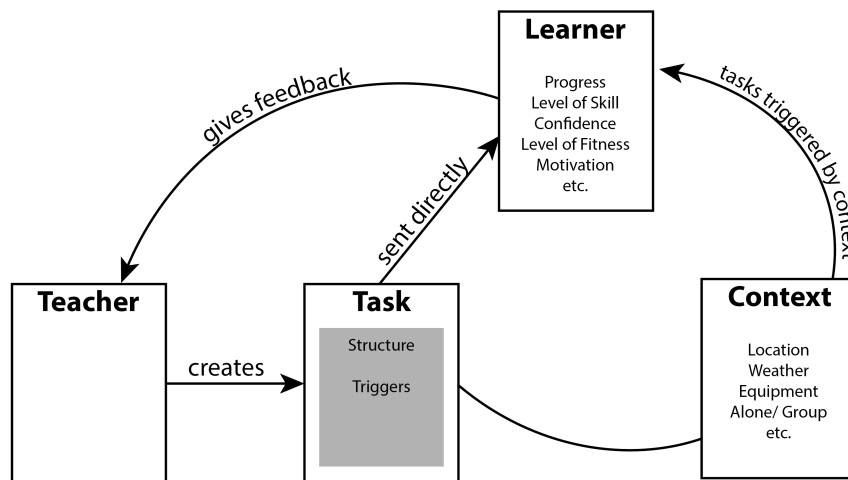


Figure 3.11: The three underlying parts of the DynQ concept (task, learner and context) and their connection to the teacher.

feedback and how anonymous or personalized it should be are out of the scope of this PhD work.

In an optimal case, the teachers can connect possible triggers as well as learning tasks, and they understand which information about their students would be useful to use as triggers and what they need to see as feedback. In the task design process, teachers must think about the creation of a trigger, insert the usual task information (content) and decide which information to track throughout the task for receiving visual or numerical feedback about the students' progress. For example, a student can pass a location during a task, and the location triggers a learning task specific for that location. Further more, after finishing a task, a student can trigger another task with a specific requirement, such as, for example, a summative result of having reached a maximum speed of 30 km/h.

Chapter 4

DynQ System Design and Development

This chapter describes the central aspects of the system design and development, including the concept design and the prototypes used for testing.

4.1 System Design

In this thesis, certain game elements and processes that are connected to how tasks are dealt with in games were identified. Those elements and processes make the tasks more personalized, flexible and contextualized.

Adapting these ideas into our Dynamic Questing Application (DynQ) core concept means, that DynQ needs to have dynamically occurring tasks that offer flexible and on-time task designs and changes, which should support the individual teacher's teaching approach. To achieve that, the concept consists of three core elements. In addition to regular known task elements, in non-technology-supported teaching, the added value is created through (1) dynamic task dependencies, so-called triggers, (2) sensor logging and (3) feedback generation (Figure 4.1.). The addition of triggers enables dynamic flexibility of when tasks appear for the individual students. Triggers are the underlying mechanism that determines when a task is shown. A trigger can be a state in which a student is (e.g., the student's location or physical position) or an achievement (e.g., reaching a certain speed), or a combination of both. The sensor-logging component can provide measured data as triggers, which in this project are speed, acceleration, physical location (GPS), and time. A trigger can be met anytime (during the whole course), during the students' specific training, or as a result of an achievement, fulfilling a certain task or a combination of tasks. An example for a trigger that can be met anytime during a student's training

is reaching an extraordinary speed while performing a task. In addition, the sensor logging provides data for feedback generation for teachers and students. Collected data can be visually presented in the interfaces of both user categories (students and teachers). According to privacy concerns, visualized data differs between the students' and teachers' view.

The system enables the teacher to prepare learning tasks before the teaching for different conditions, such as time, skill level and location. During the teaching, or during self-training, students can discover new tasks depending on their individual context (tasks appear as soon as a trigger is met), which supports personalized learning. Additionally, students are supported in creating knowledge through active experimentation, as an implementation of experiential learning. Different students trigger different tasks. This leads to different paths through the tasks and enables personalized learning to a certain degree, depending on the number of tasks created for different student contexts.

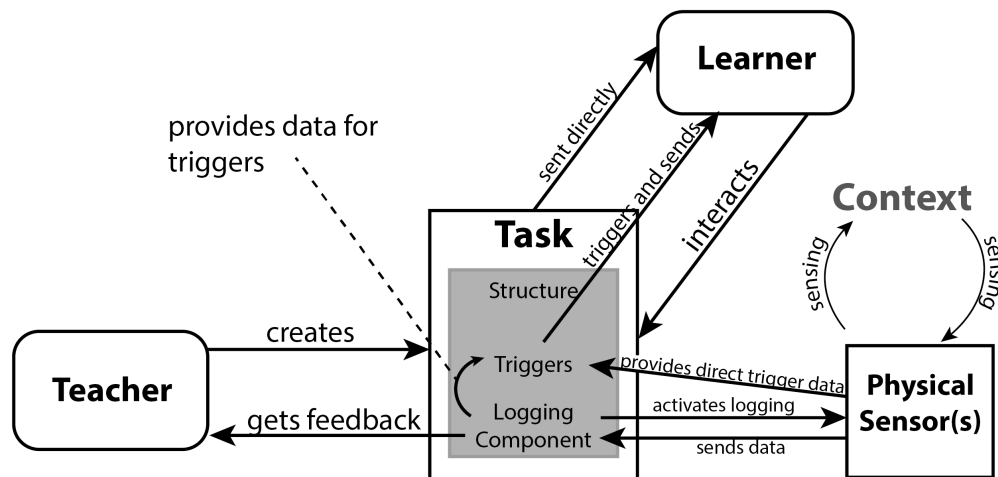


Figure 4.1: Relation between trigger(s), sensor(s) and task.

The DynQ concept aims for a context-based task personalization, i.e. that the technology (and the system architecture) must be able to sense the user's context to a certain extent to gather data for task recommendation, i.e. to know when to trigger which task. Mobile and wearable devices provide mobility and sensors to measure the user's context and progress. The combination of both opens for a variety of interaction possibilities as well as improved sensor measurement options, even though it is not practical to hold a mobile device, especially during sport activities. There are several options for attaching the mobile device to the body, for example, using armpockets or armbands, but those solutions do not allow quick interaction

with the devices. Smart devices such as smartwatches offer interaction possibilities as well as sensor measurement and are comfortable to wear. The smartwatch adds two different valuable components to the setup: (1) an additional measuring device (some smartwatches have more and different sensors than mobile phones do, for example, heart rate sensors) and (2) an alternative interface for interaction. In the use case of outdoor education, an additional interface for interaction is needed. During training, a student rarely uses her phone since it can easily be lost and the complex interactions on the smartphone screens can be affected by the cold temperatures (around -15°C). After the choice of the hardware devices, the choice which OS to use had to be made. The final choice was Android OS on the hand-held device as well as on the smartwatch due to prototyping and availability aspects. The general concept had to be iteratively tested and developed, but the concept itself is not restricted to a specific OS. The choice of Android OS was mainly due to the open developer policy, availability and price range of smartwatch devices. In addition, having a full-fledged Android OS on the wearable device gives access to many existing libraries and Software Development Kit (SDK) features. In particular with the use case of sports education, it was necessary to also test in a real-world setting and not only on emulators. So the availability of several real devices made user testing and evaluation possible.

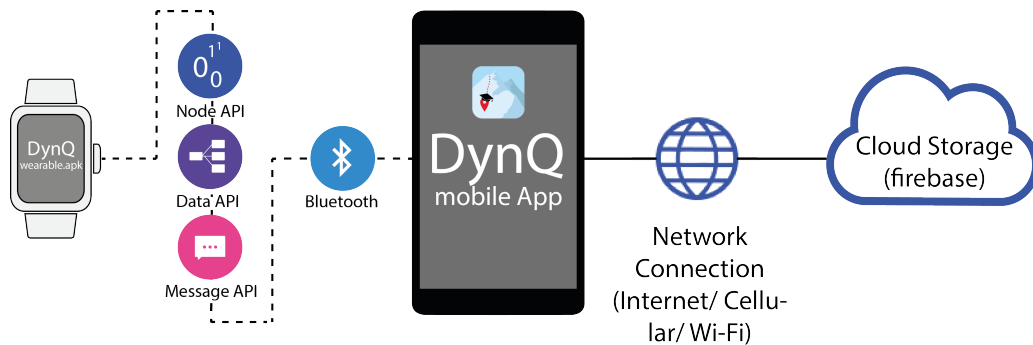


Figure 4.2: Android wear application architecture for one instance of the prototype, connecting a smartwatch with a smartphone.

Figure 4.2 shows the Android Wear application architecture. Between the smartwatch and the smartphone, the Wearable Data Layer API, consisting of three basic APIs (Node, Data, Message), facilitates the sending and syncing of data [58]. The Message API provides a low-latency, one-way communication mechanism to send byte arrays (without acknowledgment for sent data). This can be used for remote procedure calls (RPCs) such as starting the sensor logging on the smartwatch from the smartphone. The Data API allows the syncing of data between the smartphone and the smartwatch. The Node API helps to establish a connection and localization

of devices. It handles connection failures and can discover when a device comes into range. All three APIs use a bluetooth connection for not only simple messages and notifications, but also sensor data exchange between the smartwatch and the smartphone. The hardware devices chosen for this project are Sony Xperia Z5 (Android) and Smartwatch 3 (Android Wear, Display: 1.6" 320 x 320 Transflective TFT LCD (280 ppi), Processor: 1.2 GHz ARM Cortex A7, Dimensions: 36 x 51 x 10 mm, Weight: 38 g (watch), 36 g (armband), Battery: 420mAh, Memory: 4GB internal storage with 512MB RAM, Sensors: Accelerometer, Ambient Light Sensor, Compass, Gyroscope, Charging: MicroUSB, IP Rating: 68). The communication between the two devices uses Bluetooth, whereas the communication between the mobile phone and the cloud storage uses mobile data (cellular network)/Wi-Fi.

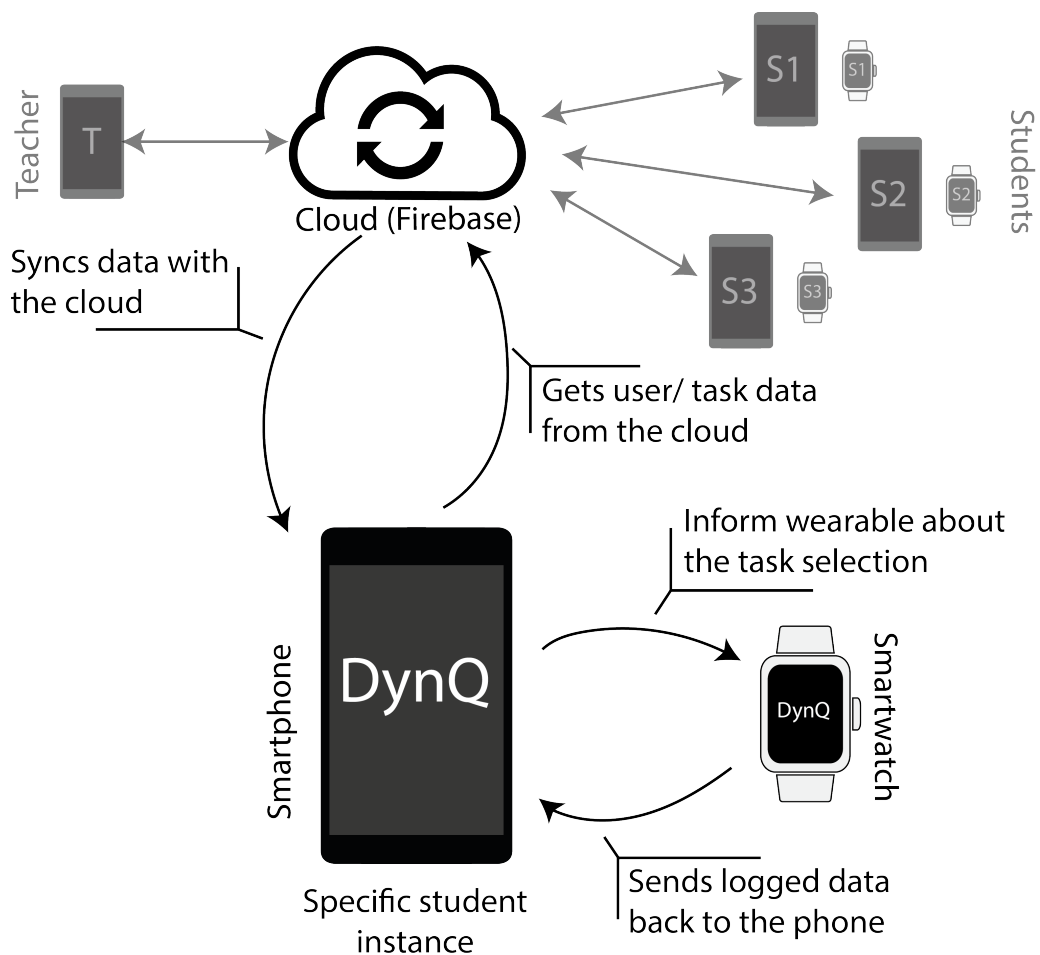


Figure 4.3: System architecture overview of DynQ.

Within the system architecture it must be known that there are two different user roles: the teacher (task creator) and the students (task consumers). Only the task creator should have access to the creation area, where courses and tasks can be

made. The students can select courses and receive the tasks connected to those courses. The teachers are responsible for the task design, including deciding which sensors are tracked during a task and upon which triggers the task shows. Deciding about sensor tracking has a direct influence on what is possible to get as feedback for students and teachers and for trigger possibilities for future tasks. Figure 4.3 shows the connection between the combined subsystems (the smartphone and the smartwatch) and the complete picture of the system architecture. The teacher can have the same combination consisting of a phone and a smartwatch, but he/she is not required to have a smartwatch connected for task creation. On the students' side, a minimum of a smartphone is needed, but the combination of a phone and a watch is recommended (especially in an outdoor learning environment). Sensor and task progress data is stored locally until a connection to the cloud can be established to sync the data.

4.2 User Interaction and Interface Design

In addition to the creation of a user interface for common interactions (such as navigating through the app), the concept design has two crucial user interaction challenges. The challenges central to this work include task-trigger display and design as well as sensor measurement selection options. Based on the requirements, the interface has to support several interaction possibilities connected to both challenges. Teachers expressed interest in logging and measuring the following (Paper G):

- average speed during a task,
- maximum speed during a task,
- highest acceleration (for some tasks) over a certain amount of time,
- number of accelerations, and
- time spent doing a task, i.e. completion time.

Measured data has several purposes. It can be directly displayed as feedback to the student, it can be sent as feedback to the teacher, it can be used to store scores and it can be used to trigger new tasks. Newly recorded data has to be compared to triggers created by the teacher and if the trigger condition is true or fulfilled, the associated task is made available to the student. There is a distinction between active and passive triggers, i.e. that some triggers can only be checked when a previous task is completed, while other triggers have to be updated and checked regularly throughout the training. An example for an active trigger is the location, i.e. constantly checking where the student is and if there are associated tasks created for

this specific context location. A passive trigger, for example, can be the recorded maximum speed. There is no need to constantly check and compare speed measurements; it can be evaluated upon having completed a task. At the same time the comparison takes place, the student profile could be updated with a new achieved maximum speed, if necessary.

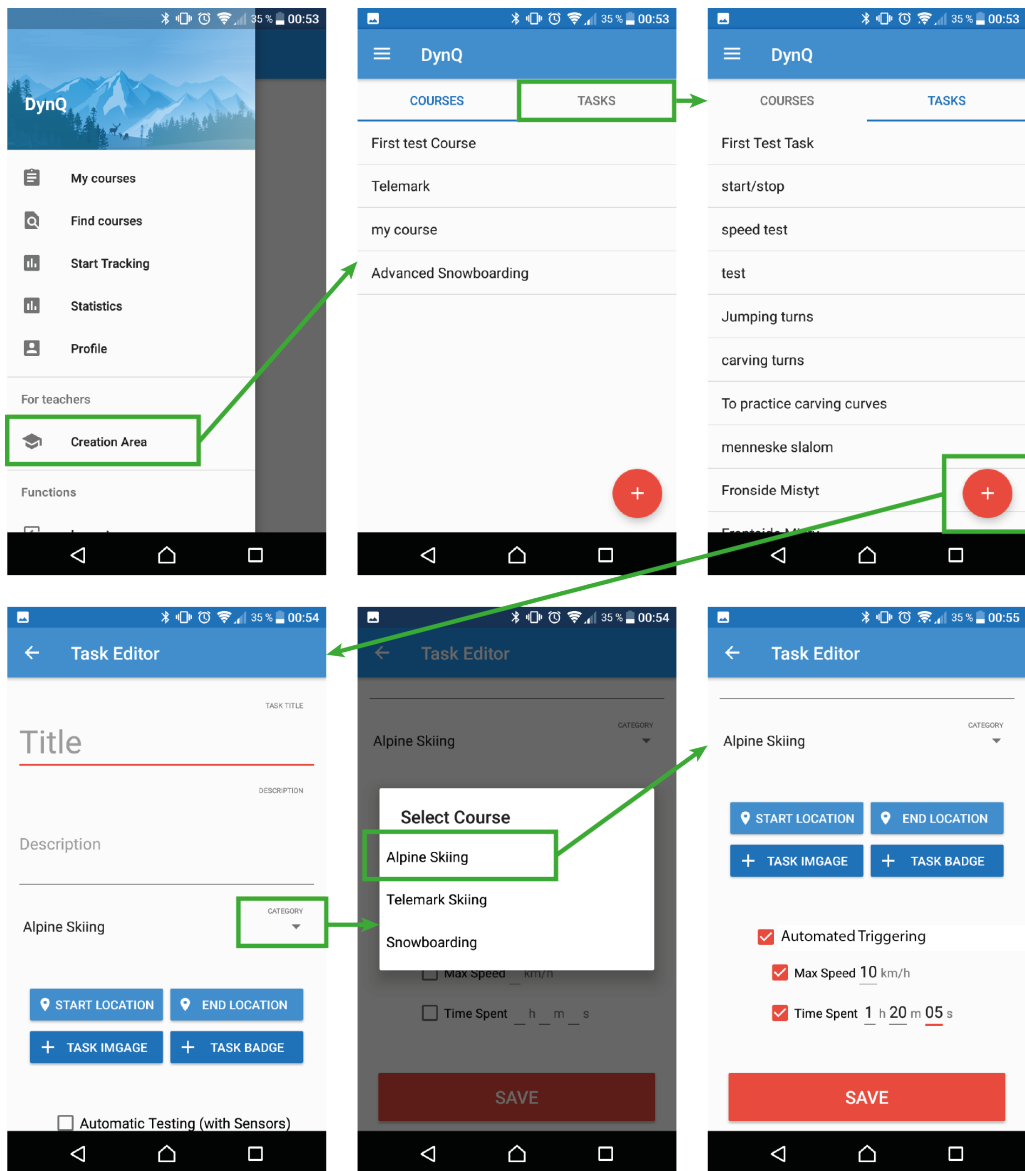


Figure 4.4: Interaction steps to create a learning task listing real examples of learning tasks that teachers made during field testing.

Figure 4.4 shows the main steps of creating a task from the main menu. The teacher can select the creation area, where the course creation is shown first. Through swiping right to left or clicking the task category on top, the teacher gets redirected to the task creation. Mandatory steps to create a task are aimed at providing a task

title as well as a description and to assign a course. In the shown prototype version, the teacher can select a start and end location through Google maps, add a descriptive picture or gif as well as has the possibility to add a badge that can be shown to the student upon completion. Automated triggering can be chosen so that the task is shown when the conditions are met.

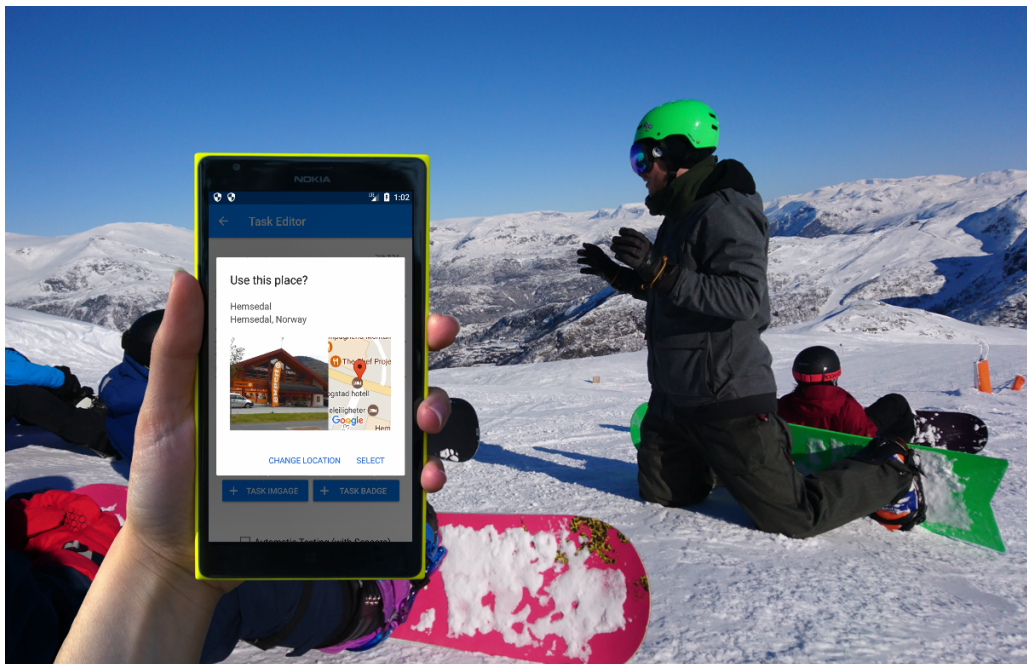


Figure 4.5: Learning task creation interface featuring location settings; background photo taken during the field observation and user testing in Hemsedal, Norway.

The strong connection between recording data during tasks and data that can trigger new tasks can be very confusing to the teachers. One component that adds to that is that from a step-by-step view, a trigger reveals task; hence, comes first. From the task-creator perspective, however, a trigger is created for a task within the task creation interface, making it a part of a task at the same time, whereas the data to record while the task is performed have to be chosen. The data that is recorded while performing a task can however not trigger the same task but only future tasks. We found that giving the full freedom of all theoretical possibilities to use sensor data as task-triggers is too difficult to handle for teachers. Therefore, we predefined the trigger possibilities for user testing (fitting to the used sensors and the teaching conditions), thereby giving teachers a limited but defined choice. Those triggers can be the following:

- A student can reach a certain speed (in km/h) (from checking the saved maximum speed reached by a student).

- A student can maintain a speed over some time (i.e. minutes, using previous speed data compared to their time stamps or directly compared to the average speed data).
- A student stays under a certain speed.
- A student has spent a number of hours/minutes for self-practice (related to time in task(s) total).

Figure 4.5 shows part of the interface design of the latest prototype application. The location can be selected via Google maps by either typing in the location name or dragging the map to a specific location and picking, thus enabling very specific picking of a location using GPS coordinates.

4.3 The Applied DynQ Concept to Use Case: Alpine Sports

Most of the learning tasks are the same for each group and individual. Teachers can prepare the learning tasks before the course by adding the most important triggers to the tasks. A trigger that does not require sensor measurement but is central to teaching is "previous completed task". Teachers can make tasks dependent on having completed prior tasks, so that the hierarchical concept introduced in the beginning can be followed. Additional triggers can be added and new tasks that are only triggered by certain contexts can be designed by the teachers. Depending on the used technology for the prototype, the task structure for a sample task is presented in Table 4.1.

The students receive the task either directly or when the triggers are met. In addition, task with trigger can be made visible to the students (but cannot be started without having met the trigger) to provide an overview of upcoming tasks. Deciding which tasks are visible must be made by the teacher. The sample task requires a specific type of slope, which is steep enough and wide enough for beginners. In this case, the teacher can set one or multiple locations as triggers, but since it is a beginners' skill, it is recommended that the learning task is shown in the task list to know that this is an upcoming learning task that requires a specific location (on a map). By doing so, the teacher can redirect the students to the necessary locations. Figure 4.6 shows two different students using the second DynQ prototype during the field testing in Hemsedal.

During the morning meeting of a course day, teachers usually prepare the groups and plan for the day. If the weather or other conditions vary from what was planned,

Table 4.1: Matching a snowboard beginner task to the learning task structure of DynQ.

Course:	Snowboarding
Title:	Stop (using heel press)
Description	Stand with your entire body facing downhill and your board across the incline. Stand with your knees bent, and stay low. Concentrate on what edge control and stopping feels like. Press your heels into the back of the board and lift your toes off the ground very steadily.
Short Description:	Press heels, lift toes.
Difficulty:	Easy
Media:	<image>
Location:	On a gradual or beginner slope.
Dependencies:	Task (skating), Task (stopping with one foot out), Location.
Hidden/Shown:	The task should be shown, even if the dependencies are not met.
Badge(s):	-
Which sensors to log:	Number of accelerations and speed.

learning tasks can be altered or new ones can be created. For example, if a slope is closed due to maintenance or an avalanche, other locations can be chosen as triggers for a task, or tasks with similar goals can be created to substitute for the unusable location. This can also be done by the teachers during teaching. Tasks can be prepared and sent directly to the students, with the teacher acting like the trigger by sending them without any other dependencies. Those tasks can, for example, prompt students to change the location, if they have stayed in the same terrain for a longer period and have not explored other locations for a while. A teacher who recognizes that some students need more advanced tasks can send learning task possibilities to the students to encourage them for further training. Triggers to recognize advanced students can include a combination of completed tasks, highest speed achieved, and locations explored. Exploration of difficult terrain (recognized by GPS in combination with slope difficulty) and a high completion rate in the basic tasks indicates advanced students. Those students have a tendency to fall into the boredom zone under the flow zone and need further guidance and possibilities to improve even further.



Figure 4.6: Students using the second DynQ prototype during the first field testing.

4.4 High-Level Context Information Integration

The DynQ concept relies on context information to trigger tasks that are appropriate for each student. The role of technology integration leads to an approach in which sensor technology is responsible for the context sensing component, i.e. the task triggering is restricted to measurable context data. As sensors improve and find their way into affordable everyday technology, such as mobile phones and smartwatches, more and more context can be sensed. Still, there are certain variables of a persons' context that cannot be measured directly. These variables are referred to as "high-level context information". There are approaches to derive high-level context from low-level context information [110].

Sports literature suggests that several high-level context related situations and variables have an impact on sports performance and learning [50], [49]. These include psychological, social, tactical, performance related, technical and physical variables. Even information about whether a student trains in a group rather than alone, enables the possibility for collaboration tasks. Information about the student's high-level context can add value to task triggers (Figure 4.7) and does not change the initial DynQ concept, since in the concept, it is not further specified how the context is measured by sensor technology.

Teachers could add specific recommendations for learning tasks within the trig-

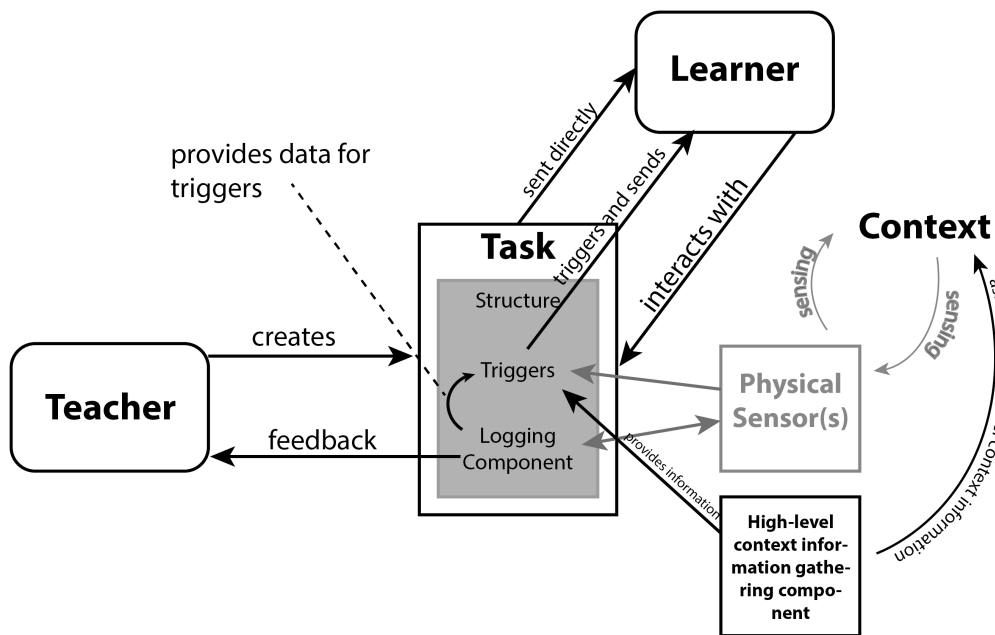


Figure 4.7: The DynQ concept including a high-level context-information-gathering component in addition to sensor logging and sensor-based task triggering (Paper F).

gers or add additional warning tasks, for example, a task for taking a break. Some training might not be appropriate for highly exhausted students, and injured students might need special recommendations for their training plan.

This approach comes with challenges. The first challenge is how to obtain high-level context information. The second challenge is how to integrate this additional level of trigger complexity.

Recent technology integration (as referred to in RQ 1b) can also refer to the usage of technology to collect personal high-level context data in a motivating or persuasive manner so that users willingly provide data for learning task triggers. This approach is presented in Paper F.

Through a questionnaire, participants were asked if a gamified approach could help to motivate them to provide personal context data and to frequently update their data. This type of task is considered repetitive and boring, which is why engagement through gamification was conceptualized. Three different visualization approaches of the same underlying concept were tested. The basic concept asks users to input information upon starting the app and asks to change the information when context variables change. The first approach is only text based, without any gamification elements. The second approach includes a visualization including a status bar, showing feedback about the currentness of participants' context data, thus providing visual cues to update data and to show the lack of updates. The third

approach includes a mini-game in form of a monster-pet (shown in Figure 4.8). The same principle is applied; the monster shows visual cues of missing data, only in a more complex manner and by asking to be "fed with data". Even though all three approaches have the same basic underlying concept, they can be perceived and accepted differently. The outcome of the questionnaire suggests that the second approach was most accepted by the participants, using moderate gamification.

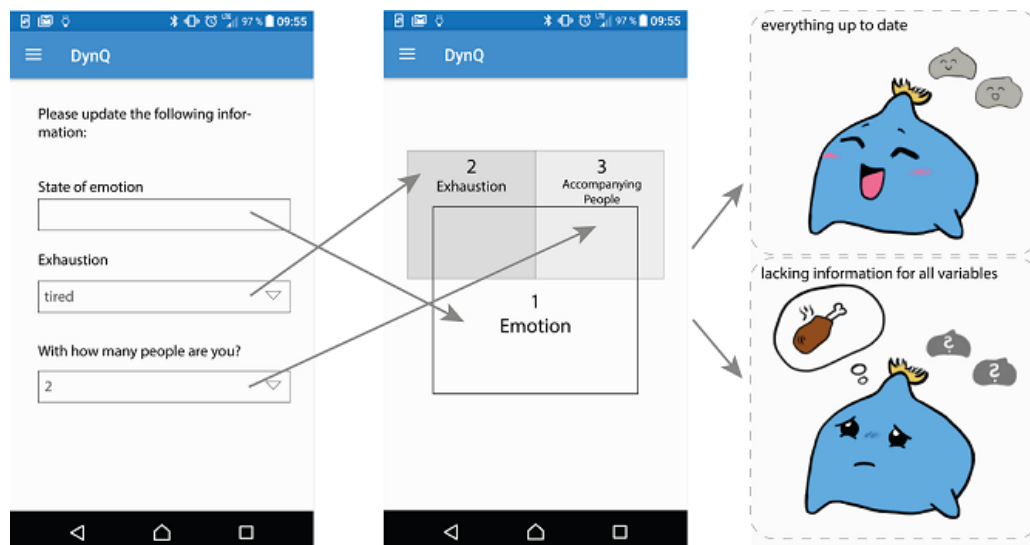


Figure 4.8: Possible visualization for three attributes within the monster-pet concept (Paper F).

This approach to gathering high-level context data proves that there are alternative possibilities for gathering information about the user's context, even if no fitting sensors can be found. The DynQ concept can integrate other triggers that are not sensor based, if a common interface is developed in a fully functional system.

4.5 Testing and Evaluation

In this section, user testing and context of use analyses are described. The analysis of the context of use was an ongoing process and new insights into the context of use derived from field testing, observation and user testing. That is why user testing and context of use analysis are connected in this section. User testing was conducted in all three iterations of the HCD process. Different testing phases were aimed at different testing variables. Some testing was conducted to refine the context of use analysis, while others were aimed at concept testing and testing of the design solution (the prototype).

4.5.1 Context of Use Analysis

In the beginning, surveys, interviews and a focus group discussion with teachers from various fields of study were conducted. Field observation including real teaching analysis was conducted to analyze and specify the user needs as well as requirements and to gain more insight into the teaching approach within alpine sports. This was necessary since the verbalization of thoughts and concepts about the course, its teaching, and, especially, the expression of user needs is not straight forward. A large part of the first field observation was to build a common understanding between users/teachers and researcher, so that it was possible to work closely together. This included understanding the teaching approach, including the specific language (i.e. special and technical terms). The outcome of this observation was a deeper understanding of the course pedagogy and structure.

4.5.2 Concept Testing and Evaluation

It is important to not only test by building and using a prototype, but also to test the concept behind it. In this case, it is important that users understand the concept of dynamic tasks and how they are designed in the system. Concept and understanding were tested within three iterations of the HCD process, during field observations and in interviews, surveys as well as focus groups. The testing sessions were conducted with teachers who had previous knowledge of this project and with teachers who had no prior knowledge.

The support tool DynQ should be usable for more than only alpine sports and outdoor education; therefore, its applicability and acceptance to different areas was tested. Testing with teachers without prior knowledge served the purpose of testing the applicability of the concept in a different context. In addition, it gave insight into the new context of use as well as additional requirements for new use cases, including sports and outdoor-related courses such as nutrition, sports theory and sports injuries.

To evaluate the concept of dynamic tasks, the following research questions should be answered:

1. Can the concept of dynamic tasks be easily understood?
2. What challenges do teachers have in designing learning tasks using the concept of dynamic tasks?

The focus group discussion included a showcase prototype. To analyze the focus group discussion, a qualitative content analysis approach was chosen [111], [112]

to determine if the central aspects of the DynQ concept were understood. The three main parts of the concept (Figure 4.9) relate to being able (1) to identify tasks within the teaching approach, (2) to understand the concept of conditional tasks and what triggers certain tasks (what must be fulfilled for the students to get a new task) and (3) to know what sensors would be meaningful for tracking throughout the task for student and teacher feedback as well as for future triggers.

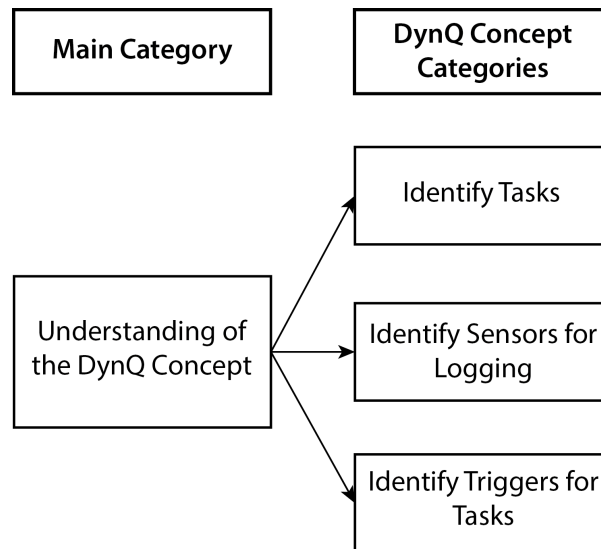


Figure 4.9: Main qualitative content analysis categories to evaluate whether teachers understand the DynQ concept (Paper H).

From the focus group, interviews and surveys, it became clear that the basic concept is understandable. However, it is challenging to understand the connections between what the hardware devices and sensors can measure and what triggers can be used to enable tasks for students. In reality, the possibilities for sensor logging are limited to which sensors can be provided through recent technology. To analyze teachers approaches and needs, not forcing the teachers to think about the real sensor possibilities (GPS, speed, and acceleration) was found to be more productive, but letting them express what they would have liked to measure to trigger tasks. For the implementation, the mismatch between what can be measured technically versus what teachers are used to evaluating during the students training, such as a specific technique, body movements, specific angles and even the emotional state of the student while training, can be a challenge. Expressed needs must be translated into requirements towards existing sensor technologies. Since this tool should not replace but support teachers, it is acceptable if tasks have somewhat limited triggers that help the students to progress.

Another challenge could be the manner sensor logging and triggers are dis-

played. For the teachers it was easy to confuse those two. In future research and prototype design, the task creation must feature a clear distinction between logging (for feedback and future triggers) and the trigger(s) for a created task. In fact, triggers that are designed for a task must be supported during students' activity to enable a task to be triggered.

To make the understanding and the support of triggers easier, the most common triggers that the sensors of the mobile or wearable device could measure were predefined. That helped the teachers a lot to understand and select triggers, and constant measurement of the basic sensors in terms of the predefined triggers ensured that those were supported. For example, the maximum speed, the average speed, as well as the maximum and the average acceleration a student achieves during a task activity are always measured, to make using "student has reached a maximum speed of" as a trigger easier in tasks. Those standardized basic triggers and sensor measurements must be developed according to the teachers' needs and hardware possibilities.

4.5.3 System Testing and Evaluation

System testing was conducted for major proof-of-concept decisions as well as functional, and non-functional (organizational and qualitative) requirements. Some of the proof-of-concept decisions are back-end solutions, and some of them are graphical user interface (GUI) implementations. One of the important back-end tests concerned communication between the sensor devices, i.e. the smartwatch and the smartphone. Another important communication and data flow between the local storage of the smartphone and the cloud storage was tested. The solution needs to be able to handle time spans without network connection and be able to locally store the sensor data on both the watch and the phone, if necessary. To this end, the interval of data logging was adjusted multiple times to allow for longer logging without losing needed accuracy. To save storage, only a detected major change in location starts the location logging (i.e. saving the position of the student in the database over the course of a task). In general, sensors should not log continuously but can be started and stopped during active practicing (sensed by movement or heart-rate) or learning task progression (while a task is started) to save battery.

The GUI must represent the user interaction possibilities, also connected to the design of affordances. The GUI was heavily changed over the course of the three different prototypes, with varying affordances and actual functions shown to the users. It became obvious that task creation, as the main function that teachers need to use, needs to be accessible with only a few interactions.

The following system requirements and proof-of-concept aspects have been tested:

- data transfer and communication between the smartwatch and the smartphone,
- data transfer and communication between the smartwatch and the cloud storage,
- starting and ending tasks from the phone (with the watch's response),
- starting and ending tasks from watch (with phone response),
- Upon ending a task or manual stopping of data logging: data must be stored locally on the watch.
- When a Bluetooth connection (after the connection was lost) between phone and watch is established, the watch transfers logged data to the phone.
- When an Internet/cellular connection is established (after the connection was lost) between phone and cloud solution, data are sent to the cloud storage/database.
- Automatic local storage happens as long as there is no connection between devices or the database and devices.
- Accurate but efficient logging intervals are necessary for saving battery lifetime and storage while maintaining accuracy.
- only logging when necessary (for example: start GPS logging on position change)
- User interface interactions, such as touch gestures, must be simple to also support users with gloves.
- easy to understand learning task creation interface for the teachers (which supports the DynQ concept: creating triggers and choosing sensors to log (for triggers and feedback))

The proof-of-concept functions could be tested successfully. The hardware could support the concept. The biggest limitations lie with available sensor devices as well as problems with task-related communications and cloud storage when students are located in a zone without cellular connection/WLAN for a long time.

Chapter 5

Discussion and Limitations

This chapter answers and discusses the research questions following their structured sub-questions. Thereafter, influences of the DynQ concept on learning theories and teaching pedagogy in higher education are reviewed. Finally, limitations of this research are discussed.

5.1 Processes to Design a Digital ICT Solution to Support Teachers

Research question 1 is "Which processes are needed to design a usable digital ICT solution that supports teachers in their teaching processes?", and it was addressed in three detailed questions.

RQ 1a) *How can the HCD be used to address teachers' needs in depth?*

First, we found that the HCD can be used for our specific problem. The problem space made clear that the technology integration is highly dependent on the human needs (teachers' and students' needs) and teaching processes. **By following the HCD process** as described in ISO 9241 - Part 210 [42], the teachers were involved in the research and development process from the beginning. **Combining qualitative and quantitative methods**, it ensured sure that **teachers' needs were gathered and requirements were analyzed**. Teachers were interviewed, surveys were conducted and field observations were carried out. An important factor to why user involvement was critical is that teaching processes are not always documented and difficult for one to verbalize without being in the situation. Being a part of and an observer to the real teaching scenario helped the researcher **to understand**

teachers' problems and language as well as unveiled the processes and learning task structures that are used in alpine sports teaching.

The continuous testing in the HCD process ensured that the understanding of the researcher matched that of the teachers and helped him/her to further define problems as well as solutions on the level of conceptual design, visual design and features. We found that for such open and large problem spaces, such as technology in education, the specialization in one possible solution approach was constructive. Further, to get in-depth knowledge about one possible solution, the selection of a use case was beneficial, especially for the use of the HCD. Users who are involved in the process (who know its background and are willing to contribute) help in speeding up the process and getting more in depth in every research step. During user testing, the time spent on the introduction and explanation can be kept to a minimum, since the participants know the process and are involved in shaping the ICT solution. In addition, reference participants or groups without prior knowledge are a beneficial addition for getting outside views to keep the concept on track by not being too specialized despite the specific use case. For us, the contrast between alpine sports teachers from Norway and general sports teachers from Uganda was very interesting. The Ugandan teachers were involved at a very early research stage to analyze the context of use and involved in a concept testing stage at a later stage.

The HCD was found to be a useful tool for developing for teachers' needs. However, this does not mean that the methods used to follow the HCD approach are the only possible solutions for approaching this problem. Other projects go a step further and use participatory design [113] or co-creation with users [114]. There is no hard distinction between most of these approaches, since some of them have overlapping methods and approaches, in which a distinction can be made between a design-led approach, a research-led approach and the central mindset (expert versus participatory mindset) [115].

This problem could also be approached from the technological point of view, not from directly developing for teachers' needs but for technological invention. However, I argue that leaving the users aside, would result in non-acceptance and that technology will most likely not be integrated due to its mismatch to actual user needs. However, it is not impossible to design a system that integrates as much innovative technologies and develops new teaching possibilities that, in the end, will be accepted and offers much more innovation in teaching than a solution that is based on existing teaching approaches.

RQ 1b) *How can recent technology be integrated as useful and supportive teaching technology?*

The first aspect to this is that **technology gets integrated when it is perceived as useful and supportive**. Using an HCD approach uncovers and can **address, the teachers' real needs**.

The second aspect is that technology fitting to the DynQ concept had to be found. According to what was found as central, technology with the **ability to sense user context** was needed. Teachers and students are not forced to accept new kinds of technology when they use technology that is already used by most users. The added value of combining a smartwatch with a phone for the usage of the DynQ concept within alpine sports is significant. Handling a phone in the cold is rather problematic, and the phone can be lost easily.

This means that the **technology has a higher chance to get accepted and integrated by the teachers if it fits a teaching concept, is chosen based on the needs, is easy to use and integrate, is available and adds significant value to the teaching process**. An application for smartphones and watches must stay up-to-date and requires constant adaption to the market; updates in operating systems and technology have a continuous impact on applications. It has to be clear for teachers and the educational system that the integration of technology, even to support common practices, means change in the long term. Using possibilities from technology opens up for new teaching processes, and that is what has to be accepted in the long run.

The technology was fitted to the teachers' needs that were found in the context of use analysis. This approach prioritizes teachers' needs, thereby implying that teachers know what they need without knowing the technological possibilities. Another approach here could be to first analyze technological possibilities to then adapt teaching according to the new given technological possibilities.

RQ 1c) *How to motivate teachers to integrate recent digital technology into their teaching processes?*

The first part to it is that **technology that motivates students to engage with the content also motivates teachers** to include such technology into their teaching processes. In addition, the processes that teachers' expressed as motivating during teaching are concerned with **teacher-student interaction as well as their ability to see and observe the students engaging with the learning content**.

The introduced technology has to be perceived as supportive, to support the processes that were expressed as motivating for teachers to teach and to, in particular,

not hinder them. A fear that was expressed by teachers was that technology will get in the way of teacher-student interaction and lessen the direct communication and feedback. The **technology must add value to the teaching process**, either due to improved learning experiences or both improved learning and teaching experiences. In addition, technology that allows for new and improved teaching processes can be seen as extra motivation for its integration. If the technology, however, forces too much change in an instant, its rejection is likely. A balance or balanced opportunities between old and new processes have to be found.

Teachers' motivation was found to come mainly from their intrinsic motivation to teach and the idea to have motivated students through technology. One could argue that both motivations might not be strong enough to actually make teachers integrate technology. Another strong factor is reliable, usable as well as stable design and technology. In this project, we focus on the concept of a system that has the potential to be perceived as supportive and motivating through in-depth analyses of real teaching scenarios. Usability testing as well as final design for a reliable and stable system has to be done in the future. In the end, only the combination of the two, a useful and meaningful concept and a usable design, has the potential to change teachers perception on the usefulness of technology integration for the better.

5.2 How to Support Learning Tasks through Digital Technology?

This discussion refers to research question 2: "How can learning tasks be supported through digital technology?" The question was solved in three sub-questions concerning the following: concepts that are needed (decoupled from the specific technology), how learning tasks can be designed in a motivating manner (combining the motivational aspects with specific technology to realize the motivating aspects) and the insights achieved by analyzing the use case in detail. This means that the answer to this question includes the detailed analysis of user needs and requirements, mainly from the teachers' perspective, specifically directed at learning task processes (creation, distribution, feedback). Before technology can be added to support learning tasks, a central concept of what needs support and what kind of support, was designed based on the analysis. The outcome of that was the DynQ concept. This concept requires specific technology that can sense the users' context to function as sensing tool for providing task triggers and feedback on the learning

progress.

RQ 2a) *Which concepts are needed to support tasks in a digital technology solution?*

Task concepts address task-specific structures as well as processes within and surrounding learning tasks. The **DynQ concept was created from learning task structures used in traditional classroom teaching and alpine sports teaching in combination with structural elements analyzed from games.** The DynQ concept consists of three core elements: task triggering, context sensing and feedback generation. Only through technology support, tasks can be personalized based on individual students' context through the availability of sensor technology. The DynQ concept utilizes that information to distribute the right tasks to the individual students. Teachers are able to create tasks for varying learning situations and skill levels that their students are at. Enriching the traditional learning tasks with a task structure that comes from the perspective that tasks were made to be enjoyable and motivating creates the basis for motivating learning tasks with updated or new processes around learning tasks. The central learning task processes range from task creation and distribution to feedback and cover the interaction of teachers with students mediated by learning tasks. The processes that should be supported are those that motivate the teacher to teach and add value to his/her teaching. On the students' side, the task processes such as getting tasks, storing and executing tasks have to be supported. The game task processes mainly had an impact on the teachers' creation processes, including new structural elements and dependencies between tasks, as well as task processes on the students' side, such as triggering tasks and automated feedback.

The specific technology, to implement the DynQ concept is not necessarily pre-defined. The technology needed can sense the users' context and has to be mobile. From what is available today, the combination of a smartphone and a smartwatch were chosen to support the learning task, but through availability of newer and more enhanced technology, this combination can be replaced and enhanced. The addition of virtual or blended reality devices could be practical. For example, a visual interface implemented in the ski goggles could help to facilitate learning tasks. Another aspect is the user interaction to start and end tasks as well as to search for and display learning tasks. Audio interfaces could read the learning tasks to the students while they discover or encounter them, and students could start them using speech to be less disrupted in their learning or training flow. The more the learning task processes blend in, into the reality of the students, the more immersed the students can become.

RQ 2b) *How to design engaging and motivating learning tasks?*

From the students' perspective, the content of the tasks themselves has to be motivating. However, more importantly, the **tasks have to be contextualized and fit the students** learning progress. This includes that tasks should be designed to fit the **zone of proximal development (ZPD)** for the individual students. In addition, games were analyzed on how they provide motivating tasks and what aspects are used within games to keep players motivated. It was found that **following the gamification principles**, such as clear rules, structure, challenge, exploration and personalized experience does help, but concrete implementation guidelines are missing. The game analysis provided insights into how these game-design principles are **implemented in structure as well as processes** and provided the needed information **to bring those into the educational context**. From the teachers' point of view, learning **tasks are perceived as a motivational part of teaching when they motivate students to engage with the learning content**. In addition, teachers expressed their motivation to integrate technology if the technology supported task design in a manner that gives an **insight into the learning progress and creates new opportunities for feedback and student-teacher communication**. New and innovative learning task possibilities and enhanced teaching structures can **help the teachers to improve their teaching processes** and motivate the students to engage with the learning content.

Alternative approaches could have focused on how to create an advanced interface for learning task creation on a larger screen system, such as a PC. This is due to the fact that creating multiple learning tasks on a smartphone can be exhausting. However, the mass production of tasks was not in focus on this project, but we are well aware of the fact that the preparation of learning tasks would be better supported on a PC software solution or a web solution that is connected to the database of the app. Through providing a task-creation interface in the application, teachers are able to create tasks on the go while teaching or during the students' self-practice phases, and they have more flexibility to intervene. Having an interface that can support such flexible and spontaneous task-creation processes was of greater interest than duplicating the task-creating interface into a PC or web solution.

RQ 2c) *What can be learned from challenging courses that do not follow the typical classroom setting about how to design learning task processes?*

Sports teachers, especially the observed alpine sports teachers, only partially follow traditional learning task approaches. However, learning tasks occur in all teaching situations, in fixed-location classes or in courses without fixed locations. The beauty

here is that there is a **match between existing sensor technologies and the needed context information** exists, which allows the teachers to create new kinds of learning tasks. Only through having this match, was it **made possible to conduct user testing with a functional prototype and get deeper insights into how to support tasks with technology**. Measuring the students' context in traditional classroom settings is limited but can be found in the literature, in which it is indicated that the technological support for context measuring is rather limited (for example, showing activity levels in forums/LMS or word or code line counts). **Finding a new perspective that introduces new technology into learning task processes will be beneficial for such traditional approaches to get a new perspective on context-measuring possibilities**. Tasks that are triggered individually per student create a more personalized learning experience than introducing all students to all tasks at the same time. New dynamics in teaching situations with or without the teacher can be created. In addition, the available sensor technology can help to assess learning progress more precisely and even from a distance. It was shown that the concept of having personalized and contextualized tasks can be supported through sensor technology. **The right sensors and measurement values have to be determined for other courses, including more traditional classroom courses**.

A different use case might have led to different sensor usages. It is expected that varying use cases need different sensor implementations. The implementation of the DynQ concept must come with a flexible sensor interface to support the needed sensors for the courses (for example, a waterproof pressure sensor for diving, a heart-rate sensor for fitness courses, or sensors to measure light intensity for photography courses).

5.3 Influence on Learning Theories and Teaching Pedagogy

Designing supportive technology for existing teaching processes means supporting these processes instead of altering them. However, technological possibilities allow for enhanced or improved processes. Adding the possibility to have improved information due to sensor measurements does lead to new processes. There are existing learning and teaching frameworks and theories; therefore, one has to discuss how the introduced DynQ concept influences those. It is important to know about the teacher's role in the learning process for a digital teaching-supporting solution. Teachers must provide their students with a framework for appropriate learning, learning experiences, as well as learning opportunities [116]. Such a framework has

to allow learners to test and construct understanding as well as knowledge and skills in social interaction with others [117]. The individual construction of knowledge is covered in the constructivist paradigm, which claims that meaning is constructed by each learner [118]. The learner draws on existing experience, knowledge and dispositions and then interprets the learning experiences, which then leads to the construction of new knowledge or the change of existing knowledge [119]. Learning of an individual in sports and the executions of a skill are described as a complex phenomenon including engagement of the athlete's (sport student's) mind, body, sensations, emotions as well as the learning context [120]. Alpine sports education often takes place in an ever-changing environment that has to be reacted to (fluid physical context). In such conditions, the environment and context have a high influence on learning and knowledge construction [121]. Environmental factors are, for example, varying slope conditions, surrounding people and varying difficulties due to terrain. Drawing from that and therefore, considering that a learner and learning are not separated from the physical and socio-cultural environment in which learning happens, learning a skill (in sports) requires more than reproducing a shown technique by the teacher [119]. Social interaction and dialogue is highly emphasized in social constructivist pedagogical approaches, which can include collaborative problem solving in groups or teams. This is highly representative in game-based sports that require tactics [122] (football, basketball, and hockey) but can also be found in individual sports such as skiing and snowboarding. An example for this is a group of snowboarders who discuss together and encourage each other to practice complex skills such as jumping or off-slope boarding. Beginners especially need the help of professionals or peer feedback to reflect on their actions and movements to know what they are doing and what potentially has gone wrong. This is not much different from a group studying mathematics together and pointing at one another's solving approaches while discussing their approaches and solutions.

5.3.1 Experiential Learning

Based on the constructivist theory, Kolb's theory of experiential learning (ELT) states that learning does not occur passively but based on experience and reflection [123]. The specific steps are concrete experience, reflective observation, abstract conceptualization and active experimentation, in which learning does not necessarily have to start with the experience [124], [125]. The experiential learning can also be initialized through reflective observation. In sports education, as observed in the alpine sports courses, the four elements of experiential learning are actively used as teaching method. During the teacher-guided phases, the ex-

periential learning is often kicked off due to reflective observation and initialized abstract conceptualization through the teacher's explanations. Students are then encouraged to engage in concrete experience, following the teacher, imitating the skill that was demonstrated. With the guidance of the teacher, the students get the toolkit to reflect on mistakes as well as improvement and continue to experiment during the learning task. Gentry [126] stated that pedagogies such as live case and computer-assisted instruction facilitate experiential learning. A live case is naturally given in alpine sports education. Using the DynQ application, the students can continue to experiment without the teacher but still have an instance that can help with abstract conceptualization in the form of feedback and learning task recommendations. Important factors in this approach are having a highly controlled environment, a clear structure and constant feedback. Personalization possibilities are based on the amount of learning tasks designed by the teacher. The more different learning tasks are designed for a variety of learning approaches and possible mistakes the different students make, the more controlled the learning environment becomes. Based on the given sensor possibilities, automated recommendations based on the students' context measurement is still limited. However, teachers can offer a variety of learning tasks based on the students' self-evaluation of what went wrong. Learning tasks can include a list of possible pitfalls while training a specific skill so that appropriate hints for abstract conceptualization are given. Drawbacks mentioned by Gentry [126] are losing the contact to the real world by mainly communicating to a program. In the use case of alpine sports, that cannot happen. Students must practice in the real world and use an application for feedback and guidance as additional resource. Training and learning cannot occur without the students participating and experimenting with learning tasks. Another aspect here is that Gentry's drawbacks were written in 1990. Since 1990, technology has developed enormously. Systems can now offer much more immersive and real experiences than almost 30 years ago, thus reducing most of the stated risks. The application of ubiquitous elements or virtual reality can shape a whole new concept of experiential learning, not directly being a real-world experience but being very close to it. I would argue that with enhancing sensor technology and the development of natural user interfaces, including the interaction with technology through speech and vision, the drawback of mainly communicating with technology during computer-assisted instruction is being minimized tremendously. The drawback then might turn into an advantage, i.e. not being disrupted in the active experimentation but still being able to receive guidance in critical moments.

5.3.2 Group Learning and Collaboration

As observed in the use case of alpine sports education, many learning activities are carried out in large or small groups before students proceed with individual training. It is not required in the course that students practice alone; the self-practice can also be conducted in pairs or smaller groups. From the interaction and collaboration between students, educational value is derived [127]. Learning in such conditions cannot be entirely separated from context factors. This includes social interaction. Social constructivism, influenced by Vygotsky [128], acknowledges that the development of cognition and knowledge is constructed not only intrapersonally but also through social interaction, collective knowledge, knowing and activity. It includes the individual's social experience and participation in the larger social and cultural setting in which learning takes place [129], [130].

An important view on group learning in this context is Computer Supported Collaborative Learning (CSCL), because of the introduction of a digital solution to the traditional non-technology-based teaching approach.

"CSCL is a field of study centrally concerned with meaning and the practices of meaning-making in the context of joint activity and the ways in which these practices are mediated through designed artifacts" [131].

Learning task distribution should not aim at an approach that encourages a "go through all tasks as fast as possible on your own" approach but incorporate the existing collaboration between students, mainly within the phase of self-practice. If the group and collaboration support component would be completely dismissed in a digital technology solution, it would neglect high possibilities of constructing knowledge and training skills.

As observed, despite the normal use of smartphones, no specific learning technology is used during the self-practice phases, but students occasionally practice in groups of two or more people. Encouraged by the teachers, advanced students helped beginner students during those phases, but also students at the same skill level practiced in groups, especially because of navigation and safety issues. Collaboration in tasks and through support is encouraged by the teachers. One of the major challenges is the gap between what the students think they do and what they actually do. That often requires an observer who gives feedback or even video-recorded material to analyze and show the student his/her posture, movements or

reactions. From understanding the mistakes, students proceed to understand how to improve their techniques and that leads to motor learning. Teachers can analyze the students' movement and are capable of observing and describing as well as identifying cause and effect of the students' performance [6]. Technology could help students who practice together to give meaningful feedback, for example, in the form of video recording. In addition, if teachers design tasks that are specifically made to be done in groups, technology can help to facilitate them. Examples for those kinds of tasks are the human-slalom and jumping exercises in which students place objects in front of one another. Many students reported that they felt encouraged to try new things by practicing in a group and had a certain feeling of safety. One example situation was when a group of moderately advanced snowboarding students were encouraged to try a jump. Many of the participants never tried to speed up, go straight and then jump using a natural hill (similar to a small version of a skiing quarter pipe) and many were afraid to fall. Students were surprised how well it went, based on the explanation of how to conduct the jump, including tips by other students and the teachers' advice.

5.4 Limitations

With a PhD project restricted to three years, there are some natural limitations in time and resources. Due to the time limitation, the alpine course could only be used twice for user testing, since it only runs once per year. There was also a limit in how far the prototype could be developed, due to the time constraints. The focus was on the teachers' creation of learning tasks, so the students' part was not developed. For future testing, especially for the motivation for teachers to integrate this technology into their teaching processes and students' engagement towards the learning tasks and system usability in the long term, a full system would be required.

There were also limitations within this specific project, especially regarding the user testing. User testing and evaluation in any extreme environment, such as alpine sports, requires a specific setup and planning. Although the field observation and user testing were carefully planned, there was no special equipment available. Recording equipment such as cameras, microphones and notepads could not always handle the extreme weather conditions that were encountered. The batteries of the cameras used for observations happened to discharge fast during cold weather conditions such as -15°C . The cold also affected the touchscreen functionality of the smart devices. It was observed that some smartphones lost the touchscreen functionality completely, whereas others showed delay in reaction time. Only waterproof

devices were used on the slopes due to the possibility of snow contact. Furthermore, it is impossible to take off gloves during a strong wind and snowfall, which made touchscreen interactions nearly impossible. Some gloves offer touchscreen functionality.

Despite the limitations, the research questions could be answered. Alternative research approaches were considered. Different approaches to analyzing the teacher-centered problem would have possibly led to the same findings. A different use case might have had an influence on the used technology, but the DynQ concept was developed due to the stated problems and can be implemented using different hard- or software. Including a concept such as the DynQ concept and innovative technology into higher education has an influence on teaching processes and vice versa. There are teaching processes that have special requirements toward technology to support them. For example, to support collaboration, the implementation needs to feature student group functions for collaboration tasks. This means that whenever developing for an educational use case, one has to consider learning and teaching theories, what influence these theories have toward the development, and how they are influenced through the system usage.

Chapter 6

Summary and Future Directions

To close the gap between latest and innovative technology and the technology used in education, with a goal of not only keeping education up-to-date with current technology but also making use of the technological potential to enhance learning and teaching, a new concept called DynQ was developed. To design technology that should be perceived as usable and supportive, teachers have to be put more in focus. Even if the development of ICT solutions for learning is about enhancing the learning progress and experience of the students, the teacher plays a vital role in this process. For successful technology integration into education, technology must fit the used teaching approaches and support the teacher.

Getting the teachers on board using a human-centred design and research process enables for new insights into teachers' needs, requirements and issues regarding used technology. Working closely together with sports teachers helped us to understand the vast diversity of learning situations and inspired the use of a mobile and flexible technology solution. Learning situations such as sports education are in need of context-aware and highly personalized but durable technology.

To solve a motivational problem, it can be beneficial to look into gamification. It should be noted that the simple adding of game-elements is not likely to end up as a motivating product, but rather a detailed analysis of the approach and concepts found in games and the transfer of such into the educational context might lead to new and enhanced processes. Adding another perspective on tasks, such as a game perspective, can help in designing new task structures and processes. The outcome of combining educational requirements toward tasks with the added game perspective created personalized tasks and learning experiences, including triggers and context-sensing technology. Triggers and context-sensing technology make it possible to distribute tasks whenever a task fits the user's context.

By tackling an exceptional and challenging use case within alpine sports educa-

tion, the expanded usefulness and valid potential to use context sensing and mobile devices became visible. Findings from this use case and the concept basics are expected to also have an impact on future designs for less challenging courses.

6.1 Main Contributions

According to the problem statement, there is a need to investigate the processes to get two things together: education and technology. The research questions, as stated in the beginning, and their contributions are summarized below:

RQ 1) *Which processes are needed to design a usable digital ICT solution that supports teachers in their teaching processes?*

The first research question was divided into three sub-questions that are addressed as follows:

RQ 1a) *How can the HCD be used to address teachers' needs in depth?*

By following the HCD process, i.e. combining qualitative and quantitative methods, it could be ensured that teachers' needs were gathered, and their requirements were analyzed. Through a flexible research and design process, which allows for several iterations, teachers' problems, language, learning task processes and structures (used in alpine sports teaching) could be analyzed and understood. The main methods that were beneficial to use for an HCD were interviews, surveys, focus groups and field observations.

RQ 1b) *How can recent technology be integrated as useful and supportive teaching technology?*

Technology gets integrated when it is perceived as useful and supportive. This is the case when teachers' real needs are uncovered and addressed. The ability to sense user context was found to be a mandatory attribute for technology to be useful for the DynQ concept. In general, technology has a higher integration chance if it fits the teaching concept, is chosen based on and developed in accordance to the teachers' needs, is easy to integrate and adds a significant value to the teaching process.

RQ 1c) *How to motivate teachers to integrate recent digital technology into their teaching processes?*

Technology that motivates students to engage with the learning content also motivates teachers. The added value to the teaching process must be significant, for example, supporting the student-teacher interactions to increase feedback and to help teachers keep on track with the students' progress.

RQ 2) *How can learning tasks be supported through digital technology?*

The second research question is addressed in the following three sub-questions.

RQ 2a) *Which concepts are needed to support tasks in a digital technology solution?*

The DynQ concept was created from learning task structures used in traditional classroom teaching and alpine sports teaching in combination with structural elements analyzed from games. The three core elements of the DynQ concept are task triggering, context sensing and feedback generation. Without technology, such a concept cannot be implemented, since it heavily depends on user-context-sensitive and automated task triggering.

RQ 2b) *How to design engaging and motivating learning tasks?*

This question has to be answered from two perspectives. The teachers expressed that they were motivated to use technology if the students were motivated by it to engage with the learning content. To design motivating tasks for the students, pedagogical principles such as ZPD and flow have to be considered. In addition, it is very important to have personalized and contextualized tasks. Gamification/game-design mechanics were found to help design motivating learning tasks for students.

RQ 2c) *What can be learned from challenging courses that do not follow the typical classroom setting about how to design learning task processes?*

The match between existing sensor technology and the type for needed context information made conducting user testing and evaluation with a functional prototype possible. This led to deeper insights on how to support learning tasks and teaching processes with technology. The ability to have several iterations of testing and evaluation helped the researcher to define the concept in more detail. The DynQ concept itself is not bound to a specific type of hardware technology. To adapt it for other courses, the right type of sensors have to be determined so that fitting contextualized learning tasks can be triggered.

6.2 Future Directions

There are several possible future directions that build on what was found in this PhD research project. Limited time and resources do not allow for long-term studies or for the complete implementation of systems. Therefore, the most essential future directions are the following:

Full Implementation: An implementation of the full system on both ends (teachers and students) would be required for further investigation. The impact on student engagement and teachers' motivation can only be researched upon through a fully functional system.

Task Dependencies' Visualization and Creation Process: Teachers' cognitive processes to make and design tasks must be supported in an improved user interface so that they are guided through the learning task design possibilities. This refers to how tasks are designed in relation to one another: hierarchical, parallel or completely disconnected. Some tasks only rely on sensor triggers, whereas others would require a student to have done another task first. Showing the task structure and making it easy and understandable for the teachers during the creation process might need further research in the direction of visualization of such structures. One idea is to follow the concept that can be found in the skiing and snowboarding literature, which illustrates tasks in a hierarchical structure or network form. Dependencies can be seen between the learning tasks. Core tasks are marked and alternative paths can be seen.

Usability and User Experience Studies: Design of interfaces and user interactions has to be usable and has to provide a positive user experience. Due to the complexity of triggers and recommendations, the user interface to create learning tasks (referring to not only the visualization but also interaction possibilities) has to consider many different variables that were not possible to address in this PhD research. Different input techniques as well as their connection to newer and updated sensor devices must be considered. A direction that was found during the user testing is the complex visualization to create tasks and show dependencies among them as well as a wide range of possible task triggers. Tasks cannot only have one but multiple mandatory or multiple independent triggers and visualizing such relations is not trivial. Research on such a topic, to design a usable and understandable interface that covers the complexity of task and trigger interrelations, would be mandatory for a good user experience on the teachers' side of use.

Expanding into other Fields: Extensive testing of the concept in other sport-related or sport-unrelated fields would provide further insights into how the DynQ concept can be improved and possibly adapted to various teaching situations. This includes finding a standardized interface on how to include variations of sensors that suit different learning and teaching contexts. A further step could include finding, defining or enhancing a standard such as xAPI (Experience API) for interchangeability of learning tasks and activity data with other learning platforms.

The work done in this PhD research is a good basis for future development for contextualized and personalized learning. The concept can be used with different technologies that fit a concrete use case, thus making it an adaptable tool of improving future education and closing the gap between recently available innovative technology and technology used in education.

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PART II

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Paper A:

Supporting Teachers' Needs Within and Through E-Learning Systems

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Supporting Teachers' Needs Within and Through E-Learning Systems

Renée Schulz, Ghislain Maurice Norbert Isabwe, and Frank Reichert

Abstract — These days more and more digital learning and teaching opportunities emerge into the world of higher education. In this upcoming project which is described in this paper, the teachers' needs, especially their teaching motivation will be regarded. This project is part of a bigger project, where several different faculties will work together. This combination of faculties is beneficial for topics like these, because the approach combines pedagogical and technical knowledge. This topic regarding teachers' needs deals with the initial and ongoing motivation as well as behavior and attitudes toward current or upcoming ICT systems for education. The main aspect of the project is to specify issues about current systems and analyze requirements for enhanced future e-learning systems. This analysis will spent special attention on requirements for an enhanced teacher motivation. In this paper the motivation and background of the project will be described, as well as the state of the art and the research approach including hypotheses and research questions. Also preliminary results are outlined, which lead to the conclusion that the two major issue areas are interaction support between students and teachers and the individual teaching style. Additionally future directions are described.

Keywords—E-Learning, Motivation, User Needs, Requirements, ICT Systems for Education, Human-centered Design.

I. INTRODUCTION

A lot of ongoing research work deals with enhancement of e-learning, mobile learning or e-teaching systems. In this paper the term e-learning is used to describe any form of e-learning or teaching system or tool whether it is mobile or not. This includes tools which are used in face-to-face scenarios as well as Learning Management Systems (LMS) and virtual teaching systems. One aspect to enhance the use of those systems is, to research about the issue of acceptance and motivation regarding those systems. In this project the motivational aspects and attitudes should be researched on. On the one hand technical requirements have to be met as a basis to get a running system, but like it is known from a human-centered design approach, the actual user needs have a crucial role in the design process. They are needed

to build not only a usable system, but also a system with a satisfactory user experience. Since teachers' (and students) motivation, behavior and attitudes are very different from a situation to another, they have individual requirements for suitable supporting tools and systems. A teacher with face-to-face students may need different tools than a teacher of an online based course. Many existing systems should support those different situations. There are very specific tools supporting one clear defined action in a classroom, like in-time questionnaires, and complex systems like LMS. "The teacher" as an important stakeholder in the learning process influences students through his teaching style, motivation, attitude and behavior. The assumption is, if the teachers' motivation is better, also the students' motivation will get better. Complex teaching scenarios are even more difficult to handle. For example having face-to-face students at the same time, when also distance students attend the class. This teaching scenario happens for example at the University of Agder in cooperation with Makerere University from Uganda. All those surrounding variables and needs should be analyzed in this project. First, the issues, problems and current needs of teachers shall be analyzed. The second step will be to extract requirements from the analyzed teachers' needs. In this paper the background and state of the art, the research questions and the research approach will be described.

II. STATE OF THE ART

Teacher motivation is important because it influences the students learning process. It is researched from different point of views [1, 2, 8, 9]. Most publications deal with surrounding variables like the general teaching environment, teaching opportunities, attitudes towards teaching, resources and salary.

Contrary conclusions exist about the influence between students and teachers [1, 2, 8]. Depending on the teaching scenario itself, it can happen that teachers are not influencing students that much [1]. That is because the environment of the teaching scenario has more critical factors from outside of the teaching process itself, for example in developing regions. In developing regions exists a more critical and different situation regarding environment and teaching material, than in most developed regions teaching situations [1]. That leads to the assumption that the teachers' influence is less than the materials' influence. Studies of Schacter, Thum [8] and Hiltz [2], however, found an influence, shown by high correlation between teachers' effectiveness and students' academic performance.

Those aspects are hard to measure because teachers' motivation depends on a lot of different variables [9] as well as their attitudes towards e-learning systems [4]. There are stated important aspects which are influencing the teachers' motivation in general, which are described in the following. The perceived usefulness,

ease of use and playfulness are key issues to influence behavioral intentions [4, 7] like using an e-learning system for teaching. That means teachers are willing to use e-learning systems, if the environments are perceived as useful [4]. Additionally aspects like level of computer integration, positive expectations, comfort level, beliefs, training, and support, are influencing the teachers' motivation to use e-learning systems [9]. From the students' point of view, three factors are positively influencing the attitudes towards an e-learning environment: e-learning as a self-paced learning environment, e-learning as a form of multimedia instruction, and e-learning as an instructor-led learning environment [4]. The interaction between students and teachers is a critical factor to affect the learners' attitudes and a success factor for enhancing e-learning effects [4]. Therefore the interaction between teachers and students has to be designed carefully, considering both perspectives and requirements regarding the usefulness of an e-learning environment.

There are many concepts and aspects to build and keep the students' motivation, like gamification. But we argue that "Gamification" from the teachers' point of view focuses still on how can I use gamification to motivate students. These applied gamification examples have a high variety [3]. Most of the teachers use gamification to encourage and motivate students to learn, like Lee Sheldon [10], who gamified his own class work and class structure. But the question in this project will be how gamification can be designed and used to improve the teachers' motivation.

III. RESEARCH QUESTIONS

The main aim of this project is to discern requirements and to design concepts for a better teaching motivation support in e-learning systems.

Already identified issues lie in the areas of teacher-student-interaction and feedback, as well as support for individual teaching styles. These areas, which should be supported through e-learning systems, are highlighted in hachures in Fig. A.1 and Fig. A.2. In this project teacher-student interaction describes the interaction between students and teachers within or through an e-learning system. This interaction can be a) a face-to-face interaction involving e-learning systems support or b) a virtual interaction through e-learning systems. Teaching scenario refers to all possibilities of occurring teaching situations. This includes distance teaching which can be held entirely virtual. Another teaching scenario is face-to-face teaching including e-learning systems in the real time class work. The mixed teaching scenario including virtual connected and face-to-face students can also occur. Teaching scenarios can differ in aspects of synchronous or asynchronous use of e-learning systems. That means that teachers and students can interact with e-learning systems at the

same time or one after another. The conclusions drawn from our semi-structured interviews about issues regarding current existing e-learning tools lead to the following areas in which the most support from e-learning tools is needed:

1. The individual teaching style (Fig. A.1)
2. The interaction with students (Fig. A.2)

Some teachers have to deal with many different teaching scenarios, which make their requirements regarding a supportive and useful e-learning tool even more complex. That leads to the formulation of individual mix of teaching styles (Fig. A.1).

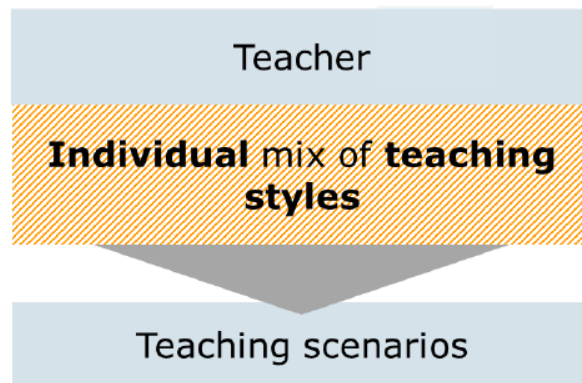


Figure A.1: Individual mix of teaching styles as method for teachers to approach their teaching scenarios.

An interactive teaching system can provide support for the interaction between teachers and students for example for feedback in both directions: from the teacher to the student and the other way round to enhance communication between them (Fig. A.2). The project scope comprises of the following three guiding hypotheses:

- H1:** Teachers' motivation influences students' motivation and learning outcome.
- H2:** E-learning tools affect teachers' motivation (acceptance/ attitude) positively and/or negatively.
- H3:** E-learning environments have to support individual teaching styles for a better motivation and better students' learning outcomes.

Those hypotheses are leading to the following research questions:

- R1:** What is the relation between the teachers' and students' motivation? (according to H1)

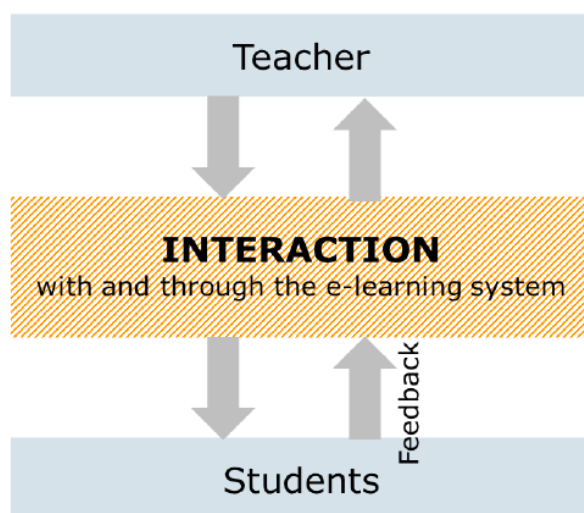


Figure A.2: Interaction between teachers and students with or through e-learning systems.

R2: What are the problems with current e-learning environments (regarding acceptance, attitude and motivation)? What are the showstoppers? (according to H2)

R3: How can the different individual teaching styles be supported by different/flexible digital teaching tools? Which adaptation of the system towards the individual teaching style is necessary for a better teaching motivation? (according to H3)

IV. RESEARCH APPROACH

The motivation of teachers to use digital learning environments is one of the key issues that have to be tackled. The point is that teachers are not demotivated to use those systems in general. There are rather critical aspects and problems with current e-learning systems which demotivates teachers to use those systems. Such aspects and problems have to be analysed and solved. Most of currently available e-learning systems have a clear focus on the students' learning process. That is, of course, the right priority, but there are always more participants involved in an e-learning environment than just the students. For the utilization of a digital learning system, it is very important to include teachers, because they are one of the major stakeholder groups. The motivation base and the possibilities for a good teaching style have to be more regarded in order to design better digital learning systems from scratch. The assumption is, that the more motivated and supported teachers are, the better the outcome of the students' learning process will be.

The first step is to analyse the current situation for teachers regarding the use of digital learning environments. This includes conducting of research methods on and about different existing ICT environments. Teachers currently using e-learning systems will be interviewed about their experiences during the use of those systems.

The aim is to find out about current problems and issues of those systems. Also the experiences by teachers from Norway will be compared with experiences and issues by teachers from Uganda. The assumption is that both deal with very different issues regarding the motivation to use digital teaching systems. The comparison is needed because there could be noticeable differences between research outcomes from different countries. The assumption is that there are also important similarities across different countries [11]. It has to be analysed what influences the teachers' attitude and what are the main reasons for that. Concluding from this, requirements for new (or improved) systems can be derived.

The second step is to carry out case studies to observe issues and problems regarding the use of e-learning systems during courses. Most of the research will be done through qualitative research methods, because the main aim is to research about attitudes, motives and behavior. For the different research questions semi-structured and structured interviews, questionnaires (including the likert scale for analysis) and discussions as well as expert interviews will be conducted. The case studies will take place in courses involving the use of e-learning systems. There are differences between size, divergence (cultural aspects as well as gender and age) and distance (physical distance between students and teachers) which have to be considered during those case studies. These methods will help us to discern requirements for better fitting and adjusted e-learning systems. These e-learning systems should be able to address the teachers' special needs better. This can make it more likely to motivate teachers to use e-learning systems, than existing and currently used e-learning systems. The teachers will be asked in an interview before the class about their motivation and attitudes towards the use of the given e-learning system. During the lesson an observation will take place. The main aim is to find problems during the interaction between students and teachers, and issues related to the teachers' individual teaching styles and preferences. After the lesson, students will be asked to rate the perceived motivation of the teacher and how motivated they felt during the class. The outcome will be: issues and problems with current systems, wishes and requirements as well as needs regarding e-learning systems. These case studies have to take place in Norway at the University of Agder and in Uganda at the Makerere University.

After having conducted the research methods, the analysis phase begins. The teachers' behavior will be examined from a cognitive point of view to analyse intrinsic factors for motivation and attitudes towards the used e-learning systems. The interaction between students and teachers can be interpreted from a socio-cultural perspective. The results of different case studies will be analysed to find connec-

tions between the students' and teachers' motivation, as well as similarities and differences in the two countries. Further investigations are carried out to verify or adapt our research hypotheses and research questions.

The outcome of this research should be requirements and concepts of how to design better e-learning tools to motivate teachers to use them. The result should lead to better motivated students, because the teachers' motivation (which should be increased through the analysed requirements) is passed on through the e-learning tools and positively affects the students' motivation.

V. PRELIMINARY RESULTS

Conducted semi-structured interviews revealed several aspects, which may influence the teachers' motivation. One teacher spoke about his small class size and made the following statement: "When I have to prepare the lessons for small classes I am less motivated compared to when I know that I have to teach big classes". This statement can refer to the opportunity of e-learning systems to add virtual connected students to the class. The more students are enrolled, the more this particular teacher feels motivated to prepare the course material. Another observation was that students tend to get quite active before deadlines and try to get appointments with the teachers to discuss their group work. The teachers don't have the time to review that amount of group work in a very short time, which leads to frustration on both sides. On the one hand, motivated teachers would like to discuss the students' group work, but on the other hand, they don't have enough time. Also the students feel left alone and unheard. An e-learning tool which addresses this particular need to exchange group work and supports reviewing could motivate teachers to keep in a constant touch with students.

Fronter, the LMS in use at University of Agder, is also under constant discussion. Most teachers feel uncomfortable to use it. "It feels so unnecessary to upload some PDFs there, when I could use the mailing system instead. I know that students will not look them up there and it takes me way longer than to send a quick mail." This and some more statements like "I can't find anything there" lead to the assumption that the LMS is too complex for most purposes. LMS try to cover lots of functions which are not needed for every course. Also the LMS seem to be too static. Even though a teacher doesn't need all functions, they are still available making the use way too complex. We argue that teachers would be more motivated to use the LMS, if there were possibilities to reduce or expand the functionalities according to their specific purposes.

Another teacher complained about the fact that e-learning systems in use are most of the time not up to date. "I would like to use new and up to date tools and try

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out new things together with my students and experience new ways of teaching”. This statement refers very strongly to given restrictions in university environments. That leads to the assumption that restrictions and the time spent for tools and equipment acquisition are also influencing aspects regarding the teachers’ motivation.

Listening to the students’ points of view also revealed the lack of sufficient possibilities for interaction. The LMS in use is not made for synchronous interaction and students are not used to the given asynchronous interaction possibilities, therefore they tend to not to use them. The interaction through the LMS seems to include an overhead. These statements provide further evidence that e-learning systems have to better support the interaction between students and teachers.

VI. FUTURE DIRECTIONS

First issues are already identified through semi-structured interviews with teachers and students. From those interviews the two main research areas were identified: Supporting the individual teaching styles and encouraging as well as supporting the interaction between teachers and students, in order to increase the teachers’ motivation to use e-learning systems. The selected research methods, comprising of interviews, questionnaires and observations will help to verify or adapt the given hypotheses and research questions.

The outcome of this research is expected to help improve existing e-learning systems and upcoming ones. That is to make sure that teachers, as one of the main stakeholder groups, are included and considered in the needs and requirements to support their teaching motivation and attitude towards e-learning systems.

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Paper B:

Investigating Teachers Motivation to Use ICT Tools in Higher Education

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B

Investigating Teachers Motivation to Use ICT Tools in Higher Education

Renée Schulz, Ghislain Maurice N. Isabwe, and Frank Reichert

***Abstract* — There are a lot of information and communication technology (ICT) tools for education, but the motivation to use those varies from teacher to teacher. In this paper we present results of an international survey on teachers' use of ICT tools in education. The purpose of the survey was to find out what motivates teachers to use ICT tools in the context of teaching. The survey also intended to reveal which tools are used as well as the needs and requirements that are not covered by the existing tools. Most of the 45 respondents suggested that the integration of tools depends on how well they fit into the learning and teaching process and how easy it is to integrate them. The first category of indicated influencing factors comprises human factors like the teachers' skills, attitudes and opinions towards the tools. The second category is about intrinsic values including teachers' satisfaction, level of interest, joy and entertainment. The third category of influencing factors consists of user requirements towards ICT tools such as usability, level of interactivity, adaptability and meeting learning requirements. There are also issues related to limited teacher-student interaction. This study suggests that teachers should be more involved in designing ICT tools for education. It is also indicated that gamified ICT tools could be promising to enhance the intrinsic motivation for teaching and learning processes.**

Keywords—ICT Tools, Teacher Motivation, Gamification.

I. INTRODUCTION

ICT tools for education increasingly spread into teaching and learning. But why are some of the tools used successfully while others are not used at all? There is a need to analyze actual issues and factors which affect teachers' motivation to teach using ICT tools. For this reason, a survey was conducted to look at possibilities of enhancing future development of ICT tools for education. We argue that teachers are as important as learners in the use and development of learning technology. It is suggested that teachers influence learners; however the degree of influence is widely discussed [1]. In higher education scenarios, teachers play a key role in selecting teaching approach and the learning materials. ICT tools like a Learning

Management System (LMS) may be compulsory for all teachers in some higher education institutions. However, they could also use additional systems to support their teaching. In this survey teachers were asked what motivates them to teach and which role ICT tools play in that motivation. The findings can be used to improve existing or upcoming ICT tools for education. Teachers may have different teaching approaches for different contexts and therefore different needs and requirements. To understand the context of use, the survey asked questions about the teaching environment. Some of the teachers are teaching only face-to-face classes, others are involved in blended learning environments. There are also those who teach in online distance environments. The survey is a first step of requirements analysis for future ICT systems for education. The goal is to make tools that are usable, motivating and offering a good user experience.

The survey questions focus on teachers' motivation to use ICT tools for education, and their opinions regarding the level of technology support in their own teaching approaches. In addition, the survey investigated whether gamification of ICT tools has a potential for higher education.

In the following section, we present an overview of the literature review and discuss how we selected the survey questions. Section 3 consists of the methods used to conduct the survey as well as the analysis of survey results, including participants' background, opinions on teaching motivation, current use of ICT tools as well as games and gamification. A description of future ICT tools for education is presented from the participants' perspective, with suggestions of what can be improved. In Section 4, the paper provides a comparative description and categorization of factors that may influence the motivation to use ICT tools for education. The final section concludes with suggestions of how to enhance existing and upcoming tools from a human-centered design perspective.

II. LITERATURE REVIEW

The materials and tools used in teaching have an influence upon the students as well as the teachers [1]. In a world with more and more emerging computer systems, mobile devices and ubiquitous computing, it is important to adopt teaching methods that make the best use of technology. We argue that the teachers' motivation to use new emerging systems is very important, especially for teaching technology subjects or subjects involving the production of digital media. It is also noted that ICT tools can support the teaching and learning process regardless of the topic being taught.

The motivation to use ICT tools in education is a complex research topic. Earlier studies [2, 8] have considered variables such as teaching resources, teaching

environment, teachers' salary, policies and support for teachers. It can be challenging to measure motivational aspects; hence previous studies considered the aspects which influence teachers' motivation [7, 10, 11]. One aspect is teachers' general attitude towards e-learning systems or more generally, towards computer systems and media as well as their confidence to use ICT tools and their opinions about them [2, 6]. Our study included questions about private and work-related use of technology. Participants were asked whether they could think of setting up a new online course, and why if not so. This kind of questions could provide indications on motivation influencing aspects such as teachers' computer integration, expectations, training and comfort level [11]. The perceived usefulness and playfulness of ICT tools could also have an influence on teachers' motivation [8, 10]. The number of teachers using a certain tool or software may give indication of its perceived usefulness, but that doesn't explain why some systems are perceived more useful than others. Participants were asked about their dream systems: what would they like to have in the future. To find out whether playfulness is an important aspect to teachers, our study included questions about the participants' attitude towards gaming. That includes analog and virtual games, online as well as offline. The degree of interaction between students and teachers is also a critical factor for teaching [8]. Therefore, participants were asked to describe the common channels of communication and common problems when using non-face-to-face channels.

The gamification (the use of game elements, mechanics and other aspects in non-game contexts [4]) has attracted a lot of interest in the research community. This recent phenomenon is expected to motivate users to have a more playful experience [4] while using gamified systems. However, authors in [12] state that the underlying game dynamics and concepts (Freedom to fail, Rapid Feedback, Progression, Storytelling) are very important to create motivation and not just achievements, badges and game looking graphics. The utilization of gamification may not always be beneficial for teaching and learning motivation, but it certainly is a concept to enhance motivation. It has to be carefully developed, with the user in mind to actually achieve a motivation increase. This work addressed questions about teachers' use of analog or virtual games to analyze if gamification has a basis of interested people in the teaching community. Generally speaking, it is beneficial if the teacher has basic skills in gaming to use gamified systems or to create game-like experiences during teaching. However a user (teacher) centered ICT tool should be capable of enhancing the teachers' motivation irrespective of their gaming knowledge or skills.

III. THE SURVEY

A. METHODOLOGY

An online survey questionnaire was created using Google Forms. The questionnaire included both multiple choice questions and open questions. The link to the survey was sent to random participants via e-mail, the target group being teachers in higher education institutions. Additionally, participants were randomly contacted in person at an international conference on web and open access to learning. It should be noted that most of the participants at the conference are involved in research about using ICT tools in teaching.

The survey was anonymous and no personal data was collected. The survey responses included both qualitative and quantitative data; therefore a mixed-method analysis approach was used.

B. PARTICIPANTS BACKGROUND

In total 45 participants answered the survey. The age range is from 21 to 61 years and above. The age range is very equally distributed. 20% of the respondents were between 21 to 30 years old, 27% between the age of 31 and 40, 20% were in between 41 and 50, 22% between 51 and 60 and 11% of the participants were 61 or above. More than $\frac{3}{4}$ of the participants were male. Ten different countries were mentioned as current teaching location (Finland, Germany, Italy, Nigeria, Norway, Portugal, Rwanda, Sweden, Uganda, and United Arab Emirates). Most participants (91%) are teachers in higher education. In total there are tutorial assistants (18%), lecturer 4% assistant professors/ senior lecturers 18% and associate professors/ professors 49%. The area of teaching is widely spread from Engineering 44%, Social Sciences 7%, Natural Sciences 24%, Arts 2% to others 22%. The daily use of social media differed a lot. 47% used “no social media” (score 1) to “medium use” (score 5) and 53% ranged from “above medium use (score 6) to “always use” (score 10). The familiarity with software was overall very high. 69% chose the score for the highest familiarity (10), 29% ranged from score 7 to score 9 and only one participant chose “not familiar at all” (score 1). Smart phones and tablets are used by 49% of the participants on a daily basis as part of everyday life, but 11% also stated that they do not use smart phones or tablets at all.

C. TEACHING MOTIVATION

First, the participants were asked to describe what motivates them to teach in general. This question was formulated to find potential motivational factors which

should be considered for making ICT tools more attractive to use. Since this was an open question, a lot of different answers were given. Most of the answers (60%) involved statements like “I like to see the students learn/ to understand” or “to transmit knowledge”. The second most given answer was (22%) that they are motivated by “the social contacts (with the students)”. 18% of the respondents said that their motivation derives from “developing a better understanding by themselves” or “personal growth”. Other respondents’ answers involved “using creativity”, “contributing to a better world”, “making use of my own knowledge”, “teaching is important” and “passion for the topic”. Of course some teachers were also motivated by the fact that they “get paid for it” (8%) and for “reputation” (4%).

Our study results suggest that the highest motivation is generated from the fact that teachers can see or experience the development of their students from the establishment of social contact with their students. This can be a first indicator why ICT tools or e-learning systems are not that much used and why teachers have a tendency to keep a distance to those tools, because for most teachers “the use of ICT tools” implies less face-to-face teaching or even the fear that they would have to switch completely to a virtual distance teaching approach. These current distance tools do not support the social contact and feedback the same way as face-to-face teaching does. Similarly, they don’t allow teachers to experience students’ development in the same intensity as face-to-face courses do.

D. CURRENT USE OF ICT TOOLS

The participants were asked to choose from a list of 20 different ICT tools, with an additional option to suggest any missing tools. It was found that the tools for slides/ presentations are used the most (84%). The second most used tools (67%) are Learning Management Systems (LMS). Further on, 51% of the participants use e-mail as a communication tool in their teaching. Additionally, quizzes (38%) and online questionnaires (24%) are used for communication. The survey results also show that 49% of the participants use videos or video lectures.

Educational tools can be classified into different categories. There are hardware only tools, digital communication (and data exchange) tools, tools that support various functionalities, preparation and post processing tools. The tools can be further distinguished between the in-lecture-use and out-lecture-use. These In-Lecture-Tools and Out-Lecture-Tools are shown in Fig. B.1. The tools used in lectures are the most interesting ones with regard to the teachers requirements (to rather teach face-to-face than virtual based and to keep in touch with the students) and could be subdivided into two different categories: general tools, which can be used for any type of course, and course specific tools, which are, in some cases,

Table B.1: Tools used during lectures.

In-Lecture-Tools	
General tools	Topic specific tools
<ul style="list-style-type: none"> • Slides/presentation (84%) • Video/video lecture (49%) • Electronic quizzes (38%) • Simulation tools (27%) • Online questionnaire (22%) • Material sharing (22%) • Learning games (9%) • Audio tools (9%) 	<ul style="list-style-type: none"> - Shell - Wireshark - Mathematical assessment - Compiler tools - Adobe Creative Cloud - Programming tools
<ul style="list-style-type: none"> - Competitive games - Semantic media wiki - Video feedback - Gifs/vector graphics 	

also used by professionals in work environments. The specific tools are often part of the taught material, for example compiler tools used in a programming course. Tab. B.1. shows a list of In-lecture-tools identified by our survey. Those with percentages were chosen from a list given to survey participants, whereas the others were suggested by respondents. From this list, it can be seen that specific tools are frequently used tools. This is explained by the fact that they were used in courses with computer based systems as the topic of study or a subject which uses computers as a compulsory tool (for example designers who use Adobe Creative Cloud) and most participants were from engineering and natural sciences.

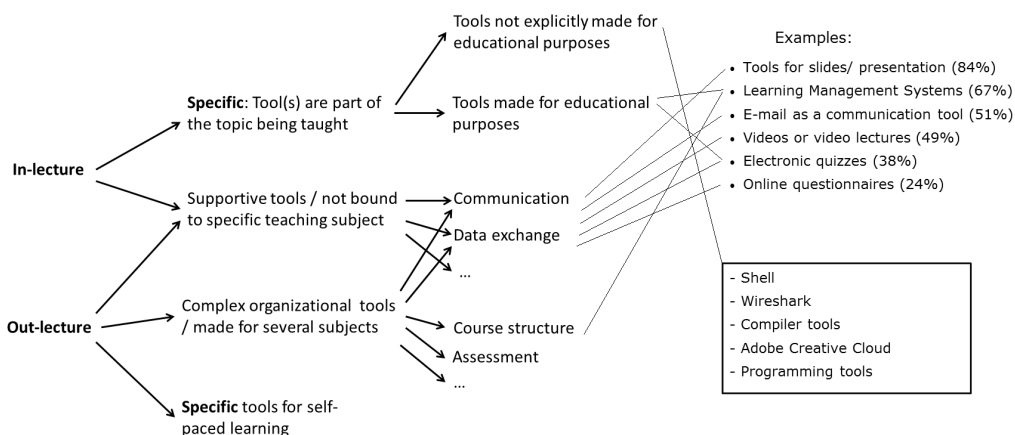


Figure B.1: Categories of tools used in teaching.

The survey found out that a rather considerable number of teachers (16%) still do not use slides or presentation tools in their lectures. On the other hand, a look at

Table B.2: ICT tools used for communication between teachers and students.

Face-to-face	44	97,8%
E-Mail	38	84,4%
LMS	23	51,1%
Social Media	9	20,0%
Video conference tools	8	17,8%
Forum	6	13,3%
Chat	5	11,1%
Other	1	2,2%

the hardware tools being used reveals that mobile devices are emerging into the teaching environment (27%), even though desktop computers are still dominant (69%). Other hardware tools include smart boards (18%), white boards, projectors, document cameras and flipcharts.

Communication between teachers and students can also be supported by ICT tools, however the survey revealed that most communication is held face-to-face followed by communication via e-mail. LMS are more frequently used than social media, but the communication through social media has already a huge impact with 20% of the participating teachers using it. Some of the indicated tools in the category “other” include Skype, Dropbox and Google Drive (Tab. B.2.).

With regards to class preparation and post processing of lectures, it was found that anti-plagiarism and information retrieval tools are respectively used by 22% and 16% of the respondents. Some of the teachers also use reminder tools (13%) and to-do-list tools (7%). It should be mentioned that tools from other categories such as communication tools and LMS could also be used for preparation and post processing. Further on, students’ hand-ins, submissions into assessment systems and results of questionnaires have to be evaluated post lecture. It is understood that the tools are used in both preparation and post processing phases of teaching.

The participants were asked in which teaching situations they use ICT tools. The results are the following:

E. GAMES AND GAMIFICATION

Gamification has recently attracted a lot of discussion, ranging from “does gamification work?” [5] to “which aspects really work?”[9, 12] and “is it really usable in serious education environments?” [4, 7]. A number of studies dealt with the effects of gamification on the students’ motivation [4, 5, 7, 9]. To the best of our knowledge, teachers’ perspectives on gamification are still missing. There is also a lack of knowledge on the teachers’ role in a gamified e-learning system and how teachers

Table B.3: Teaching situations in which ICT tools are used.

Preparation of teaching materials	34	75,6%
Lecture	34	75,6%
Communication	34	75,6%
Assessment	29	64,4%
File sharing	30	66,7%
Student administration	26	57,8%
Practicals/ Laboratory work	23	51,1%
Collaboration	17	37,8%
Other	1	2,2%

can be motivated to be part of a game or a gamified system. In addition to finding out what can generally motivate teachers to use e-learning tools, it is necessary to know how difficult or easy it would be to motivate teachers for using gamified systems.

Or is gamification also motivating for teachers? Intrinsic motivation is one of the most important motivational drivers and games tend to inherit intrinsic factors a lot. Therefore, it could be worthwhile to include lessons learned from games into the research about enhancing motivation not only for students but teachers as well. Motivational concepts from games could be analyzed in the context of serious teaching. They may have an impact on both the students and the teachers' motivation. This research work intends to find out how many teachers actually have basic skills or interest in games. Teachers may have different needs in terms of games related skills depending on the level of gamification that would be included into the teaching process.

Surprisingly many participants were casual to routine gamers of analog or virtual games (online and offline). More than 57% were regular players in any category (score ≥ 3 in analog or virtual game usage). 33% participants chose a score 4 or above in any category and more than 15% chose the highest possible score in familiarity with games. The highest score was mostly given to virtual games. Over half of the participants are knowledgeable in games from any category. This can be taken as a good sign that gamification could have a valid basis among those teachers. The teacher has to know how to embed gamified e-learning elements into the teaching process to make gamification useful. There are indications that younger people are more into gaming, but in this study the representatives from the age group between 51 to 60 included 19% of regular gamers (score ≥ 3). More than 30% of the regular gamers are between 21 and 30, and more than 23% are 31 - 50 years old.

F. REQUIREMENTS FOR FUTURE TOOLS

To get a broad overview of teachers' ideas about future ICT tools, the survey contained open questions about potential future enhancement. One of these questions was why new tools are not integrated more frequently. The most selected answer is "because of time constraints". The reasons for not integrating new ICT tools more frequently include:

1. Time constraints (47%)
2. Lack of training to use new tools (18%)
3. Lack of infrastructure (18%)
4. Tools are not usable (bad usability) (16%)
5. I / we don't know that many tools (16%)
6. High cost (13%)
7. I prefer classic lectures/ pen & paper (11%)
8. I don't know how to integrate ICT systems into my teaching (7%)
9. Bad visual design (7%)
10. I'm not motivated to try new technology (2%)
11. Other reasons (38%):
 - (a) Non-ICT tools should also be used
 - (b) Because of the students (acceptance/ excessive demand)
 - (c) Missing knowledge, discussion and shared experiences
 - (d) "I only integrate when necessary"
 - (e) "Human to human interaction is still worthwhile"
 - (f) "I rather master the programs that work"
 - (g) "I don't trust new ICT tools"
 - (h) "ICT tools don't help pedagogically"

Many participants indicated aspects other than ICT tool design as a hindrance to their motivation to integrate ICT tools more frequently. Only 16% think that currently available tools are not usable and 7% state that most tools have a bad visual design. But security, reliability and trust aspects are also mentioned. Many participants are concerned with the aspect of time (47%) and skills (18%). Teachers claim

to have time constraints, lack of proper training and knowledge about how to integrate tools into their teaching (7%). Furthermore, teachers most often don't see the opportunity to use ICT tools in addition to face-to-face teaching. It is often implied that ICT tools would replace human-to-human interaction; therefore the use of tools should be limited. We suggest that the aim of integrating new tools into teaching should be about making them feel both natural to use and useful at the same time. New ICT tools should be an efficient addition to other teaching tools, as ICT based presentation tools have become before.

Additionally, teachers were asked to describe their imaginary dream systems. Many answers described functionalities and wishes that are already supported by existing systems. Those functionalities include synchronous, asynchronous communication and collaboration, reliable communication and sharing channels, free online learning material and usable but flexible platforms. More descriptive answers mention aspects like the possibility of "talking, listening and observing students in their engagement with the material", "transfer experiences to students" or "seeing more than just the students' face in online teaching". These answers refer to the missing dimensions that come with online learning and teaching. Also the majority of participants interpreted "ICT tools for education" in an online or distance teaching approach, which is quite interesting. This may be due to the fact that most participants teach in face-to-face settings. They don't necessarily see ICT tools as relevant to their teaching even though there exist such tools that support face-to-face teaching.

Other interesting answers referred to gamification and alternative interaction methods as a potential strong motivating factor. Participants expressed a need for the integration of more natural interaction and, context-awareness into daily learning and teaching. The idea of using virtual reality devices and immersive technology (for example virtual reality headsets for 3D visual experiences) was also suggested. Furthermore, one participant expressed the wish for teaching opportunities in a virtual reality game based form. On the other hand, many participants wished for a concrete balance between ICT tools and face-to-face engagements with students and a more limited use of ICT tools, because they value the existing tools.

IV. CATEGORIZATION OF THE INFLUENCING FACTORS

The literature as well as the survey participants described different factors that influence the motivation to use ICT tools for education. This paper gives limited attention to the situation and surrounding factors. That includes the circumstances around the actual teaching like salary, time, financial constraints and lack of infrastructure. They are important for future implementations as well, but in this study

the focus is on factors that can be addressed directly through user-centered design and also factors that should be related to intrinsic motivation rather than extrinsic motivation. Cox et al. [3] suggest two main categories of factors that influence the teachers' motivation.

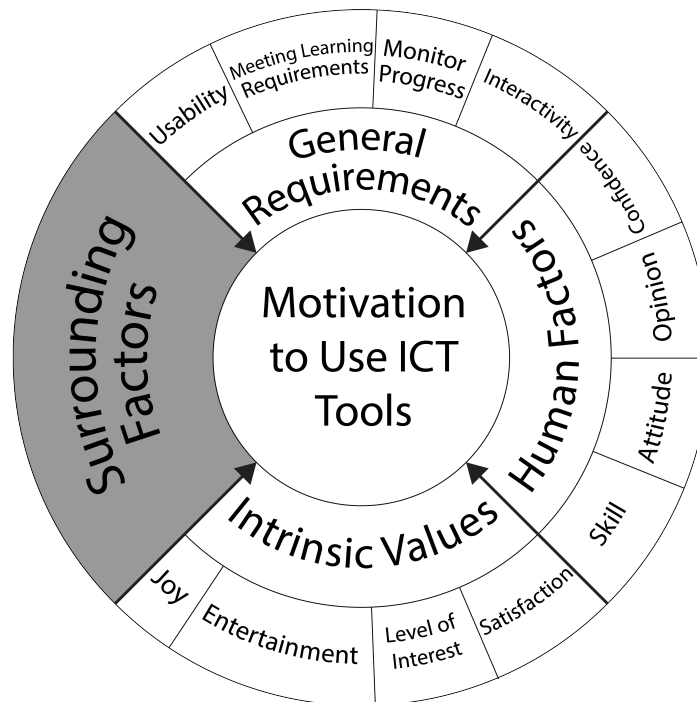


Figure B.2: Influencing factors to use ICT tools.

The first category comprises the teachers' skills ("perceived ability to use ICT" and "difficulties experienced in using IT"). The second category is about intrinsic factors such as "satisfaction with IT" and how "IT [...] is considered to be interesting and enjoyable". Authors in [6] have described many influencing factors and their connections. They can also be categorized into surrounding factors as well as issues of teachers skills ("level of teachers' ICT skills"), "teachers usage of ICT outside school") and intrinsic motivational values like "entertainment value of educational software". Furthermore, there is a third category of influential factors which describes the requirements towards a tool on a general level. These requirements described in [6] include the tools' "level in the ease of use", "ability to satisfy learning objectives" and to "remedy misconceptions", the "interactivity level", the "ability to monitor students' progress", the "availability of specialized" tools, the "ability to adapt to needs and preferences" and to "satisfy learning requirements". Furthermore the survey results indicate that teachers need a "reliable communication channel to their students", "get valuable feedback from the system as well as through the system from the students" and to "see the students learning/ progress-

ing”. The literature analysis and the survey results show that there are three main factor areas besides the surrounding factors as shown in Fig. B.2:

1. The **human factors** (most often related to skills, attitudes, opinions and confidence)
2. The **intrinsic values** (including satisfaction, level of interest, joy and entertainment)
3. **Requirements towards the tool itself** (including usability, interactivity level, monitor progress, specialization, adaptability, and learning requirements)

In a user-centered design process the human factors cannot be left aside. It is important to consider the teachers’ level of skills, as well as their attitudes and opinions when designing an ICT tool. To have a better understanding of the context of use when designing an ICT tool, it is important to have an overview about the common influencing factors that occur. But the more detailed analysis can first be made, when taking the next step into a specific teaching case.

V. CONCLUSION

This investigation found three main categories of factors that influence the teachers to use ICT tools in addition to surrounding factors. These three categories consist of important factors which have to be regarded in the design of ICT tools for education. They are critical in a human-centered design process and have to be investigated during the context analysis. The three categories are human factors (most often related to skills, attitudes, opinions and confidence), intrinsic values (including satisfaction, level of interest, joy and entertainment) and general requirements towards the tool (including usability, interactivity level, monitor progress, specialization, adaptability, and learning requirements).

The ICT tools used in education should feel both natural to use and useful. The usability of many existing tools remains a challenge for teachers. Teachers would like to provide and get richer feedback, but currently there are still limitations on tools support for interactivity and communication.

Teachers should be considered among the key stakeholders when designing ICT tools for education. They should be included at every step in the design process. Future work could consider how to enhance ways of interaction between teachers and students. ICT tools should support both face-to-face teaching and distance learning. There is a general misconception that ICT tools are there to mostly support virtual teaching and learning. However there are teachers who would prefer teaching in

face-to-face scenarios supported by ICT tools. Therefore, tools should be designed to cater for both face-to-face and virtual teaching. Furthermore, there should be more investigations on how to use gamification in a beneficial and balanced way, so that the seriousness of and awareness for the topic is maintained.

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Paper C:

Ethical Issues of Gamified ICT Tools for Higher Education

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C

Ethical Issues of Gamified ICT Tools for Higher Education

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Abstract — A recent trend in e-learning is the development of ICT tools with game elements to increase the motivation of using new technology in teaching and learning. In most cases, games possess different ethical constraints than regular e-learning systems. For this reason, additional implications and issues deriving from the combined development of games and e-learning technology have to be considered. During the development process of gamified e-learning systems as well as during the use of gamified ICT tools in education special attention must be paid to ethical constraints. This paper presents ethical considerations as to how to properly motivate teachers to adopt new technology in their teaching practices. For this purpose, the paper investigates ethical issues inherent to the design process of gamified e-learning systems as well as the usage of gamified tools in teaching in order to determine how the ethics of games can affect the teachers' roles.

Keywords—E-Learning, Gamification, Ethics

I. INTRODUCTION

Information and communication technology (ICT) tools for education are becoming more and more common in face-to-face teaching, blended teaching as well as virtual teaching. The usefulness of the tools currently available varies a lot and there are many studies that investigate [2, 5, 7, 10, 11] why teachers decide to integrate certain tools into their teaching while others are ignored. One of the recurrent questions of our research is how to increase the motivation to use ICT tools in education more effectively. We found indications that it is especially important to spend more attention on the teachers' needs as key stakeholders alongside the students [11] when it comes to using new technologies in class. Since they are the ones who ultimately decide whether or not to use additional ICT tools in their teaching it is of vital importance to consider both their individual requirements as well as their attitudes and motivations towards technological trends. In other words, if the tools are not deemed useful by the teachers, the tools will never reach the students because they will never be integrated into the teaching process in the first place. Therefore, the

development process should rather be human-centered in order to better understand the users' needs and requirements. By the same token, we investigated possibilities of increasing the intrinsic motivation to use ICT tools in education and we found that gamification (the adaption of game elements into non-game contexts [3]) could be a possible approach to increase the motivation of both teachers as well as students [11]. Ethical responsibility is very important, especially when it comes to ICT systems and tools which involve the users during the development phase to a high degree. The development of an interactive system should follow a human-centered design process to meet the user needs and requirements accurately. Therefore, it is necessary to involve users at most stages of the development process, including user testing and evaluation. This strategy assures that the designed ICT tool can be tailored to the users' individual demands. Such a high degree of involvement on part of the users includes ethical responsibilities like rights to privacy and property, physical welfare, informed consent, trust, and accountability [4, p.1178]. Even more responsibility is required when designing tools which are built to influence attitudes, beliefs or behavior. Those technologies are called Persuasive Technologies. ICT tools for education can be a kind of persuasive technology since they can aim at increasing the motivation to study or at inducing a more positive attitude towards learning. Gamification adds new variables of persuasion-possibilities which can be included into the development process of ICT tools for education. This means integrating lessons learned from games, such as concepts like game metaphors, interactions, mechanics, graphics, principles and many more into the learning and teaching environments. Games are known to be addictive, highly motivating and often inherit persuasive characteristics. These game elements have to be investigated so that fitting elements can be integrated as persuasive devices to increase the motivation of using ICT tools. The adaptation of game elements into ICT tools for education could import the persuasive power of games into the real-life experience of education. In addition to the user-centered design process which can be ethically critical, the persuasive power of gamification requires thinking through its ethical implications before using it as a tool in teaching.

In the next section, a background about e-learning and gamification is provided. In the third section, the ethical responsibility within the human-centered design process of gamified e-learning systems is discussed. After that, ethical constraints deriving from games are described in section four. Section five discusses the ethical responsibilities of using gamified technology in higher education and how this involves design issues, the inclusion of the teachers and how it affects their roles as well as aspects of privacy and data security. This paper ends with a summary and

conclusion section.

II. E-LEARNING AND GAMIFICATION

The term “e-learning” has many definitions. In this paper, e-learning refers to all variations of learning and teaching with ICT tools. These tools can be used in distance learning, face-to-face learning or blended learning. These ICT tools can inherit Learning Management Systems (LMS), mobile learning applications, software to support the preparation of lessons and many more. E-learning systems are used to support teaching approaches or to enrich teaching situations. They can provide a whole new form of teaching and learning experiences. However, many students as well as teachers are not motivated to effectively use new technology in learning and teaching. From the teachers’ perspective there are many complex variables that influence the motivation to integrate new tools into their teaching. For example, time and cost constraints have to be taken into consideration but also the teachers’ attitudes towards e-learning, their confidence, skills and opinions. Other factors which influence the motivation comprise the level of satisfaction with a tool, the level of interest as well as the joy and entertainment when using the tool [2, 5, 11]. Due to these influencing factors, means of increasing the motivation for the highest possible amount of users have been searched.

One way of making it more attractive to use ICT tools can be gamification since it addresses intrinsic motivation. Simply put, the recent phenomenon of gamification describes the “use and adaption of game elements in non-game contexts” [3] to improve aspects like motivation, enthusiasm, attitudes, fun and others that games are known to provide. But gamification is much more than game-elements brought to a different field [3]. Gamification can also make activities feel more engaging and motivating [15]. Moreover, it can enhance abilities by promoting learning activities. Possibilities to promote learning can be provided by achievements, badges and creating an area of confidence [15]. The game mechanics are also as equally important as visual game elements to positively affect the users’ intrinsic motivation [8]. Gamification as a method of increasing motivation and of improving the students’ behavior towards learning has to meet a balance between seriousness and fun, which is why it is necessary to decide how many game elements should be used in learning and teaching environments. In the research provided by Liberoth [8] game artifacts (in this case: isolated, physical game elements) were tested separately from a combination of game mechanics and game artifacts. He found out that game artifacts can increase the intrinsic motivation on a similar level. He points out that it is important to study the impact of different game elements (artifacts, mechanics etc.) separately in order to find out which aspects or elements are beneficial

in which situations.

In the research of [12] gamification was also found to be beneficial for e-learning and its social interaction features. The study also raised the awareness of ethical issues in case students lapse into a comparison mode against other students. They named this mode “Player Killer” which basically summarizes the assumption that many students have the need for aggression [14] and that a comparison mode does not come without any ethical issues. The research of [9] points to various ethical implications concerning the context as well as the user when it comes to gamified e-learning systems. They likewise underline that the competitiveness and comparison provided by game elements is not without ethical issues. This mode produces winners and losers and may have negative effects on both of them. In addition, they argue that gamification can force play in an unsuited environment so that students may adapt this way of interaction (for example the “trial & error”-behavior from games) to other situations as well [9]. Most research pays much attention to the effects on the students and how it changes their life if gamification is used in e-learning. That’s why we tend to focus more on the development process and the teachers’ perspective and what gamification can mean for their role as educationists.

III. THE DEVELOPMENT PROCESS

E-learning systems are interactive systems that have to meet the users’ needs and requirements to help them learn a specific topic. The users in that case are students and teachers or other people involved in the learning process. Therefore, these systems should be developed first and foremost with such users in mind. This implies that they should be able to adopt the human-centered design process. In human-centered design processes, as shown in Fig. C.1, the users are involved in the design of the system from the very beginning. Involving students and teachers from the get-go makes it more likely to satisfy the user needs and requirements but also helps to create useful and accurate game elements, mechanics or game experiences based on the needs and requirements of the stakeholders. ISO 9241 – Part 210 shows a human-centered design process [6] in six stages that can be iterated if need be [Fig. C.1]. The different steps have to include game-specific development phases in order to ensure a human-centered gamified e-learning system. The first step is to “plan the human-centered design process” [6] which can also include the idea of adding game aspects to enhance the intrinsic motivation of the stakeholders, however in this step it is not necessary yet. The next step is to “understand and specify the context of use” [6]. In this step the main stakeholders will be analyzed so that it can be ascertained in which context the interactive system will be used. The context of use can indicate that an enhancement of intrinsic motivation would

be beneficial for the use of the interactive system. This would be a first indicator that game elements, mechanics or other aspects could be used to influence the users' behavior. Afterwards the "user requirements have to be specified" [6]. In this step, not only do the learning requirements have to be specified, but also the concrete game elements, mechanics or other aspects which could support and align with the user demands. This means that the gamification aspects must not deter from the seriousness of the learning environment or distract from the topic being taught. In other words, they have to be synergetic with the user requirements.

The last step is to "evaluate the design against requirements" [6] and against intrinsic motivation increase or other behavior which was aimed to be improved. A game about environmental issues for example should not only motivate the users to successfully finish the course, but should also lead to an increased awareness about environmental issues in the students' private lives. If the "designed solution meets the user requirements" [6] and the used game elements affect the users in the intended way, the development process is considered complete. One of the major advantages of the development process outlined above is that all its individual steps can be easily iterated should the stakeholders' feedback indicate this to be necessary. If the continuous feedback from stakeholders indicates a necessary change to different design solutions, the designers can jump back to a previous step to enhance the system on the basis of user feedback. This also means that the best outcome can only be achieved by a high degree of user involvement. If the future users are involved in so many steps of the development process and the research associated with it, questions about ethical constraints can be conveniently tackled as well.

IV. ETHICAL CONSTRAINTS LEARNED FROM GAMES

The use of ICT tools for educational purposes also has to regard ethical aspects. Many ICT tools and e-learning systems are used by a broad range of students, student groups, teachers, teacher groups and administrators. Games can address ethical constraints, for example through their content or their tendency to be addictive. This is why gamified applications can also effectively address ethical constraints like overly motivated users and intentional persuasion. From a virtue-based theory view there are certain ethical virtues which should be encouraged. Those virtues include for example courage, temperance, friendship, wisdom and justice. Does that mean that games have to promote friendship, caring or compassion [4, p.1181]? Maybe it would not be considered as mandatory if the game itself was designed ethically, but friendship is a virtue that would make the game more valuable in its own right. Friendship or relationships in general are one of the most powerful persuasive forces in games. In cooperative games, players are stimulated to act either

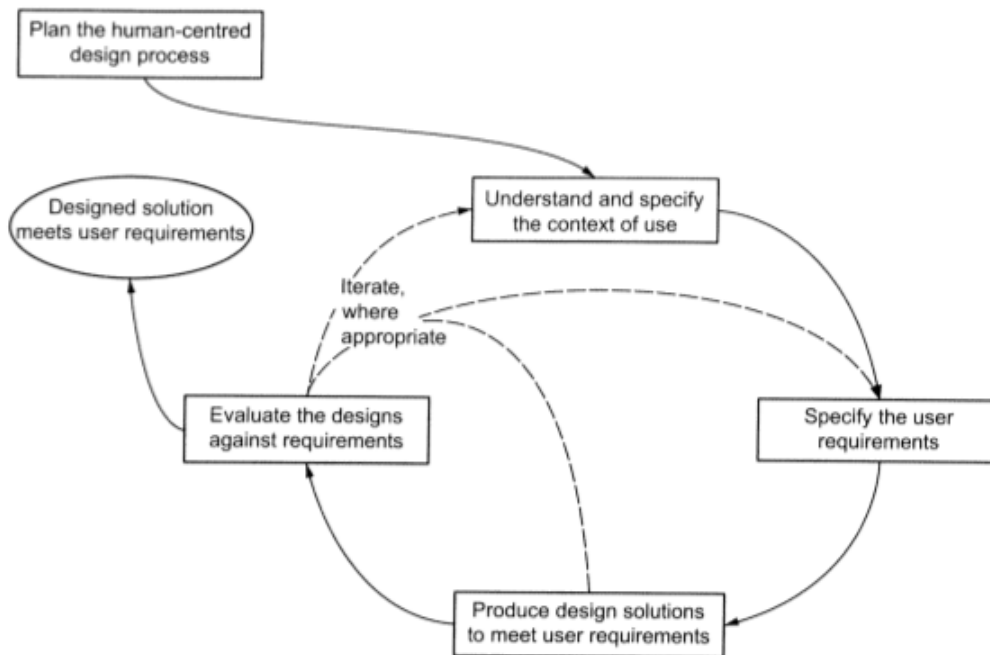


Figure C.1: ISO 9241 – Part 210 Human-centered design process [3].

because it furthers the good of the group or because it shows their willingness to help others. That is why social aspects like badges and high score lists are often added to non-game environments as parts of gamification. Introducing elements of social competition in order to promote teamwork and friendship is of course not without its faults. In many cases the users can turn on each other and exploit the weaknesses of other users in order to rank themselves better in the system. This is what developers and teachers have to be aware of when they use social competition aspects in their e-learning systems. Fan-Chen Tseng [14] found that there are two motivational factors why people like to play online games. One factor is the need for exploration and the other factor is the need for aggression. Provided that those two factors are also the factors that motivate students in gamified environments, there is a problem with those design concepts that only encourage aggression. Therefore, design elements that promote aggressive behavior on behalf of other users should be minimized. However, if they are left out entirely, the tool might lose a considerable amount of attractiveness for users who feel especially motivated by the aggressive factor. Another possibility for games to attract a great number of people is by creating huge and complex worlds. [1]. This possibility may be difficult to provide in a goal oriented e-learning system. Billieux [1] also stated other motivational factors as to why people play MMORPGs (Massive(ly) Multiplayer Online Role-Playing Games). The factors of immersion and socialization are somewhat

related to the need for exploration. The factor of achievement can be compared to the need for aggression, since achievement always implies some kind of competition. But those factors mentioned by Billieux [1] seem more neutral and more detailed. He also mentions negative motives to play games. He calls these motives “advancement” and “escapism”. They are related to achievement, competition and immersion, but they point out that there can always be a downside or a negative effect on some people. Since games can be highly addictive, the gamified e-learning systems should prevent that users lose control over the time they spend in the system. Excessive play can have negative results (depression, loss of social contacts, starvation, dehydration, anxieties, boredom) [1]. Another extreme is displayed by players or learners with an uncontrolled drive to hunt for achievements [1]. This implies that it can also be very hard to distinguish between high engagement (progression) and escapism (dysfunctional or excessive use) [1]. An exceedingly high degree of engagement or over-competitiveness can cause learners to disregard the actual learning content [13] and therefore miss the intention of the learning tool completely. Not only may overly motivated players disregard the actual content, they may also get influenced by high score lists and competitive aspects. The participants may regard these rather simple means of gamification very differently [13]. Some may find those aspects highly motivating, but others may be demotivated instead. Some of those people who feel motivated by their need for aggression tend to have fun during PvP (player versus player) phases of the tool or e-learning system. This bears the risk that they could try to impede the positive learning or gaming experience of other players for the sake of their own entertainment.

V. RESPONSIBILITY IN HIGHER EDUCATION

If an institution of higher education decides to use gamified ICT tools they should be aware of possible ethical impediments that the persuasion of students can cause. Additionally, they also have to be aware of the misinterpretations that the gamification of an educational tool is liable to. In many dimensions the gamified tool or e-learning system should be engaging like a game, but it must not inherit those game features that tend to digress from the actual content. If the e-learning system conveys the impression that it degenerated into an oversimplified game rather than a gamified learning environment, both teachers and learners alike would quickly discard it as untrustworthy.

A. DESIGN ISSUES

There are several ethical aspects which should be considered when designing new gamified ICT tools for education. In this section we provide aspects that we found

during our research about increasing the teachers' motivation to integrate ICT tools into their teaching. We do not claim that they are complete or final, but they should reveal areas where ethical responsibility plays a vital role.

- Even though the gamification has to be goal oriented there has to be a balance between gaming and learning experiences.
- A gamified ICT tool has to feature a defined end in the context of higher education and should not pull the students into a never-ending game world since the topics of courses have to be covered in a specific time (for example in one semester).
- The ICT tool should not have exploitable bugs so that students cannot cheat to get better grades.
- The gamification should not be able to degenerate into a PvP (player versus player) game where the students turn on each other to get more points or better grades.
- Although helping each other is a promotable asset, students should not get a disproportionate advantage by helping each other or by getting help from more advanced students in the interest of fairness. Students who have less social contacts than others should not have disadvantages.
- The gamification should be highly motivating but not addictive. After the gamified e-learning has been used in a course, the students should be able to separate from the game-like experience again.
- A gamified ICT tool has to find a balance for the level of difficulty so that the students neither get overly frustrated because of the system nor get bored because it is too easy.
- The system has to be accessible from every possible learning level in the class. It should be possible to include every student (and associated teacher). This does not mean simple tools and game elements, it means appropriate for everyone.

B. TEACHERS' INCLUSION AND THE TEACHERS' ROLE

The teacher must have an appropriate role in a gamified ICT tool supported environment. Many roles can be taken, but the teacher's role has to follow ethical

guidelines as well. Teachers' roles in gamified learning environments can be affected by roles that can be found in games. Typical examples of roles found in games include player character roles as well as non-player character (NPC) roles. In the following, some of the roles which derive from typical characters found in games are described from a teaching perspective.

If the teacher takes the role of the *opponent*, it may be easy for many students to see a goal in what they try to accomplish: Defeating the teacher. But this role implies that the teacher is the enemy and thus a negative character. For opposing roles in the tool the teacher has to set clear rules and goals in order not to promote PvP as something desirable in education. The gamified tool may rather be set up as a challenge than a K.O. (knockout) system. In a challenge, the roles of opposing characters may not be as clearly defined as in an enemy based K.O. system where there are clear winners and losers.

Alternatively, the teacher can take the role of the *supporting character* who provides help and information to the students if need be. In this case the ethical issue is concerned with the equal division of help and fairness. The teachers' amount of help is limited by time and effort. This amount has to be split fair and equal.

Another possibility for the teacher is to stay on the *storytellers'* side. The teacher guides the students through a journey providing information and background knowledge. This role may be the one with the least interactions between teachers and students. That means that the few interactions and tasks that are given have to be clear and understandable for the students. It also has to be made sure that all participating students are on the same level in the story/guide. This role also requires that the teacher gives out the tasks, takes in the completed work and hands out possible rewards in return. Rewards can have different shapes. They can be clearly extrinsic like extra points for the exam but can also inherit intrinsic values.

The teacher can also function as a *bonus character* – or *hero character*. This effectively turns the teacher into the joker for the students who helps them on difficult tasks but who will rather be seldomly available. This role should rather be considered as an additional role since it could provide too little interaction between teacher and students on its own.

Likewise, the teachers' role can be that of the *group leader*. This role implies that he is in the same group as the students, leading them during their actions. What is problematic about this role is that it may result in recognition loss since the teacher more or less acts like one of the students. On the other hand, the close proximity to the students may allow the teacher to see the students' progress more clearly and enables him to intervene when things go wrong. However, the students

may feel observed and queasy. A balance between the level of closeness and a mere unclear role of the teacher (because of missing distance and no clear difference between the students' role and the teachers' role) from the students' point of view has therefore to be maintained.

The teachers' role does not need to be affected by typical game characters. This paper tries to emphasize that games can have an impact on the teachers' roles and which directions it can take. In addition, it is clear that the teachers' role influences the students and their personal roles. The students can develop different roles depending on how they categorize the teachers from their own perspective. Students with a certain hang to PvP may go for an opponent-perspective while others try to see the teacher as a guide or leader if there is room for different interpretations within the gamified e-learning system. This is important so that the developers of gamified e-learning systems are aware of those implications and are able to address possible ethical issues within their design.

C. PRIVACY AND DATA SECURITY

Privacy and data security play the same big role in gamified e-learning systems as in non-gamified systems. Most surrounding factors are the same like for example that the data produced in gamified e-learning systems could potentially be accessed by many different people. These people or groups of people comprise of the students themselves, student groups, teachers, teacher groups, administrators and any other people who are integrated into the learning, teaching or administration process. It should be clear to everyone who can access what and when and this has to be agreed upon. In addition, it has to be made clear who owns co-created (for example by students groups) artifacts in the e-learning environment. It is also highly debatable what kind of rights the teacher or other administrative employees should get and how much they should interfere in the students' gamified learning process.

In gamified environments, achievements and badges or similar methods can be used to motivate through competition or rewards. Often leaderboards or public achievements are visible to every participant. It should be discussed whether those methods are suitable for a certain learning content and if the public competition is a promotable good in this context. Some examples of gamified environments use averages instead of leaderboards with visible participant data [12]. The learning status and the personal achievements need to be stored safely for every student. Other people should not be able to manipulate or falsify their data.

VI. SUMMARY AND CONCLUSION

The ethical constraints of gamified e-learning systems are very similar to non-gamified systems but they are complemented by the additional responsibility deriving from the use of game aspects. Those game aspects can be taken from games which have different requirements to ethical correctness than e-learning in general does. Therefore, the ethical implications deriving from games have to be carefully considered. Gamification can be used, within a certain extent, to increase the intrinsic motivation to use ICT tools in education. Even simple, not completely thought-through mechanics taken from gamification like points and badges can lead to teamwork, social competition but may also promote aggression against each other.

During the user-centered development process the ethical constraints of user testing and evaluation have to be regarded as well as the ethical responsibility for the design of the system. Additionally, it is very important to also regard the teachers as one of the key stakeholders when it comes to ethical constraints in gamified e-learning systems, since ethical issues do not only concern the students but may affect the teachers as well. The role of the teachers may change because of a gamified system. They can be integrated as *opponent*, *supporting character*, *storyteller*, *hero character* or *group leader* into a gamified teaching environment. These are roles which can typically be found in games and can have an influence on the teachers' teaching approach. Therefore, the designers should take care of the directions in which their product may influence the teachers' roles and teaching. The most important aspect, however, is to remember the purpose e-learning systems are made for. They should support the teachers in the best way possible to conduct ethically correct teaching to help students getting a deeper understanding of the learning content. The use of gamification must not violate any ethical principles. This includes key security considerations like the confidentiality, integrity or the availability of information in any case.

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Paper D:

Development of a Task-Driven Mobile Teaching Tool for Enhancing Teachers' Motivation

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D

Development of a Task-Driven Mobile Teaching Tool for Enhancing Teachers' Motivation

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Abstract — Mobile technology is widely available and has a potential to support teaching and learning. However, teachers are not motivated to integrate new technology frequently. Therefore, innovative technology is missing in most teaching situations. This research put emphasis on teachers' needs and requirements since they are as important stakeholders as students. To increase motivation to use mobile technology in teaching, we propose to focus on task design and distribution. That fits well to the flexibility and personalization aspects of mobile technology. In this paper we present the results of user studies conducted in Norway and Uganda, at early development stages of a task-driven mobile teaching tool for enhancing the teachers' motivation. The study participants indicated that the use of mobile technology can help to enhance motivation to use technology in teaching. This article describes the requirements for developing an innovative task-based tool for teaching.

Keywords—Human-Computer Interaction, Mobile Learning, User Evaluation

I. INTRODUCTION

The context we are going to discuss in this paper is teaching in higher education with a special focus on the teachers' perspective and needs towards supportive Information and Communication Technology (ICT). Our observation is that there are plenty of possibilities to introduce new technologies, especially mobile technologies, into the teaching process which could be motivating as well as beneficial for the teacher to use. Many ICT tools are already used in teaching and learning environments (Hwang et al., 2015) and the use of mobile devices in educational settings increases (Jacob and Issac, 2008). A pilot study revealed that teachers use diverse kinds of ICT tools in their teaching process (Schulz, Isabwe and Reichert, 2015). The tools used the most are those classified as "tools used for presentation", "complex, but unspecific tools" like Learning Management Systems (LMS), and topic-specific tools, which are not explicitly developed for teaching but part of the topic being taught. It was found that generally many tools which could support teaching are not being used. The teaching process comprises of various components which could be supported by technology: creating student tasks, tracking student activity,

supporting interactions (teacher-student, student-student, student-material) and student support at different phases of learning. We would like to augment the support of those teaching components through the use of mobile technology in the teaching situation. However, technology cannot be integrated into the teaching process without regarding the teachers' motivation to use additive ICT tools in their teaching first. The simple question is: What motivates teachers to teach in the first place and what could motivate them to support their teaching process with ICT tools? The main drives to teach, apart from external motivators such as salary and reputation, seems to be "to see the students learn", "to see them grow" and "to have personal interaction and feedback" (Schulz, Isabwe and Reichert, 2015). Some of the teachers prefer face-to-face teaching over virtual teaching and in addition to that, many different teaching methods are being used. Tools which are able to support these individual teaching approaches could be perceived as beneficial from the teachers' perspective and therefore motivating to be used.

The initial research question for this project is: "What are the requirements for ICT tools to be motivating for teachers and how to design them"? It was found that mobile technology could be used in teaching and motivating to use if it can support the teaching process meaningfully. The demand, that the tool is not specialized for one course and one topic raised the question, what common elements the teaching process contains. The idea is to design a supportive and motivating tool that helps the teacher to design and distribute tasks for students and build new interaction possibilities between the students as well as the teacher and the students. It should be usable for teachers with different teaching approaches. This implies that it should support face-to-face teaching as well as distance, blended and virtual teaching. The focus should be on (personal) mobile devices to support the interaction between teachers and students and between students themselves. More precisely the following research questions were stated for the current stage of progress:

- What are the teachers' perceptions about a task driven tool that improves motivation to use technology in teaching?
- What are the requirements for developing a task-driven mobile teaching tool that improves motivation to use technology in teaching?

In this work we adopt the human-centred design (HCD) process to develop a supportive mobile learning system. This article presents the analysis of the context of use, user needs and first steps of user testing and evaluation to specify the requirements. Important aspects to support are the interaction between learning and teaching participants, feedback and to address the need for students to better manage their learning. Our main focus is on the teachers' viewpoint since we found that

their perspective is widely missing but essential for future systems. This paper is structured as follows: related work is presented in section 2. In section 3 we describe the conceptualization of mobile teaching. Afterwards, in section 4, we focus on the user evaluation as a part of the human-centred design process. Conclusion and future directions are stated in section 5.

II. RELATED WORK

The term mobile learning refers to the use of mobile technology, including mobile devices, to conduct learning and teaching. This device can be used as an exclusive device for learning and teaching or as a supporting tool used for example in a face-to-face class environment. Mobile learning can occur in face-to-face courses, blended learning courses and virtual courses. The learning and teaching process becomes unbound from local restrictions which in turn creates more possibilities in terms of time scheduling. Using mobile devices enables more flexibility and spontaneity for the users (Lehmann and Söllner, 2014; Traxler and Kukulska-Hulme, 2005). Recent research speaks about ubiquitous learning rather than mobile learning to differentiate it from the concrete use of technology, in this case smart phones or other mobile devices.

Mobile learning can be used to enhance the interaction between students, teachers and also their learning material. It is noted that interaction is one of the most important factors for designing effective e-learning environments in general (Liaw, 2004). Further on, there is a study indicating that a theory-driven approach can be used to increase the interaction in large-scale lectures using a mobile learning application (Lehmann and Söllner, 2014). That study focuses not only on increasing one type of interaction but supporting three different types (Moore, 1989): learner-content-interaction, learner-lecturer-interaction and learner-learner-interaction. These three types are important for our work because our preliminary context analysis indicates the need for better and increased interaction, with at least two of the three aspects (learner-lecturer-interaction and learner-learner-interaction) (Schulz, Isabwe and Reichert, 2015).

We would also like to focus our attention on task design, distribution and evaluation as this has a potential to improve both the interaction and self-reflection of the students. Earlier research work (Laru and Järvelä, 2015) explored how self-regulated learning and the associated learning activities can be supported by multiple software tools. The authors show how learning activities can be enhanced through technological artefacts such as smart tools. That includes activities such as “refine strategies, monitor, evaluate, set goals, plan, adopt and change belief”.

They argue that smart phones are more than simple devices; they are smart tools which can help us to mediate activities and support the everyday thinking processes. Therefore, they offer massive opportunities for educational settings (Laru and Järvelä, 2015).

For our work it is very important to look into different approaches to solve the motivation problem. An earlier study (Jones et al., 2006) analysed the characteristics of mobile devices with consideration to literature about motivation. The authors came up with six factors why mobile devices may be motivating: freedom, ownership, communication, fun, context, and continuity. In general, the literature speaks more about the motivation to use ICT tools and the factors which influence teachers to use such technology. Some of the important variables (Liaw, Huang and Chen, 2007) include personal attitudes (perceived self-efficacy, usefulness and enjoyment) and system quality comprising of perceived satisfaction and ease of use. Additionally, factors that surround the teaching situation are influencing the teachers' motivation to use ICT tools. These factors include: teaching resources, teaching environment, teachers' salary, policies and support for teachers (Wastiau et al., 2013; Schulz, Isabwe and Reichert, 2015).

To address the need for motivation we consider the use of gamification. The adding of game like aspects to a serious context is called gamification and can be a highly motivating factor when done right (Deterding et al., 2011). However, it is neither researched very often, which aspects are motivating in which context, especially in higher education, nor is the teacher's point of view usually taken into consideration.

III. CONCEPTUALIZING MOBILE TEACHING

This includes how the HCD process is applied, has been achieved until now and in which phase of the HCD process we are.

3.1 HUMAN-CENTRED DESIGN APPROACH

In our research we are using a human-centred design process according to ISO 9241-210 (ISO, 2010) to be able to meet the user needs and requirements for an interactive system. Figure D.1 shows the HCD process. What differs most from other design approaches is that it focuses on understanding the users' needs, experiences and desires (Giacomin, 2014). It was argued that HCD can be applied to model educational user interfaces (Oviatt, 2006), because they have requirements that are tightly tied to the teaching context and identified stakeholders. What is particularly noteworthy about this approach is not only the interface part of the design, but

the way people interact, the cultural challenges and the stimulation of people (Giacomin, 2014). The foundation of our prototype, we are using for the evaluation, is provided by a preliminary context analysis concerning the teachers' motivation to teach with ICT tools (Schulz, Isabwe and Reichert, 2015). User needs and requirements specification from initial analysis led to an early stage prototype. Then, this prototype was used to analyse further the context of use, to validate previous findings and to specify requirements in order to improve the system.

Considering higher education as the context of use, we carried out user testing with participants from two universities: one in Norway and another one in Uganda. The intention was to give a global perspective and validation to our findings. Since most of the study participants mainly teach in face-to-face settings, we limit this work on face-to-face teaching mode. Additionally, we chose face-to-face teaching mode as our main focus because that is where teachers expressed biggest need for new and innovative tools; as the majority of currently used tools seem to be outdated. While it is very common to use presentation slides, LMS and file sharing tools; there is a very limited use of tools that directly enhance the interaction among students or between students and teachers.

Students are often the focus stakeholder group when it comes to studies on educational technology. However, teachers should also be considered as important stakeholders for effective use of technology in education. We argue that there is a need to focus on the teachers' needs and requirements while developing technology to support various teaching methods.

3.2 MOBILE TEACHING PROTOTYPE

The use of students' tasks in teaching is a common practice among teachers. They design and develop new tasks, distribute them to students and assess students' performance based on the given tasks. This can be done in the same way regardless of the teaching mode (face-to-face, virtual or blended). The challenge is that, in some cases, teachers can not sufficiently interact with students, even though such interactions are perceived to be one of the motivating factors for teaching. We suggest to enhance the interaction between teachers and students based on an everyday occurrence in teaching: the tasks.

Given the increasing use of mobile devices in everyday activities, there is a potential to use the same kind of tools for enhancing interactions in teaching and learning. A mobile technology supported solution can primarily be considered as a platform for importing pre-designed tasks into a system which encourages further interaction between the students. It is also indicated that teachers would need to

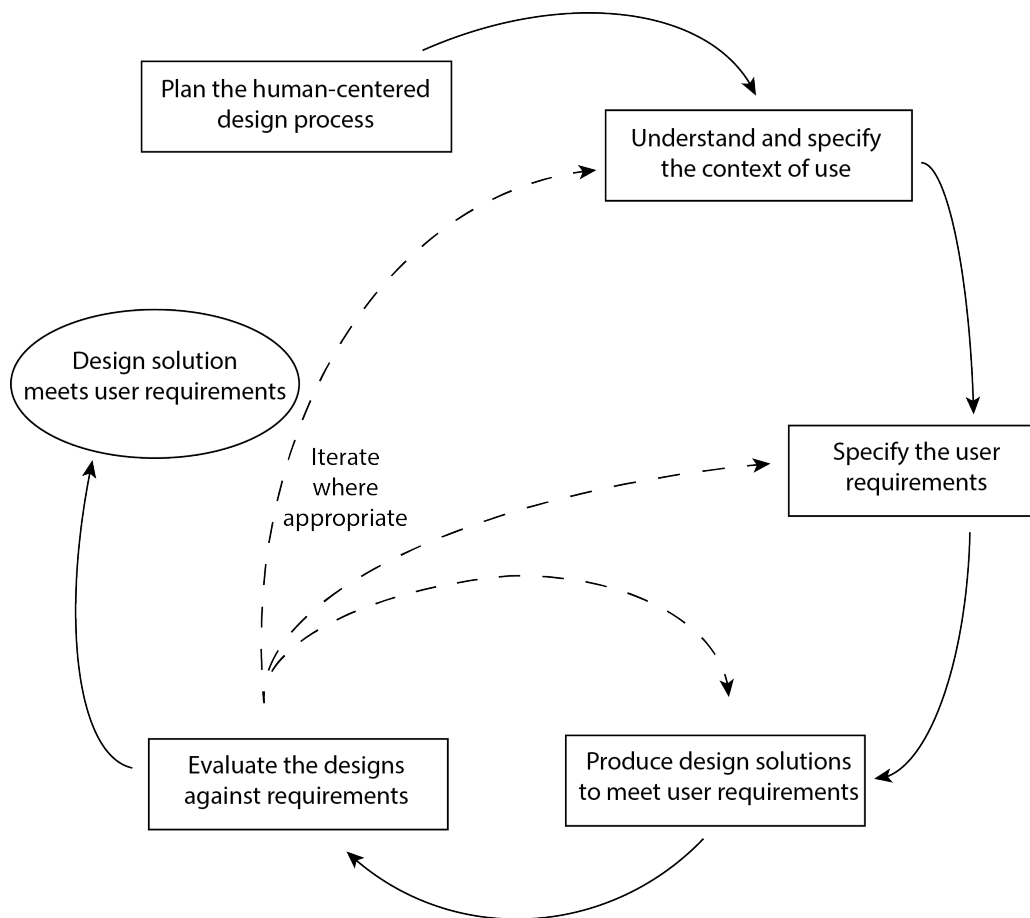


Figure D.1: The Human-centred design process by ISO 9241-210:2010 (ISO, 2010).

monitor students' performance, in order to provide better support. Therefore, the monitoring option should also be integrated into such a system. The level of monitoring may vary from a very close observation to a rather casual and anonymous overview of individual student's progress.

Teachers expressed concerns regarding too much extra work potentially deriving from the administrative tasks when integrating new technologies into their classes. It should be possible to involve students into the task design process, so that teachers focus on teaching and monitoring students' performance. One approach to promoting students' active involvement could comprise of a system which allows students to challenge each other on a given topic. Such a design decision would imply that students are able to create new tasks for a specific topic and are also encouraged to solve tasks that have been created by their fellow students. Student's ability to design tasks can lead to deep learning of the topic, thus it is beneficial to the learning process as a whole.

The new task-driven teaching tool should have support for: creating new tasks,

handling tasks and distribute tasks based on the environment and status of students. It should also support motivating aspects for the teacher to use such a system during the teaching process. To avoid too much administrative overhead, the teacher should not be expected to explicitly trigger tasks distribution. It should be possible to setup event triggers based on data measurement through the sensors embedded in mobile devices. This is one of the benefits of using mobile technology for educational purposes. These sensors can collect context information to provide a new dimension of teaching flexibility.

Prototyping allows to communicate, test and evaluate design solutions from the early stages of a development process. In this work, we developed a prototype consisting of 12 screen sketches. The prototype represents the collected ideas about task creation by students, teachers, as well as possible interactions between both groups (Figure D.2). It is important that these screens have an unfinished look so that the participants would feel encouraged to criticize and discuss them openly. In order to validate the general suitability of mobile devices for such tasks, we assembled these 12 screen sketches into an interactive prototype for an Android based smartphone. The prototype was put together by designing application mock-up screens using balsamiq (Balsamiq, 2015). Then the screens were transferred to marvel (Marvel, 2015) to make them interactive. The decision to use an unfinished and rough-looking prototype helped a lot to make the participants criticise the prototype. We actually found that for some participants the screens on the mobile phone already looked like finished product. In the beginning they only expressed additional ideas, assuming the screens they can see and use are already fixed. After some time, however, all participants were able to discuss the interface elements as well as provide feedback and critique. The arrows in Figure D.2 show the navigation between screens. By tapping the application's name on the top of the screen, a participant could always switch to the overview screen as well. The main parts shown in the prototype include an overview of recent tasks, the section to create tasks or to register a solved task. How these artefacts could be used in teaching appropriately was part of the discussion surrounding the prototype as described in the next chapter.

IV. USER TESTING AND EVALUATION

4.1 EXPERIMENT SETUP

In this phase of our project we used a mixed-methods approach. The user tests consisted of qualitative and quantitative methods with multiple steps. Purposive sampling technique was used to recruit study participants from higher education

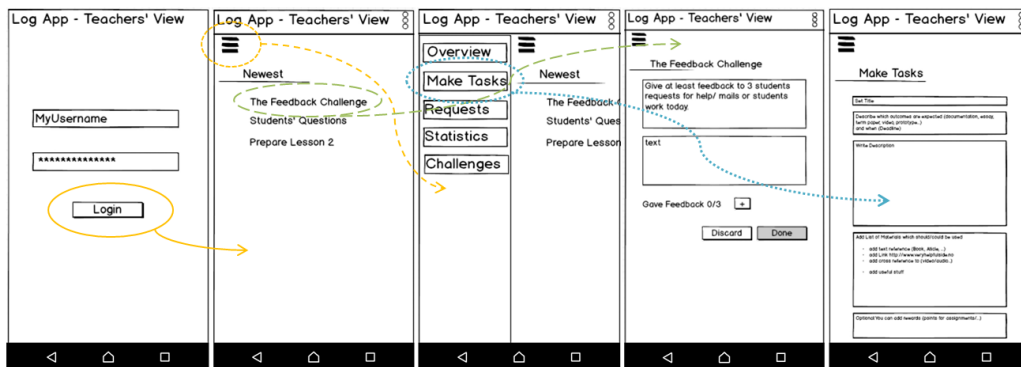


Figure D.2: Screen sketches from the prototype: (1) login screen, (2) overview of recent tasks screen, (3) overview with additional side menu, (4) one sample task, (5) screen to create tasks.

D

institutions. This study included eight teachers from Norway and Uganda, four from each country. Their professions range from lecturer, assistant professor and associate professor, to professor. Two of the participants are women and six are men. The level of familiarity with computers differs from “I can set up my own systems” (highest score 10) to “medium familiarity” (score 5) where the lowest possible score was 1. All participants had at least a medium level of familiarity with computer systems. This is the same with regards to the familiarity with mobile devices.

First the participating teachers undertook a background survey about their teaching situation. After that they could describe their teaching in a semi-structured interview which focused on task design and distribution, the interaction with students and the challenges they have during their teaching. After that phase the participants got another survey consisting of statements which they could rate from “totally agree” to “totally disagree”. These statements were the introduction to the challenges we found during the preliminary study which led to some of our prototype ideas (Schulz, Isabwe and Reichert, 2015). This section was included to confirm earlier findings, but also to see how important these are for the participants. Following this survey, the participants were asked to use the prototype and describe what they think about it (similar to the think-aloud technique). However, the emphasis was on an open discussion instead of a pure think-aloud protocol and task-based testing. All participants were at least audio recorded and most were also video recorded. The last phase was again a semi-structured interview regarding user interactions on the prototype.

4.2 TEACHING SITUATION

We tried to focus on how the teaching situation looks like in general and how tasks for the students are designed, distributed and evaluated. Both teachers from Norway and Uganda described that they have to deal with high numbers of students in most courses, especially on Bachelor level. Teachers from Norway distinguished between lectures and laboratory (lab) work. During the lectures there are a few tasks given, most often discussions are raised or quick questions are asked to the audience. Tasks designed for learning a subject in depth (with more details) are given as lab work. The lab work is often done in small student. However, the teachers in Uganda have to deal with huge student numbers in lectures as well, but without the lab work (this could be due to the field of study for the sample teachers). Tasks are given to students as homework or in classroom discussions and quick questions to the audience. There are very limited interactions during the lectures. The teachers explained that is very challenging to appropriately address all students undertaking the given tasks. They cannot differentiate between weak and strong students due to the high number of attending students.

All teachers mentioned that they create tasks before a lecture, based on the progress within the course schedule. The teachers from Norway said that they mostly prepare tasks related to laboratory work. However, there are also project tasks and student homework which have to be prepared. The teachers from Uganda prepare the tasks as well, but they most often have no additional laboratory work. Hence, most tasks are designed as projects or homework. Tasks can be small and simple or more complex depending on the teaching situation and teaching topic. It can also happen that different students get different tasks depending on their individual performance levels. On one hand, teachers and teaching assistants are very often present to guide and help students through the tasks given in laboratory. On the other hand, students generally do project work and homework either on their own (individually) or in student groups without the teachers' presence.

Through the analysis of descriptions of how the teachers design and use the tasks, we found that tasks can comprise of:

- Concrete reading
- Problem solving and creating of content
- Exploration of a given topic
- Repetition of concrete content

- Evaluation and reflection of own work
- Peer-review of other students' work
- Making definitions or glossaries
- Complex project where students have to plan their own sub-tasks

The tasks are provided during lectures and lab work via a LMS or other communication channels. The teachers from Uganda said that, in some cases, they give out tasks or homework via short messaging services (SMS). Complex tasks are written down, with descriptions either on a sheet of paper or within an LMS, together with links to additional details and/or hints on how to solve the tasks.

In this work, it was found that there are several variations regarding the evaluation of tasks. For instance, homework tasks are not necessarily evaluated because of the high number of students. That is why some teachers introduce the practice of peer-to-peer reviews allowing students to review each other's work. Homework tasks are primarily given out as self-studies whereas lab work is usually evaluated in the lab.

In addition to the use of tasks in teaching, teachers' motivation to teach was also of interest to this study. Therefore, participants were asked to give their opinions with reference to a list of statements about their motivation and the use of ICT tools in teaching:

- S1** "I like to see the students learn."
S2 "Feedback from the students is very important to me."
S3 "I like it when students ask questions."
S4 "When students challenge me on a topic based level, I feel that the students are engaged."
S5 "I frequently prepare tasks and assignments/ homework for my students."
S6 "I like to challenge my students."
S7 "It motivates me to compete with my students on an academic level."
S8 "I can imagine using mobile devices in my teaching."

The statements were to be rated on a Likert scale, from *strongly disagree* to *strongly agree*. The main purpose was to evaluate if the ideas for a supportive ICT tool,

described in the chapter “Mobile Teaching Prototype”, are accepted by the teachers. The most critical statements are [s5] and [s7] where some teachers disagreed strongly to moderately. In case of [s5] teachers said that they would prefer to use existing tasks from books or previous lectures. Otherwise, they would introduce group projects instead of single tasks for the students.

In total the teachers tended to agree strongly (4-5 on the Likert scale) to all statements. Some teachers gave comments to their selections in the interview part. Some pointed out that it is not correct to say “see the students learn”, since it is not possible to see the learning, but the message behind the statement was clear. The statement [s7] was discussed critically because most teachers pointed out that teaching is not about competing with students. This raised the question of finding out about the acceptance of a system where teachers and students could earn reward points for participating in a challenge about an academic topic. Teachers competing with students seem to be unacceptable to teachers, but they suggested instead that it would be motivating to see students compete with each other.

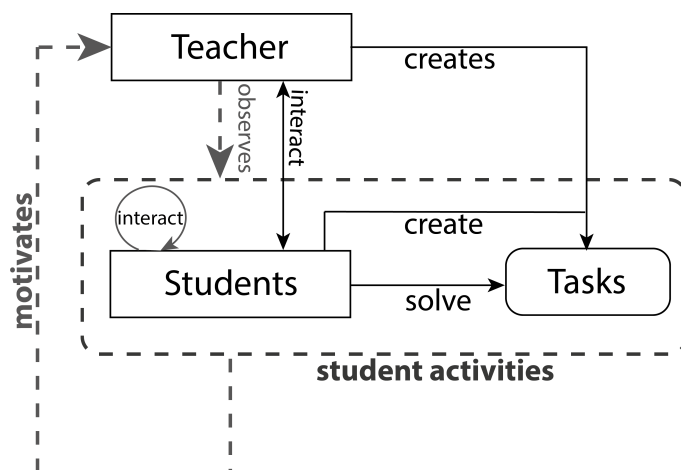


Figure D.3: Motivating activities for teachers.

4.3 RESULTS OF THE INTERVIEWS AND OPEN DISCUSSIONS

Most teachers mentioned that they would like students to use the system. They would love to see the outcome and statistics about students' task solving. However, teachers would rather not be involved in extra work such as creating more tasks or spending much time on solving tasks created by students. This also relates to the fact that some teachers disagree with [s7] (compete with the students). They mentioned that it could be very difficult to find a balance between tasks created by the teacher and tasks created by a large number of students. Overall, the teachers agreed that they normally create tasks and that it is not that much effort to refer



to those tasks in an app. It should not be a problem to quickly put those tasks into an app system where students could find them. A lot of teachers were very excited to see the statistics corner of the app (which was not yet implemented in the prototype). They thought it sounded very promising and motivating to see statistics about students solving their tasks even if it could be anonymised. Additionally, it was mentioned that feedback from students is generally very low and perhaps such an app could provide the right platform for students to give the teacher (anonymous) feedback about the task, teaching content and the lecture in general.

Figure D.3 shows a summary of our findings on what teachers describe as motivating for their teaching (Schulz, Isabwe and Reichert, 2015). It is indicated that a teacher is motivated to use ICT tools in the teaching process if the tool can help to make the student activities visible or observable for the teacher. Tasks can be created by a teacher or students themselves. To see the students interacting with the tasks, with each other as well as seeing them solve the tasks is also considered as an important motivation factor for teachers.

4.4 ANALYSED REQUIREMENTS

We propose that the main areas of focus should be:

- Task design, distribution and analysis
- Enabling quick interaction between teachers and students as well as students with each other
- Possibility for enhanced motivation through the use of gamified elements (in the task design and distribution)

It is noted that the above areas should be considered primarily from a teacher's point of view.

Based on our analysis, it is suggested that the main parts of tasks or "what is needed" to create tasks are the following (organisational requirements):

- Task title
- Short description and link to the topic
- Possibility for a long description
- Resources (links, books, pages, papers. . .)
- Affiliated people (if necessary)

- Location (if necessary)
- Rewards for completion (optional: if agreed on)

The task title is needed but could also be represented by a number as a unique reference. The short description should contain the task itself. If a longer version or more explanations besides other resources are needed, the possibility for a longer version should be given. Resources describe the material needed to fulfil the task. These resources can constitute virtual (directly linked) resources or the requirement outline for physical resources. Affiliated people can be for example the teacher, teaching assistants, other professors interested in cross-course work, administrative people for submissions or team members. Designating a location can be necessary if the task for example comprises laboratory work, field work or if certain rooms are booked for the students. The reward section could include for example, the number of credits earned for certain tasks, or the percentage a given task contributes to the final grade. This can help students to know what they get out of undertaking the task. However, the rewards part can be left out in case that would be inappropriate.

The section for statistics/analysis can include data related to (functional requirements):

- Activity of participation (in-lecture/ out-lecture)
- Engagements with the tasks/ repetition of tasks
- Open tasks vs. completed tasks
- Fail/ Pass attributes of the tasks
- Improvement/ worsening of students
- Areas in which the students feel challenged
- Questions/ Feedback
- Fulfilment of goals/ actions/ deadlines
- Time and location of task fulfilment

The teacher can use this information to improve the teaching and tailor it to the students' needs.

V. CONCLUSION AND FUTURE DIRECTIONS

This research work aims at bringing innovative and motivating technology into educational environments. The focus is on the teachers' needs to make future tools feasible and usable for teachers alongside the students. Our study comprised of international surveys, interviews and prototyping to find out the needs and requirements of new tool for teachers. This part of the research is an early step towards development of a usable and supportive mobile learning system for higher education. It points out how important it is to understand the context of use and the factors that influence motivation in the environment of the users. It is suggested that the use of mobile devices such as smart phones can support teaching in higher education. These devices offer a wide range of possibilities which are not yet explored, even though the technology is already deeply rooted in many different aspects of everyday life. In this work, the emphasis is on enhancing the interaction among students as well as between students and teachers through task design and distribution. Additionally, usage data can be generated from task-based interactions. That data could serve as feedback for the teacher and students. One of our goals is to encourage students to play a more active role in the learning and teaching process. This active role by using mobile devices creates personalised and individual feedback data. The teachers have expressed a need for more technology supported feedback and interaction with their students. But they also said that it is important to keep the face-to-face interactions. Therefore, the new system should be designed as an additional supportive tool instead of a "tool designed to contain the whole content of the course". That also ensures that those participants without mobile devices are still able to participate in the course.

We would like to continue with conceptualizing a motivating ICT tool for courses in higher education to support the teachers without forcing them to change much about their teaching approaches. One critical factor for motivating teachers to use new ICT tools is an increase in the motivation of their students. Teachers stated that they would gladly use those tools, if those tools could improve the level of students' activity. Therefore, we decided to pick out the needs about feedback and interaction between students and teachers to conceptualize a motivating ICT tool following a human-centred design process. This implies that teachers will remain part of the design process the whole time to clarify needs and requirements during the development.

As a means to designing a motivating tool we will analyse further the usefulness of gamification in a higher education context. The intention is to integrate aspects of gamification which fit that kind of teaching environment. The workings of gam-

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ification aspects are still unclear and dependent on the situation in which they are used. Therefore, the new ideas will be discussed and tested with the users during the process until they can be integrated into the teaching tool.

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Paper E:

The Use of Game World Tasks Concepts in Higher Education

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The Use of Game World Tasks Concepts in Higher Education

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Abstract — The link between tasks presented in games and tasks used in higher education might have more in common than we think. Analysing how tasks work in games and applying those structures to higher education teaching can enable teachers to develop more creative, situated and exciting tasks for their students. In addition, it can improve communication and feedback. Analysis shows that tasks are an area where elements of gamification work. This article looks into the possibility of reproducing the flexibility and key components of game tasks in actual tasks in higher education. We look at the challenges and limitations and ways to solve them. Therefore, we analyse the concept of quest-logs in games, look into the structure and its connections to the game world.

Keywords—Game Structure, Gamification, Higher Education, Mobile Learning, Wearable Technology.

I. INTRODUCTION

Too few teachers integrate new technology into their teaching process today. To improve this situation, we looked into technology integration problems and found that many tools do not meet neither the needs of the teacher nor the students. Further analyses revealed several commonly used teaching practices. Among them are task design and distribution. Additionally, teachers stated that it would be highly motivating to use technology if that can increase the frequency and quality of communication and feedback between the students and the teachers [1].

To solve the motivational problem of integrating more technology into teaching, we want to develop a gamified system, which addresses the needs of task design and distribution, communication and feedback between teachers and students. The first step was to analyze how games deal with tasks. This involves how tasks are designed, visualized, integrated into the world and how gamers interact with them. We found that there is a common concept, which we name the “quest-log concept” that handles the interaction between gamers and tasks but is also far more complex than that. The key concept behind tasks in games is their personalization and dynamics. We found that, in games there is more than one way of task assigning

involved. It is possible that the concept of dynamic tasks might be very useful and motivating in higher education. A game-like experience can be created by combining the visible interaction possibilities (mobile interfaces) and the all-knowing game-world (through sensors) supported by mobile and wearable devices.

This article starts in the next chapter with related work. Chapter 3 deals with the analysis of the different layers of interaction and explains the dynamic concept of tasks used in games. Conclusion and future work are presented in chapter 4.

II. RELATED WORK

There is more than one way to integrate games or game elements into a more serious context such as higher education. One of the possibilities is to make use of games to transform the education into a game or use games as a motivational element [2]. The other option is to use game aspects as a useful mean to solve certain real world problems. Deterding et. al. [3] define gamification as the use of game elements in non-game context. The utilization of gamification is not always successful. It is noted that underlying game dynamics and concepts (Freedom to Fail, Rapid Feedback, Progression, Storytelling) are very important and not just achievements, badges and game-like graphics [4]. Therefore, we argue that not only visible, easily distinguishable elements such as badges and points are gamification, but also more complex game concepts and cognitive elements. This matches some of the thoughts presented in the essay: “Gaming science: this “Gamification” of scientific thinking” [5]. This rough definition allows defining what exactly game elements are and how we can make use of them for learning. The following section discusses gamification beyond simple achievements, badges and graphics.

Haimari & Koivisto [6] identified nine dimensions of a gamified environment: challenge-skill balance, clear goals, control, (immediate) feedback, autotelic experience, loss of self-consciousness, time transformation, concentration, and merging action-awareness. These nine dimensions represent outcomes of gamification, but [6] does not state not how they are achieved. More research in the area of gamification looks at game structures, which might be useful in order to gamify non-game contexts. According to Prensky [7] there are six elements of game structure: 1. Rules, 2. Goals and Objectives, 3. Outcomes & Feedback, 4. Conflict/ Competition/ Challenge/ Opposition, 5. Interaction, 6. Representation or Story. Our work identified that teachers want to have a supportive tool that was able to enhance task design and distribution as well as the communication between teachers and students [1], [8], heavily relied on all of these six dimensions [7]. Tasks follow rules and have goals, as well as outcome and feedback. Further on, tasks can be challenging and they offer competition, conflict or opposition either on purpose or indirectly.

Tasks do also help for personalized learning and teaching. It is interesting to see how games handle the aspects of personalized gaming/learning and how the interaction between tasks, gamers, environment and goals are structured. This research work attempts to answer the question of how to learn from the game world and use that to create better, more contextualized tasks in higher education.

III. ANALYSIS OF GAME WORLD TASKS

We need to know about the game structure to redesign this structure in the educational setting. Therefore, we analyze the game world first, then how tasks are stored in games. After that we look into the dynamic concept and structure of task finding, triggering and delivery in games and then analyze its potentials for education.

It is important to understand how the communication between the player and the game world works. To interact with the game world, the player's action possibilities are presented by most games with graphical user interfaces (interface layer). That means, we can distinguish between the "game world" view and its "interface" as two separate layers of interaction possibilities. The interface is most commonly a layer on top of the game world (game world layer), guiding the player through the interaction possibilities. This clearly differs from the real world where action possibilities are not restricted by a number of action buttons to determine the next move. This interface-layer could be simulated by using mobile technology, showing us possibilities for our next moves and interactions. In addition, most games have settings (settings layer) where certain properties of the game can be changed. They may not necessarily have a direct impact on the game, but may change the game experience drastically. The simple change of the resolution can make visuals more clear, as well as simple helping options like "automatically follow up if there is a next task available" possible. Settings clearly affect the usability and user experience of the game. Therefore, we can distinguish between three main layers of interaction in games: Game World, Interface and Settings [Fig. D.1].

The next step is to look into the design of tasks directly (from 17 games [9-25]). This step automatically leads to a widely used concept to get, store, collect and view new and old tasks in the game: the quest-log [10], [21] (other names can be: "missions" [9], "journal" [11], [15], [22], "tasks" [16], "diary" [19], "objectives" [18] and others). This log is part of the interface (layer 2) and visualizes the tasks the player gets through game world encounters.

A visualized quest-log is the central accumulation of tasks and therefore often perceived as "to-do list". This makes sense, since it shows the tasks that are available. Depending on the different quest-log approaches, it shows also a description, context of the task, requirements, location (map), objectives, pictures and rewards.

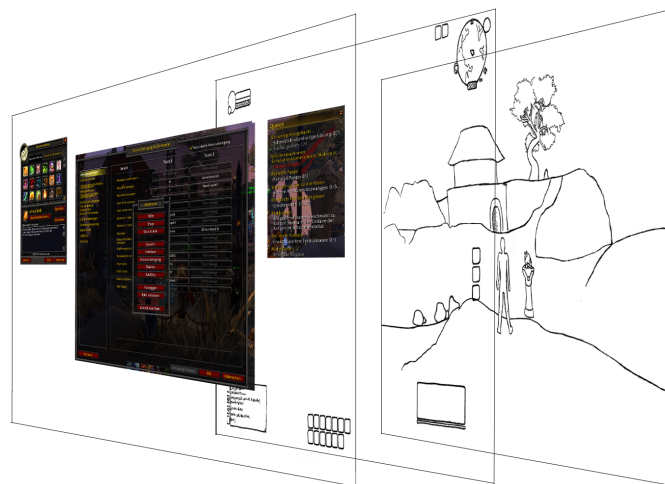


Figure D.1: Game world layers adapted after [25]. From left to right: settings, interface, world.

There are rather simple quest-logs as in ArMA3 [12], showing only a list of tasks and more details in a dropdown menu. This log is located directly in the game world. Logs can also be shown without a connection to the direct game world and can also contain game looking graphics, a very rough description and detailed objectives. However, both logs have the same structure: a list of quests and details of the selected quest. The details in quest logs from [9] are for example clearly assigned to “About”, “NPC”, “Goals” and “Reward”.

But a quest-log is more than that. Unlike to-do lists, quest-logs are used as visualization for dynamically changing tasks. Due to their connection to the game world, tasks can change, or new ones can appear and others may fail. Those changes are represented in the different layers: either in the world or on the interface layer. In some cases tasks can be adapted on the settings layer as well.

The quest-log concept involves the quest-log itself (the visualization of the tasks) as well as the concept where these tasks come from. The quest-log visualization can differ from game to game. The following elements were analyzed from 17 games [9-25]: Quest title, short and/or long description, hints towards resources, characters/ Non-Player-Characters (NPCs), travel location or area of quest completion, often with a map attached and rewards for completion.

The concept strongly supports personalization. Some players may get different tasks than other players, because their gameplay differs. Depending on skill, exploration and the way to approach problem solving, tasks can be automatically adapted. The advantage of the game world here is that it has all the data needed to do so, since the characters of the players in the game are fully emerged and every action can be tracked. This means, tasks are influenced by the environmental vari-

ables, the player's behavior or other occurring events. For example, when entering a new area, new tasks can appear and old tasks can disappear if an important NPC dies. We call these actions, events and happenings that lead to task changes "triggers". We do not have access to students' real world situation in the same way as games have, but we have technology, which can help to get environmental information. By adding the possibility to sense environmental information (and to design triggers for tasks) or other variables of the student's situation, the game experience of adapting and personally individual tasks can be simulated.

As mentioned, the quest-log concept involves triggers, which lead to tasks. Tasks can be picked up by interacting with NPCs, due to events happening, because of the time or because of the completion of previous tasks and more. All sorts of game-world interaction can lead to further tasks and those task-chains can differ from player to player. The player can encounter situated tasks by reaching a specific location. For example, the player finds a cave and gets a task to do inside. The task triggered by location is automatically stored in the quest log. In most games it is not necessary to complete all tasks, it is rather important to follow a main task-chain with an option to choose side-quests to complete. Since the game world knows "all" about the interacting character, it is easy to tailor tasks to the area, speed and skill of the individual gamer. Therefore, many games provide a personal and individually specific gaming experience through personalized tasks. This concept could be implemented in education, using sensors to collect data about the student's learning progress. By adding the possibility to sense environmental information (and to design triggers for tasks) or other variables of the student's situation, this game-experience of adapting and personalizing individual tasks could be simulated. The information about students' performance can be collected and analyzed to improve the learning (and teaching) activities. The main goal is to motivate individuals to participate in the learning process, by increasing the fun and playability and creating more lively opportunities for feedback. That can also enhance communication between students and between teachers and students; hence supporting the teacher in his or her teaching approach.

The tasks themselves come with new opportunities. Normally, the teacher creates the tasks and hands them out, but in a task-supportive system, the sensors of the mobile and wearable devices can be used to sense environmental variables so that tasks are triggered according to the situation. An example could be to trigger a specific task based on a student's location, as it is done in games when a player enters a specific area. Tasks can also differ based on variables such as time, temperature, light, acceleration, heart rate or simply on variables obtained from previously

completed tasks such as performance and level of difficulty. We found in [1] that teaching tasks normally possess: Task title, short description, possibility for a long description, resources, (affiliated people, location) and rewards for completion.

This matches the average quest-log entry from games. Some games have richer descriptions, depending on how the game is build and how complex the tasks are. This indicates that tasks can be translated into “quests” and therefore interaction design concepts from games could be borrowed for use in higher education. It should be possible to re-structure educational tasks in a similar, dynamic way as games do.

IV. CONCLUSION AND FUTURE WORK

This work explores concepts from the game world in order to help address the challenge of how to design and distribute learning tasks in a motivational and useful manner. The intention is to increase motivation through the integration of innovative technology into teaching. There are indications that due to their flexibility, mobile devices can simulate the interface layer of the game world to support tasks. For example students in outdoor context can carry this interface to get updated tasks and feedback on their learning. Devices with sensors, for example smart watches, can simulate the game world’s knowledge about context and progress of the student. Game like event triggers can be implemented by using the sensors to get information about the students’ location, speed acceleration and other sensor data. These event triggers can lead to personalized tasks that promote contextualized and meaningful learning. Using sensors can also provide data about the interaction with the tasks. This can include number of attempts to solve and solved tasks; student’s location, speed, acceleration and time. It is noted that especially in outdoor education, students often have to train on their own, without the teacher. With mobile and wearable devices as technology for the quest-log concept, teachers can give and get feedback about the students’ progress. This can motivate teachers to integrate innovative technology into teaching, since it acts as a supportive tool and not a replacement of the teachers.

Future work includes the implementation of this concept for outdoor education including skiing and snowboarding as well as other disciplines like orientation and survival. Teachers should be able to design tasks on the fly as well as in advance as tasks dynamically triggered by sensor measurements. An important work is the usable and meaningful design of the teachers’ interface beyond the graphical component. Cognitive overload should be avoided and regardless of the teaching approach, they should be able to find into the system quickly.

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Paper F:

High-Level Context Information for Tasks in Teaching

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High-Level Context Information for Tasks in Teaching

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Abstract — Tasks are often used in the teaching process. Using mobile and wearable technology, we created an application which uses sensors to support teachers in creating tasks with dependencies and feedback generation. However, in the field of sports education, a variety of non-measurable data can influence the training progress. This high-level context data can be gathered using human input. In this paper, we explain the task-based teacher supporting application and how it can be enriched with high-level context data. We use gamification for data collection and motivation of students. We conducted a survey about the acceptance of three different approaches in the field of skiing education. The survey reveals that the underlying concept is most important, so that the visual representation of the data collection can be exchanged when necessary.

Keywords— Gamification, Human-centred Design, Wearables, Higher Education.

I. INTRODUCTION

Not since long, personal technology and sensor devices have been integrated into sports science and training. In the beginning, rather complex, difficult to attach and expensive sensors were build and used, but recently the availability of affordable and handy sensors increased enormously. With technologies like the fitness trackers Fitbit [1] or Garmin [2], sensor technology for sports and training, or for personal well-being became affordable and usable for regular users.

Despite their raising availability, there is very little evidence about the usage of innovative technologies such as mobile and wearable devices in teaching, not even in sports education [3]. The goal of technology integration is to ensure quality in teaching, through usage of tools at a level on par with recent commercial technologies. However, in many cases few recent technologies are included in higher education teaching processes in general [4], as well as in sports education. We apply a socio-cultural view on learning in higher outdoor education, supporting experiential learning including ICT tools.

Our focus is on the teachers' needs and requirements, to enhance their motivation to use supportive technology to improve their teaching through possibilities of innovative technology. Teachers expressed need for support with task-design, and task-distribution to the students [5]. The use case that was chosen for this work is an alpine sports course, a combination of alpine-skiing, telemark-skiing and snowboarding. The course has naturally occurring training situations without direct face-to-face instructions from a teacher, but with a strong dependency on qualitative tasks that match the students' skill levels as well as varying location conditions.

Our system, the Dynamic Questing Application (DynQ), utilizes the concept of dynamically occurring tasks. Tasks in DynQ have the same structure as they would have without mobile system support. This concept has three major core elements. In addition to regular known task elements (task title, description, notes, resources), its added value consists of dynamic task dependencies, so called triggers, sensor logging and feedback generation (Fig. F.1.). The addition of triggers enables dynamic flexibility of when tasks are supposed to appear for the individual students. Triggers are the underlying factors determining when a task is shown (Fig. F.2.). A trigger can be a state, the student is in (e.g. the student's location) or an achievement (e.g. reached a certain speed), or a combination of both. The sensor logging component can provide measurable data as triggers, which in this project are speed, acceleration, physical location, and time. A trigger can be met anytime, during the students training, or as a result of achievement, fulfilling a certain task or a combination of tasks, for example reaching an extraordinary speed while performing a task. In addition, the sensor logging provides data for feedback generation for teachers as well as students. Collected data can be visually shown in the interfaces of both user groups.

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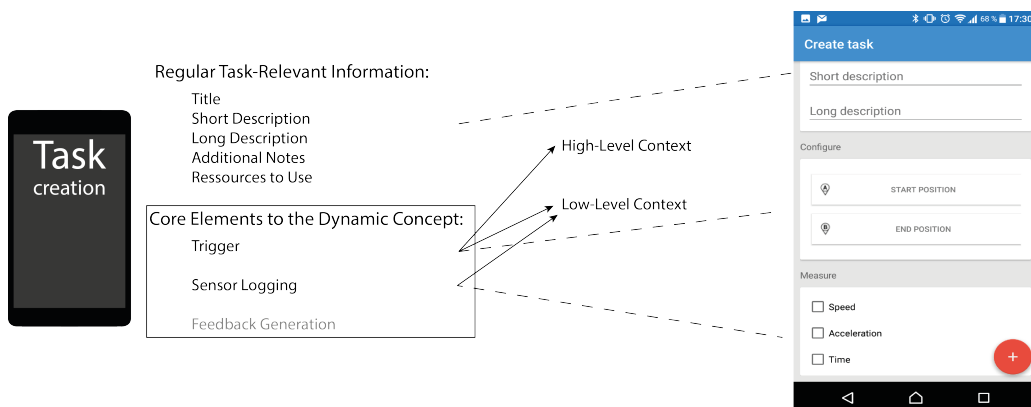


Figure F.1: Task characteristics, core elements, and representation in the prototype.

The system enables the teacher to prepare tasks for different conditions, like

time, skill level and locations, before the teaching. During the teaching, or in the period of self-training, the students can discover new tasks depending on their context (tasks appear as soon as a trigger is met), which supports personalized learning. Additionally, students are supported in creating knowledge through various active experimentations, as a realization of experiential learning. Different students trigger different tasks, which leads to different paths through the tasks. This enables personalized learning to a certain degree, depending on the number of tasks created for different student (high- and low-level) contexts.

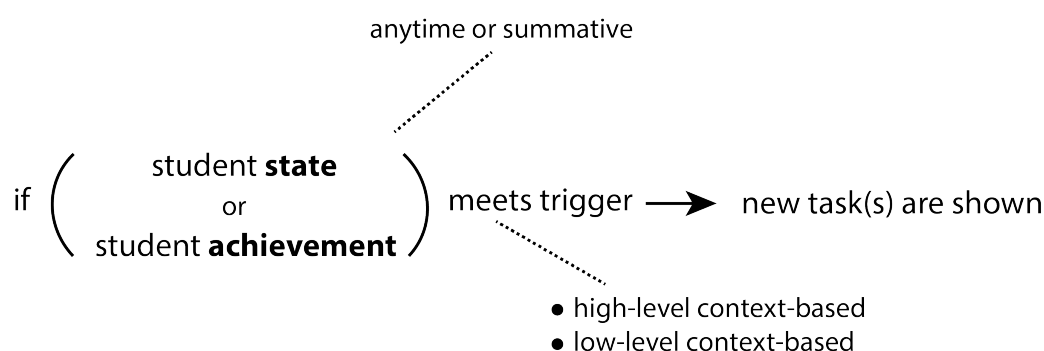


Figure F.2: The basic trigger concept.

There are several possibilities to include numerical sensor data (low-level context data) into the task recommendation process. Likewise, it should be possible to go a step further to include personal, emotional, and other environmental data (high-level context data), that we cannot measure with physical sensors. An example is rock music as a high-level specification of the type of music you are listening to. The corresponding measurable lower context data in this case could comprise of sound intensity, frequency band and more [6]. That is why directly measurable data is called low-level context data, while interpreted or subjective information is named high-level context data. Examples for low level context data in the DynQ project are speed, acceleration, temperature, time, and GPS, measured via a smartphone or a smart watch. Within the concept of task triggering, knowledge about the high-level context can add many more possibilities for individual tasks and personalized learning.

Knowing that the knowledge about the students' high-level context can be beneficial for the teachers and for task creation and distribution, the general problem is the availability of that information. How can such information be gathered? There are approaches on how to automatically interpret measurable (low-level context) data in a qualitative way, to make conclusions about the students' high-level context. However, in our approach, we would like to concentrate on the collection of



information from students themselves. For that it is important to know what type of information is needed, when and how often, how this is shown to the students and how it can be motivating for the students to make the extra effort to provide this information regularly.

To design a solution that is perceived as useful, we follow the human-centered design process [7] to understand the user's context, especially the teaching situation and approach. From that context, we derive the needs and requirements towards a supportive teaching tool. Firstly, sport and training relevant high-level context information and its integration in the educational context must be identified. Secondly, possibilities to motivate users to input their information within a task-based application have to be found. It is assumed that users should be motivated to participate in regular collection of high-level context information. Probably gamification or additional games could serve that purpose, but we could not find literature on how and if the users would accept that approach. Therefore, a survey was conducted to research the acceptance and opinions towards such a solution.

Chapter two introduces related work including the relevance of high-level context information. Pet-based mobile games (or game elements) are introduced as motivating solution within e-learning systems. Chapter three addresses relevant high-level context information for our use case, introducing the enriched task-based concept and how games and gamification can be used, as well as the results of the gamification acceptance survey. After that, the last chapter summarizes and concludes our work.

II.BACKGROUND AND RELATED WORK

The usage of context information was evaluated in other domains such as mobile news services. The conclusion was that a context-aware and content-based recommendations may result in a higher user satisfaction [8].

There are attempts to interpret measurable sensor data (called low-level context information in this paper) to make assumptions about the high-level context. This, however, is not the focus of our approach. Instead, we assume that non-measurable high-level context information can be provided by the user. Therefore, our main concern is how to build up the motivation to do so. It is common to use "human input" for data gathering, especially for high-level contexts which cannot be collected by sensors or can hardly be computed from other information sources. Questionnaires are a regularly used data gathering method to get information that cannot be obtained by physical sensors. The problem at hand consists of how to motivate people to provide information, in a short and long run.

The project by [10] solves the motivational problem by providing a competitive image comparison game in order to motivate users to put in the geographical relevance of images. This project combines a game with a serious context, to motivate its users to provide information which cannot be obtained otherwise. Two people are competing in a web-based and multiplayer game to collect human knowledge about the geographical information and topic of the picture while they were enjoying a competitive game. Even though the approach was not designed to get high-level context information, it provides evidence that combining games and serious contexts has been done previously to motivate users to input information.

When it comes to motivational games in educational settings, only a few educational context-based games can be found, including location-based games. The authors in [11] considered location in designing an orientation game to support learning in a university setting. They proposed tasks of different types, connected to different settings (significant place tasks, people tasks and event tasks). However, the people, place or events are not triggering the tasks, but they are connected to the tasks goals. For example, they must find a place, instead of having a task triggered by exploring a place. There are different types of educational mobile mini-games and pet-oriented games addressing users' affection and the ability to maintain long-term motivation [12]. Different approaches can be found in the category of pet-oriented games such as pet-nurturing, pet-collection, pet-competition, and pet-training games [13]. In the work of [12], the pet is directly connected to learning attributes and takes the roles of a reflector, motivator, and sustainer. The pet's nurturing attributes (age, gold, hunger, health, and emotion) are the transformed wrappings for cognitive aspects (remembering, understanding, applying), affective aspects (confidence, interest, and effort), and social aspects (reminding and helping) [12]. This way the pet's attributes are directly related to the learning process. In our work we focus on the connection between the visual attributes of a (monster) pet to provide additional motivation for the frequent input of context-data, which then is used in the learning and teaching process. Based on that example of connecting pet attributes to the application goals, we propose sample variables that connect the monster attributes to the high-level context information that should be gathered.

III. HIGH-LEVEL CONTEXT INFORMATION FOR THE USE CASE OF ALPINE SPORTS

3.1 RELEVANT HIGH-LEVEL CONTEXT INFORMATION

In sports and training high-level context information can have a central role. Physical and mental exhaustion and emotional stress can lead to a much lower achieve-

ment, which can then be inherently be explained by those factors. However, physical sensors can only measure “low achievement” data without the context of knowing the reason for the low achievement. To display low achievement, without the context of other important metadata, can be perceived as demotivating by the students. There is a possibility that the student just overcame a major injury or had a huge change in his or her lifestyle. Hence, the relative performance could be much better than the numerical data can state. In addition to that, exhaustion should be one of the factors that determine breaks and training ends. If a student trains in a group, that factor also has an influence on which tasks can be completed and which tasks can be recommended for that specific context. That is why high-level context data or metadata is a great addition to sensor data.

Sports literature suggests that the following high-level context related situations and variables can have an impact on sports performance and learning [14] [15]. These high-level factors can be grouped as follows.

Psychological

- Anxiety, depression, psychological well-being, stress, aggression
- Emotions, feelings (Negative feelings: lack of fun, guilt related to potentially hurting opponents), enjoyment
- Personality/ personality dispositions, self-awareness
- Self-confidence, expectations, self-esteem
- Arousal
- Feedback, reinforcement, (intrinsic) motivation
- Cognitions and worries (Fear of failure, making mistakes, lack of success in competition, athletic inadequacy, lack of competitive readiness, potential problems during competition, self-doubts about talent, perfection-ism)
- Addictive and unhealthy behavior: Eating disorders, substance abuse, addiction to exercise
- Contextual elements: Sport type, importance of competition, playing a particularly difficult shot (perceived level of difficulty), performance oriented motivational climate

Social

- Goal setting, group goals

- Group/ team dynamics: Competition, cooperation, cohesion, leadership, communication
- Interaction with other performers, communications problems, (lack of) social support, interpersonal conflicts

Tactical

- Feedback, reinforcement, (intrinsic) motivation addressed by the trainer/ coach / teacher
- Timing of training entities

Performance

- Burnout, overtraining
- Performance expectations

Technical

- Factors within the student's technical abilities, accuracy of techniques

Physical

- Injuries
- Physical or mental difficulties (Coping with injury, maintaining physical fitness, weight control, dealing with sore muscles)

Others

- Hassles within the larger sport context: Political bureaucracy, financial demands and costs, time demands and costs, accommodations, facilities, food, transportation

We argue that knowledge about these high-level factors, even if only just a few of them are regarded, can be beneficial for task-choice and teaching approach. Students can get better recommendations for their individual learning approach and teachers can get richer feedback and the options to make more diverse tasks for a variety of students.

3.2 DYNQ: THE DYNAMIC QUESTING ENRICHED CONCEPT

By adding knowledge about the student's high-level context, triggers can be much more individual and can provide a personalized learning experience. The goal is to get high-level information by encouraging users to regularly provide and update the information and changing variables, if they notice any changes themselves. The core concept of "trigger → sensor logging during the task → feedback (for the teachers)" does not change, but it gets richer in a sense that triggers can be numerical, measurable sensor data or high-level context data provided by the users. The problem is not only how to get high-level context information, but also when, through what, which reminders are important, which data is central and how long is the given information valid? For this concept, the exact data (which type of high-level context information) is not that crucial as long as teachers can work with those factors in their teaching. For the sake of our example, we pick the following factors from different factor-groups: exhaustion, accompanying people, and emotional state. Accompanying people can be an interesting information for tasks and training methods that require two or more people. In the snowboarding use case, this can be the task to learn how to jump over small obstacles. The partner of the student doing the task has to place an item on the slope, slightly ahead of the student and the student tries to jump over the item. Roles can be switched in such a way that the one in front can place another item. There can be different approaches on how to ask the students for their in-put: random asking, contextual with a directly linked reason, all information asked at the same time, with time delay, only some for some contextual tasks, depending on a valid timeframe or free by the user's own choice to provide or update data.

If a student sets the exhaustion to "very high", a task can be adapted to a simpler version. Alternatively, stretching or a break can be recommended, depending on the time of the day and how long the training session should last. Such feedback can help teachers to adapt individual training schedules, if the teacher gets to know that a student tends to be very exhausted after a short period of time.

3.3 GAMIFICATION FOR HIGH-LEVEL CONTEXT DATA INPUT

Before we can decide on the concrete game design elements to be used as gamification, we need to frame the actions that should be supported through gamification. Motivation for the initial input of information as well as for the continuous provision of information should be enhanced.

1. **Initial data input:** before the start of a new lesson, initial data input is need-

ed. To start the application and task recommendation, updated data is required.

2. **Re-entering of data:** Users need a hint that information is needed. The user must be made aware that he/ she has to take action.

In case there is no further specification regarding how often and why information becomes invalid, it is assumed that the information has a limited time of being up to date. The exact specification of valid time frames lies beyond the scope of this paper. Different information may need different update schedules, which also helps to prevent overload on the user's side. All variables are asked for in the beginning of the training, but exhaustion and accompanying people might vary more frequently, than the emotional state. A time frame for those variables can be set.

The next step is to define which game elements, mechanics, or concepts necessary to realize the above mentioned scenario. Prensky [16] describes six elements of game structure: 1. Rules, 2. Goals and Objectives, 3. Outcomes and Feedback, 4. Conflict/ Competition/ Challenge/ Opposition, 5. Interaction, 6. Representation or Story. Partly aligning to the identified game core elements, Haimari and Koivisto [17] describe nine dimensions of a gamified environment: challenge-skill balance, clear goals, control, (immediate) feedback, autotelic experience, loss of self-consciousness, time transformation, concentration, and merging action-awareness. Stott and Neustaedter [18] speak about important game mechanics for gamification, which are: freedom to fail, rapid feedback, progression, storytelling. In addition, game looking graphics can be used, as well as very often used gamification elements like points, badges, and leaderboards, even though they are just a small part of gamification possibilities [19]. Opposite to the other described elements, mechanics, and dimensions, those often-used gamification elements state what to do, but not why, whereas the other elements, mechanics, and dimensions are rather statements about what has to be achieved, to make something a motivational, playful experience.

For the high-level context data input, we want to build upon elements of surprise, based on rules, stating the clear goals of the action with feedback about the progression, or up-to-date status of the data. To prevent usage of the app without having provided the high-level context data, a screen-wide popup (element of surprise) can catch the users' attention. (However, it must be possible to use the app without being forced to do so.) The popup representation has to state that information is needed and why. By accepting the request, users should be guided directly to the information input screen. The representation of those information can vary. We decided to differentiate between a textual approach, a subtle gamified approach, and an additional mini game (Fig. F.4.) to deliver the message and help the users to

stay motivated throughout the usage. However, every representation should follow the same rules, but the level of game elements varies from lower to richer.

In the textual approach, the data is updated without any specific visual or game-like support. It would be supportive for the users to see when they updated the information and how long it will stay valid until further action is needed. The subtle gamified approach can visualize the progression of the input and the up-to-date accuracy (Fig. F.4, middle.). For the mini-game, a pet-oriented game was chosen to address emotion and affection of the users. The “monster-pet” needs data as food and therefore the game visualized the need for data input in terms of a hungry and sad looking creature, which in a sense uses the same numerical background as a status bar, but appeals to users in a completely different way. For the initial data input, however, we think that the monster-pet should start off happy, to brighten the mood instead of eventually pulling the user emotionally down from the beginning. The rule is, that a task cannot be started if its needed specific high-level context information is expired. A notification, popup, status bar in the overview or similar mechanics can make the user aware of the needed update. The textual approach uses a simple user notification that an information is outdated. The status bar approach visualizes a decrease and sets off an alarm if a certain information is expired. That can be visualized in red numbers, greyed-out tasks that are not available anymore or red exclamation marks near the menu in the application (hinting to “something has to be done”). The monster-pet can be shown in a corner of the application, or in a separate screen to visualize the status of its “hunger for data”. Speech bubbles can be used to ask for specific data. The monster-pet’s attributes represent the data accuracy. Via its emotions, it can show that it is unhappy, lonely, and gets hungry, meaning the data expires soon (Fig. F.3.). It is unhappy, asks for food, and the accompanying people are shown as “unknown” when data expires and interaction is needed. To address long-term motivation, constant experience-points can be awarded, whereas feeding the monster can lead to growing and evolving: this can stimulate a sense for collection (collecting all possible monster forms), a sense for the unexpected and a need for exploration, as well as the affection for a growing pet.

Knowing that not only the constant data input could be annoying instead of helpful, as well as that gamification (and even mini-games in education) is a controversial topic, we want to find out, how people react to the concept. Therefore, a survey introducing the three described approaches was conducted.

3.4 GAMIFICATION ACCEPTANCE SURVEY: RESULTS

Since the gathering of high-level context information requires human input and ef-

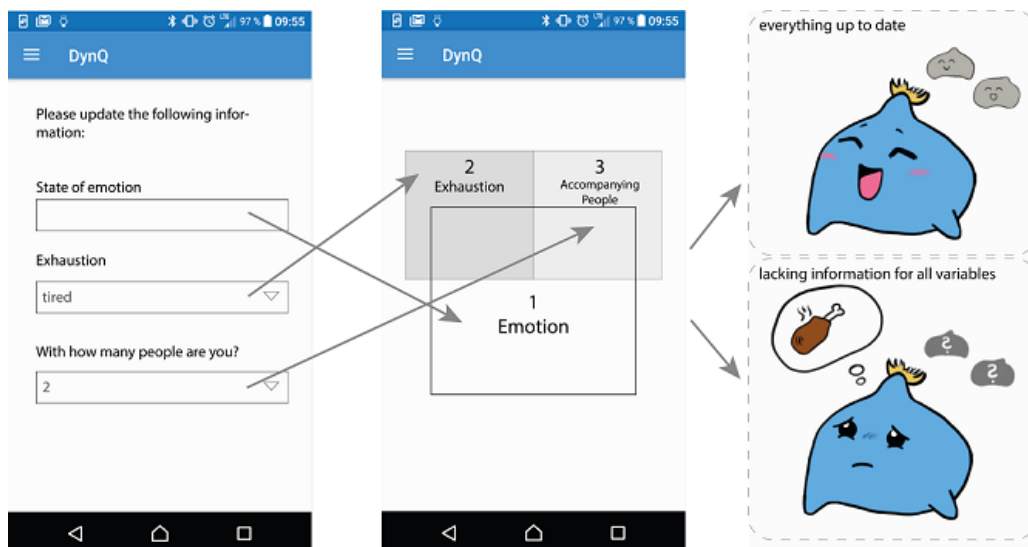


Figure F.3: Display of the three attributes within the monster-pet concept.

fort, we need to know what keeps the motivation up the best possible way. A textual approach, a slightly gamified approach, or an additional pet-oriented game on top of the application. For that, a survey was created to gather information about the preferred high-level context information gathering approach.

The 25 participants were 60% male, 36% female and one did not provide the gender. The majority of participants are 21-30 years old (64%). 8% are below 20 years old, 16% between 31 to 40 and 12% between 41-50. The participants have in total 6 different nationalities (1 American, 1 Australian, 14 Germans, 3 Japanese, 5 Norwegians, 1 Russian) and are residing in 6 different countries (1 USA, 1 Australia, 13 Germany, 3 Japan, 7 Norway). 20% of the participants are bachelor students, 24% master students, 20% PhD students, 4% associate professors and 32% are working outside of University. Their fields of work and study are spread over ICT/IT, Computer Science Education/ Educational Technology, Chemistry, Ancient History, Engineering, Sales and Distribution/ Administration and 9 participants kept it confidential. 20% say that they do not play any smartphone games, 32% rarely play, 20% play sometimes and 28% stated that they play smartphone games very often. Looking at the answers which games are players, Pokémon Go (Niantic, Inc.) has a huge influence on it. Out of 20 people playing smartphone games, 9 clearly stated that they play Pokémon Go.

The first question regarding the user's motivation asked the participants which of the three options they would find most appropriate. Taking into consideration that game elements in a serious context might not be accepted, a version with fewer obvious game elements can be chosen. The same mechanic and purpose the mon-

ster serves in the monster game can be replaced with other visual elements. Two other options are a textual visualization of the information “you need to update your data” and a graphic representation in form of a status bar. These options use the same core mechanic (to motivate the users by showing the need to update the data), but represent it in a less “gamy” way. The three options the participants were given to choose from are: Would you “1) be motivated to provide ca. 5 minutes of extra work to put your information in, because it benefits your learning?”, “2) like to see your information status to be motivated to keep it updated?” or “3) like to get an additional game to make the information providing more fun?”. Most participants answered 2) with 60%, 20% answered 1) and 3) each. The next question visualized the same question. Participants were asked which visualized approach they would prefer (Fig. F.4.). The outcome for 2) was the same (60%) but more

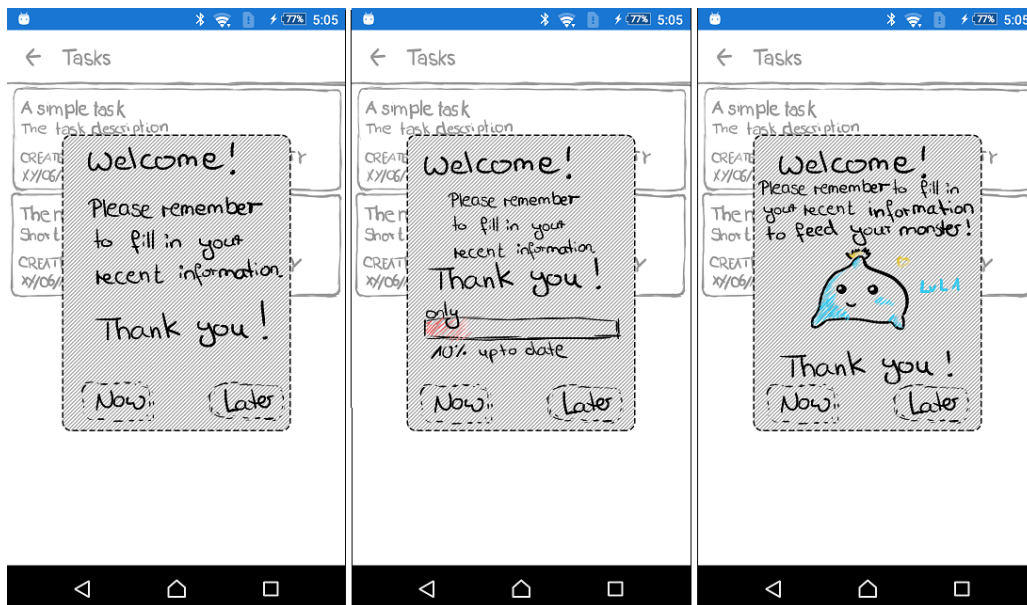


Figure F.4: 1) textual visualization, 2) status bar visualization, 3) monster-game visualization.

people chose the game (32%) over the textual approach (8%). The next question tried to clarify why the game approach was neglected. Multiple answers were possible. The majority of people who did not choose 3) “the game approach” stated that they think it’s childish (35% out of the people who chose 1 or 2) and that they prefer serious looking applications for a serious context (35%). 24% said that they are motivated enough without game elements, but 24% also stated that they would use it with game elements even though they would not need them. In addition, the fear of getting addicted to the game and forgetting about the original purpose of the application was stated (12%). Additionally, people could comment more in de-

tail why they chose either 1), 2) or 3). Positive comments about the monster-game approach mainly mentioned that fun and the cuteness of the monsters keep them motivated and help them not to feel too serious and stressed. On the other hand, many comments stated that a status bar would suit the context better, and that game elements are inappropriate. The status bar or similar graphical approaches seem to be very welcome for most people. “It shows me how much effort I put into it”, “I can see my data clearly”, “it’s concise and to the point”, and “I’m used to this type of visualization” support the neutral graphical status visualization approach.

IV. CONCLUSION AND FUTURE WORK

High-level context data is important for sports training and education. It can provide the teacher with richer insights to the student’s context and reasons for performance issues. A task-based teacher supporting app would benefit from that knowledge, providing the teachers with a richer choice for task creation and feedback. Many respondents to the questionnaire agreed on the benefits of high-level context data and showed intrinsic motivation for data-input. The difference between users liking the pet-game approach versus people feeling annoyed by it was noticeable. The most common reason against the pet-game approach was that people expect serious applications in a serious context. In addition, those participants noted that their intrinsic motivation for well explained data input is already quite high. Therefore, they perceived the motivational pet-game approach as in-appropriate. On the other hand, some participants stated that they would enjoy a non-serious element within the seriousness of sports education. The general conclusion would be that the core concept should be designed in such a way that the visual representation, from textual to subtle gamification and pet-oriented game, can be exchanged at any given moment to suit the user’s needs.

Future work includes an implementation for the core concept and how the different high-level context information types can be represented in all visual approaches and then linked to the tasks, so that they appear in the same way as sensor based triggers for the teachers. To give an example: “If a student can reach 30 km/h and is not exhausted yet, the student can proceed to a different location, where tasks requiring higher speed can be conducted.” In addition, it is important to note that teachers can make use of different types of high-level context data. They are not limited to the three sample types in this paper. In any case, there should be various ways to represent the information status in a user understandable way. The designer needs to be aware of the challenges that come with the variety of representation possibilities within the pet-game. The chosen pet’s attributes must be understandable

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and meaningful for the context of use, as well as connected to the high-level context variables they should represent. The link between the pet's attributes and the original meaning can easily be lost. The high-level context information gathering approach should be designed as an addition and support to the task-based teaching support tool.

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Paper G:

Mobile Technology for Learning Tasks in Outdoor Education

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Mobile Technology for Learning Tasks in Outdoor Education

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Abstract — Mobile wearable technology gets increasingly common, especially in the fields of application like fitness, health, and sports. Wearables can support and motivate their users by keeping track of their performance, and providing individual feedback. There is a high potential for this technology to be useful and meaningful for sports (higher) education as well, especially in learning task design and distribution. The embedded sensors can collect data and provide additional feedback information about the students' performance and therefore help teachers as well as students. In this paper, we present research work on a task management system for teaching outdoor winter sports. A high-fidelity prototype was designed and tested both on the technological and pedagogical aspects. The results indicate that teachers are motivated to use this system because it supports their current teaching approach. The system does not only provide a meaningful context of sensor usage in higher education; but it also gives teachers new opportunities for designing their teaching with consideration to real-time student performance.

Keywords—Human-centred Design, Wearables, Mobile Teaching

I. TEACHING SKIING AND SNOWBOARDING

Outdoor and sports education is a broad field. Courses are different and require special equipment, places and have specialized needs and requirements. Even though our focus is on outdoor education in general, we chose the course of alpine sports and the teachers of this course as primary use case and stakeholders, respectively. In this context, it is important to us to describe the course used for user testing, shaping and influencing our research and system design. The course we are using for the user testing comprises of three disciplines and is structured as follows: All three disciplines (Alpine Skiing, Telemark Skiing, and Snowboarding) of the course are taught in Hemsedal, Norway, over 5 days. The students are grouped with different teachers to complete all three courses one after another. The 5 days are structured as follows:

- Every group must do every discipline for one day.

- Every day (for the first three days) three groups of students practice in parallel the three different disciplines.
- Every discipline group is split into beginners and advanced students, which totals to six groups in parallel.
- After three days, each group has completed every discipline on a basic level. On the fourth day, they choose one discipline to specialize more into and follow a teacher for it.
- The last day is open for training in all disciplines. The students are expected to acquire a minimum of basic skills about the disciplines and about how to teach those disciplines to other students.

Teachers and students meet up during a joint breakfast. Teachers plan the day and check with other teachers about slope conditions, ideas and their plans. After that, all teachers and students meet outside, in front of the slopes and split up into the three different courses (alpine, telemark, snowboarding). Each discipline has 2-3 teachers and within the discipline groups, students are split into beginner and advanced groups. That makes 6 groups in parallel. If there are more than 2 teachers available, usually more teachers follow the beginner groups to support them better. Figure D.1 shows the different processes within the group of all teachers and students (dark grey), one discipline group (light grey) and task in one subgroup (beginner, white). The structure of teaching is similar in every group regardless of their skill level (beginner or advanced students), just that advanced students progress through the same tasks faster and can explore more complex and advanced challenges. Within one group for one day, the day is structured into lessons, including theory and practical tasks training, self-training, and a lunch break, as shown in Figure D.8. The students start the day with the theory, often directly connected to practical experience, go over to training under the teacher's observation and have mandatory self-training after that. The steps one to three are repeated after the lunch break. Within these processes we aim for teacher and task support, using sensor and mobile technology. For that, we need to analyze the type and structure of tasks in more detail.

Learning skiing or snowboarding requires learning different steps. The literature as well as the course teachers use a hierarchical structure of learning tasks, which broadens in the higher skill regions, meaning that more different directions of training can be taken, that require specialized and structured tasks. Skill level and tasks are also closely related to where a learner can go, in terms of which lifts

he or she can take and which terrain is needed. The terrain in alpine sports is often indicated using colors (green, blue, red, black, (double black, triple black)), where multiple possibilities for the specific terrain difficulties can be chosen. In many cases, it is not necessary to have a specific slope, rather a difficulty, so tasks only have to indicate the terrain color / difficulty. In other cases, the teacher chooses as specific location, that cannot as easily be replaced on other slopes. The learning and teaching conditions of alpine sports vary a lot. Even the same track or slope can be different depending on the time of the day and the weather. Teachers decide on tasks depending on the students' skills, the location and terrain (weather conditions) and previously learned tasks. Every group needs to go through the basics, but every group is different and learns at a different pace. The teacher needs to adjust the tasks according to the group's needs.

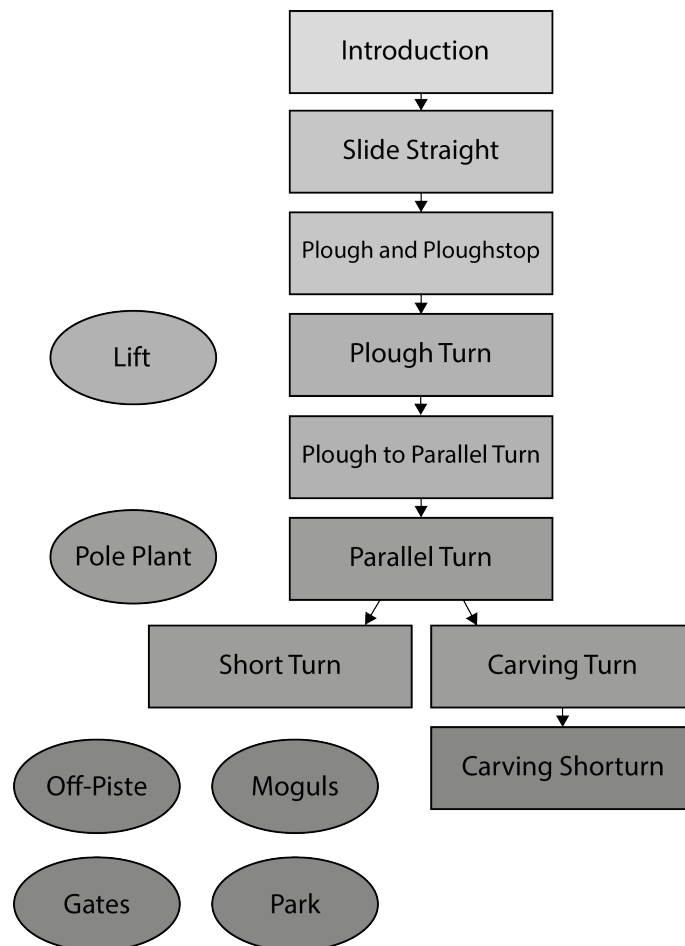


Figure D.1: The hierarchical task progression concept within alpine skiing (Harman, 2010).



II. WEARABLES IN SPORTS EDUCATION

Like e-learning systems in education, mobile sensor technology and wearables are increasingly emerging in sports and fitness (Borthwick, Anderson, Finsnes, & Foulger, 2015). To analyze the potentials of wearables in education, and to determine possible use cases, we first looked into what kind of sensor devices, in this case wearables, emerge into the market in the field of sports related subjects. Then we analyzed potential usage and purposes of sensor tracking for sports in general. Even though there is lack of extensive research in this field (Bower, Sturman, 2015), this chapter attempts to explore the use of wearables in (sports) education.

Beginning with the topic of sensor devices or wearables in general, we found that there is a variety of available consumer devices referred to as wearables on the market. Currently, those devices can be grouped into the following main categories: Wrist bands, waist bands, scales and smartwatches. These wearables can have several types of sensors. The most common sensors can measure location through Global Positioning System (GPS), time, weather (air pressure, humidity, light/darkness, temperature), movement or speed (GPS and accelerometer), heart rate (Stahl, An, Dinkel, Noble & Lee, 2016), heart rate variability and galvanic skin response/ skin conductivity (GSR) (Swan, 2012). The interpretation of the data is often presented as activity level of the user showing steps taken, calories burned, distance traveled, pace/speed of the workout, as well as heart rate intensity level. Many devices can inform the users about too long inactivity times (Swan, 2012) and can include wearing detection, sleep detection and gesture recognition (Bieber, Haescher & Vahl, 2013). This form of data collection and interpretation leads to a quantified self of the users (Swan, 2012).

Research has shown that there are also other, more specific possibilities to use wearable sensors. In the research work of Kalyanaraman, Ranjan & Whitehouse (2015), it is shown that wearable sensors can help to track climbing routes, instead of taking pictures to analyze the exact route taken. Another example is the research of Nylander, Jacobsson & Tholander, (2014), where wearables are used to explicitly analyze and enhance runners' techniques.

Research about the use of wearables in education is still limited. However, we see a lot of potential in the usage of sensor- and wearable devices, which are not yet widely used in education, but available in terms of hardware. For instance, Alhonsuo, Hapuli, Virtanen, Colley & Häkkinen (2015) found that the fact alone, that students (kids from a hockey team) thought they are tracked with wearables led to a better performance in hockey. Further on, like de Freitas and Levene (2003) pointed out, we can argue that wearables can be used for more than just the access to lecture

material while moving. For example, glasses can be used to augment a real place with information or offer virtual trips. Recently, research on wearable glasses in education was conducted (Coffman, Klinger, 2015; Wu, Dameff & Tully, 2014). But unlike this paper, there was no focus on sensor measurement or interpretation. To the best of our knowledge, the existing work in the field of wearables or sensor usage in sports suggests the use of tracked information to improve techniques, motivation and effectiveness. There is lack of possibilities to suggest (or trigger) real time sports activities based on tracked data. Usually, the information is gathered and shown to the user directly, but there are no suggestions of subsequent actions based on that information. We want to use the information gathered to personalize and improve the task flow for students during sports and outdoor education. Additionally, teachers should get an improved overview of their students' progress. This research focuses on a tool for an alpine skiing and snowboarding course as a proof of concept.

III. METHODOLOGY

In this project, we use the human-centered design process following ISO 9241 - 210 (ISO, 2010). Therefore, the research is design-based, highly interactive, iterative and flexible (Wang & Hannafin, 2005) and involves the users at every stage. The research outcome described in this paper is based on two testing phases. In terms of HCD that means, that we are in the fourth iteration of the process. As described in Figure D.2, the first prototype used for testing within the use case of sports education is the outcome of the enhancement of the preliminary prototype (Schulz, Isabwe and Prinz, 2016) for the special use case of outdoor education, enabling the useful application of sensors. Combined with the input of a game analysis and the concept of task triggering, we developed a second prototype. That means, the prototype itself was developed from two different perspectives. One is the analytic perspective of how tasks are designed now and the other perspective is how tasks are represented in games and which aspects could be used from this structure. These two sides of analysis come together at this stage of development. This second prototype was the basis for the first round of user testing and evaluation during the snow sport courses. The main goal was to further define requirements and to identify how the sensor data can meaningfully be tailored to teaching tasks. After the first round of testing and redefinition of user needs and requirements as well as preliminary testing it in an outdoor teaching situation, prototype three was developed. That prototype was the basis for the second round of testing to improve the concept and design of the tool itself.

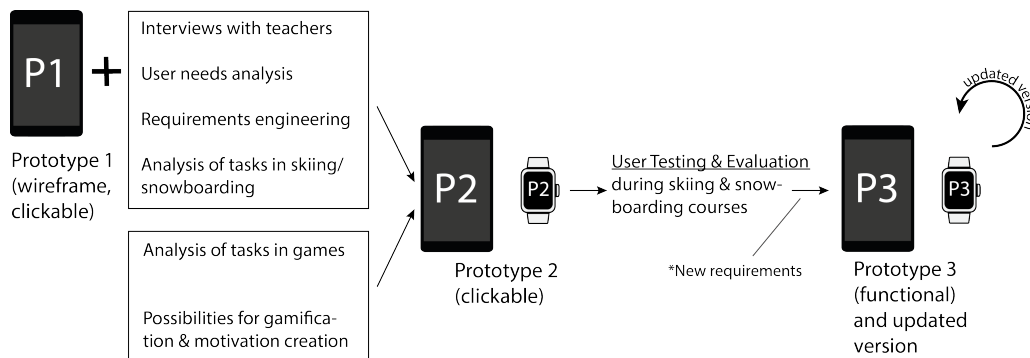


Figure D.2: Adaption of the HCD process within this project phase.

The main target user group for this project are teachers in higher education from the field of outdoor sports education. Additional users are the students participating in the three selected courses alpine skiing, telemark-skiing and snowboarding. Sports students from the University of Agder (UiA) have to complete those three courses. These courses offer a rich variety of tasks, which can be supported through mobile technology. The courses feature lectures and practice tasks with and without the teacher. To analyze the current teaching situation, the teachers' activities were video recorded and one of the authors made direct observations while participating in the course alongside the students. For further use-case analysis and requirements engineering, the teachers with their courses were filmed on the slope. Analysis of the use case is important to get a picture about how the teaching works now and where the best possibilities are to support the teachers, without interrupting their teaching flow. This analysis was done to identify options and possibilities of how to enrich the teaching situation with sensor technology. It is interesting to find out if sensor based task triggering could lead to innovative educational solutions. For this, we had to observe how and when the teacher encounters specific context conditions (e.g. location or weather) and decides to give specific tasks. Students were asked to try out the system prototype during the free practice period. The student participating in the testing got the mobile system consisting of a smart phone and a smartwatch, but students watching the participant were also invited to give comments. In this phase, the interaction with the devices was tested: what is possible and what not and which sensors can be measured. Six main teachers (two from each discipline) were included in interviews about the teacher's' side of the prototype, with a strong focus on the task creation process. In total eight teachers from outdoor sports education participated in the testing (i.e. six main teachers and two additional, spare teachers). Additionally, a focus group discussion with all eight teachers was held. In the second round of testing, seven teachers were included



in a survey, individual interviews including the functional prototype (for task creation) were conducted, as well as observation and testing during the teaching on the slopes.



Figure D.3: (1) Prototype 2 worn by a student on skis, (2) Mobile device and smartwatch, (3) Smartwatch for interaction with the system.

IV. DESIGNING FOR LEARNING TASKS PROCESSING

The concept and idea is based on a very basic problem in higher education. The use of technology in teaching is still rather rare. There was a need to find out, how teachers can be supported usefully. We found that the teachers want to keep a close interaction with the students, seeing them progress. The feedback and communication is also important. The expressed common concept used in teaching was task design, distribution and feedback as described in our previous work (Schulz, Isabwe and Prinz, 2016). Tasks play a vital role in the use case of outdoor education, especially in skiing and snowboarding. They are conducted during the time, when the teacher is present and should be worked on in self-practice. The concept design should support the teacher in this approach of teaching using mainly experiential learning. To support that concept of teaching, it is important to know how the course is structured (Figure D.4). Since this concept should support the teacher and not replace her, the focus of support lies mainly within phase 3, the self-practice phase of the students. However, the concept design should be open enough to be able to address all 3 phases if necessary. Therefore, the concept design as well as the specific task design within the concept should not only support self-practice, but also experimentation and reflection during the lecture phases.

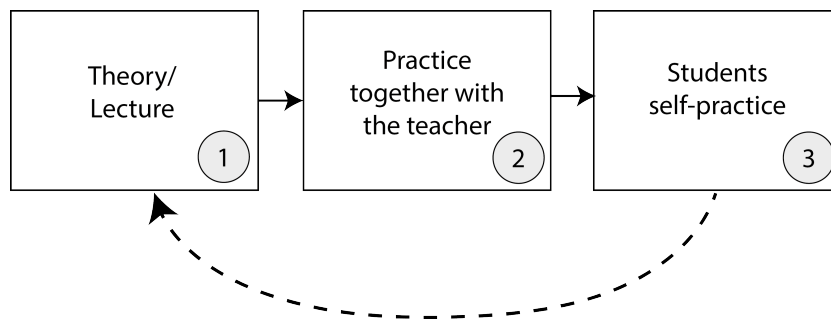


Figure D.4: The three phases within the teaching approach.

4.1 CONCEPTUAL DESIGN

Knowing that tasks have a central role in teaching as well as in many games, we analyzed how games deal with task distribution (Schulz, Prinz and Isabwe, 2016). From the analysis of how games deal with tasks, we found that games have the means to adapt tasks to the users' situation based on their context variables and skills. Adapting these ideas into our Dynamic Questing Application (DynQ) core concept means, it needs to have dynamically occurring tasks offering flexible and on-time task designs and changes, which should support the individual teacher's teaching approach. To achieve that, the concept consists of three major core elements. In addition to regular known task elements, in non-technology supported teaching, the added value is created through dynamic task dependencies, so called triggers, sensor logging and feedback generation (Figure D.5). The addition of triggers enables dynamic flexibility of when tasks appear for the individual students. Triggers are the underlying factors determining when a task is shown. A trigger can be a state in which the student is (e.g. the student's location, physical position) or an achievement (e.g. reached a certain speed), or a combination of both. The sensor logging component can provide measured data as triggers, which in this project are speed, acceleration, physical location (GPS), and time. A trigger can be met anytime, during the students training, or as a result of an achievement, fulfilling a certain task or a combination of tasks, for example reaching an extraordinary speed while performing a task. In addition, the sensor logging provides data for feedback generation for teachers as well as students. Collected data can be visually presented in the interfaces of both user groups.

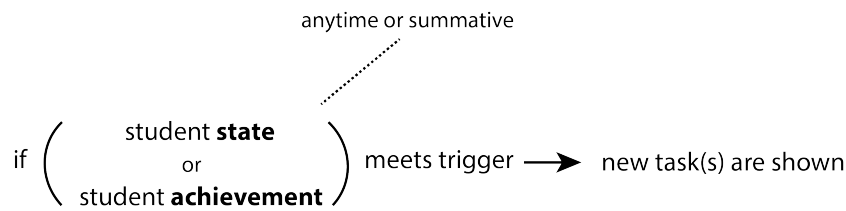


Figure D.5: The dynamic task concept.

The system enables the teacher to prepare tasks for different conditions, like time, skill level and locations before the teaching. During the teaching, or during self-training, students can discover new tasks depending on their individual context (tasks appear as soon as a trigger is met), which supports personalized learning. Additionally, students are supported in creating knowledge through active experimentation, as a realization of experiential learning. Different students trigger different tasks, which leads to different paths through the tasks. This enables personalized learning to a certain degree, depending on the number of tasks created for different student contexts.

4.2 LEARNING TASK DESIGN

The task design in the beginning was inspired by task design approaches for games (title, short description, long description, task progress, affiliated people, resources, target items, target location(s), reward(s)) as well as commonly known task elements in teaching (title, task description, related resources (books, paper, links), expected outcomes). However, during the user testing we found that some aspects from games were not as useful, but others were required. The task structure is shown in table 1. Of course, a learning task belongs to a course. Tasks should be easily findable and identifiable by the users; therefore, a title is important. In the description, everything that students need to know has to be noted. This includes everything from task steps to hints, problem solving approaches and links to resources if necessary. The short description is summarized in a quick glance and can be used on a smartwatch display. The difficulty level is a criterion for students, to help them decide where to proceed regarding the next tasks to be done. Media in this scenario refers to pictures and videos, showing the correct technique or a series of individual techniques to the students. A defined location can be picked via Google Maps, so that students can see where to go, or it can be used as a location trigger.

Teachers have an idea, which tasks can be done when, even in flexible situations like skiing and snowboarding. Tasks must be adapted according to environmental conditions as well as individual student's progress; that's why tasks have dependencies. The dependencies are tasks done previously, a specific time, a specific

Table D.1: Snowboarding beginner task sample following the task characteristics.

Course:	Snowboarding
Title:	How to stop using heel press
Description	Stand with your entire body facing downhill and your board across the incline. Stand with your knees bent, and stay low. Concentrate on what edge control and stopping feels like. Press your heels into the back of the board and lift your toes off the ground very steadily.
Short Description:	Press heels, lift toes.
Difficulty:	Easy
Media:	<image>
Location:	On a gradual or beginner slope.
Dependencies:	Task “skating”, Task “stopping with one foot out”, Location.
Hidden/Shown:	The task should be shown, even if the dependencies are not met.
Badge(s):	-
Which sensors to log:	Number of accelerations, speed.

location or an achievement (measured by sensors). Teachers can decide if these tasks are shown by default, or are hidden, so that only students who meet all requirements, will get to see them. Badges (filetype: image) can be added as rewards for the students, which (their underlying measured and saved sensor data) in return can be used as triggers. For some tasks, sensor feedback is interesting to see for both, the students as well as the teacher. In this case, the teacher decides on seeing the number of accelerations of each student as well as the speed to determine, if they really stopped and how often. The teacher can also find out if students were serious throughout the whole duration of the task or if they just switched to regular snowboarding or in the worst case, were unable to stop.

V. USER TESTING RESULTS

5.1 SYSTEM STRUCTURE

The system structure needs to support the flexibility of the dynamic task concept. Mobile and wearable devices provide mobility and support that flexibility. They also support sensors to measure the user’s progress. Sensor data is exchanged between the watch and the phone, as well as between the watch and the long-term storage, which is a cloud solution (firebase) in our case. The hardware devices chosen for this project are Sony Xperia Z5 (Android) and Smartwatch 3 (Android

Wear, Display: 1.6" 320 x 320 Transflective TFT LCD (280 ppi), Processor: 1.2 GHz ARM Cortex A7, Dimensions: 36 x 51 x 10 mm, Weight: 38 g (watch), 36 g (armband), Battery: 420mAh, Memory: 4GB internal storage with 512MB RAM, Sensors: Accelerometer, Ambient Light Sensor, Compass, Gyroscope,, Charging: MicroUSB, IP Rating: 68). The communication between the two devices uses Bluetooth, whereas the communication between the mobile phone and the cloud storage uses mobile data (cellular network)/ Wi-Fi.

The smartwatch adds two different valuable components to the setup: (1) an additional measuring device (some smartwatches have more and other sensors than mobile phones have, for example heart rate sensors) and (2), an alternative interface for interaction. In this special use case, an additional interface for interaction is needed. During training, a student rarely uses her phone since it can easily be lost and the complex interactions on the smartphone screens can be affected by the cold temperatures (around -15 degrees).

There are two user roles within the system, the teacher and the students. The teacher is the task creator, who has access to the task (and course) design interface. The students can select courses and get the tasks assigned to the course. The teacher can decide which data is tracked on the students' side while performing a task and after finishing a task, feedback is sent to the teacher.

5.2 TASK AND SENSOR DATA

From the user testing we found that the recorded data must be specified. In creating the tasks, the teachers have to define which sensor data should be recorded. The available sensor data or recordings are time, acceleration, speed and location (GPS). But only stating that "speed" or "acceleration" is recorded does not help the teacher to understand the usefulness of it and the possible feedback. For preparing data visualization, we need to specify what exactly has to be recorded. Teachers expressed interest in:

- Average speed during a task
- Maximum speed during a task
- Highest acceleration (for some tasks) over a certain amount of time
- Number of accelerations
- Time spent doing a task/ completion time

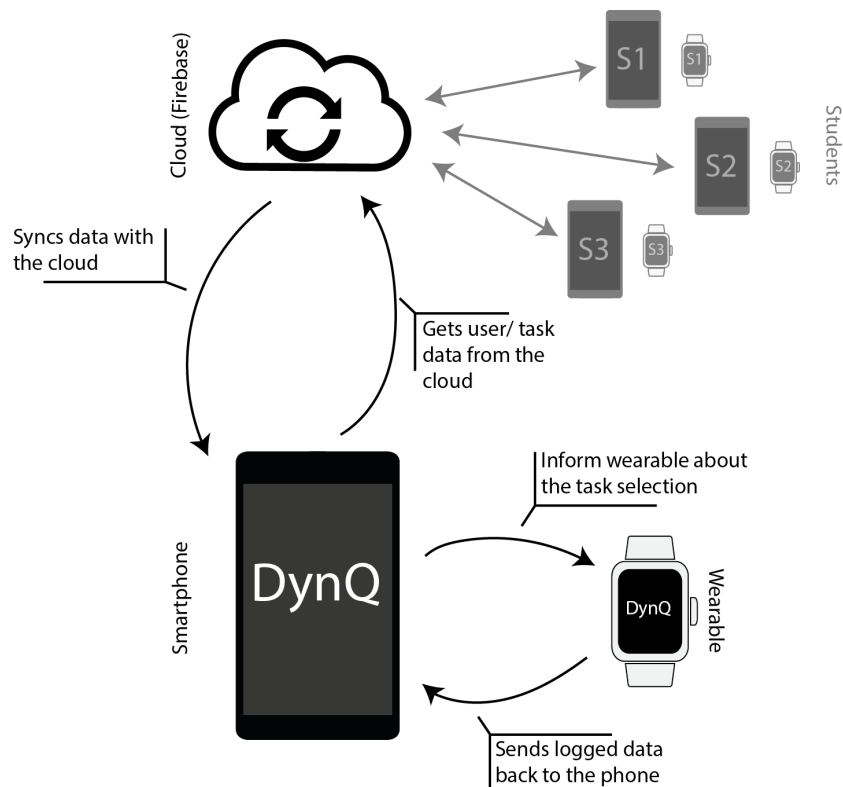


Figure D.6: System structure of DynQ.

What is recorded and saved, is directly related to the available triggers. We found that giving the full freedom of all theoretical possibilities to use sensor data as task-triggers is too difficult to handle for teachers. Therefore, we predefined the trigger possibilities, giving teachers a limited but defined choice. Those triggers can be:

- The student can reach a certain speed (in km/h) (comparing to the saved maximum speed reached by a student)
- The student can maintain a speed over some time/ minutes (using previous speed data compared to their timestamps, or directly comparing to the average speed data)
- The student stays under a certain speed
- The student has spent a minimum number of hours/ minutes for self-practice (related to time in task(s) total)

5.3 USER INTERACTION FLOW

Designing for a usable and as useful perceived application, interactions with the most important workflows must be short and understandable. In this case, the most

important workflow is the creation of tasks. The teacher should find it right away and directly enter the task creation area. In the early prototype, teachers had to find their course in the list of courses first, before starting to create the task. We found that the affiliated course is a crucial factor, but can be chosen as part of the task creation process.

Our initial task creation interface featured many separate descriptive (text) input fields for specialized task features such as “affiliated people, short and long description, and resources”. We found that teachers were rather confused about those specialized fields. If teachers are to describe those task features, they can do that in a general open descriptive text as well. From that we found that the descriptive text field should support text layout and structure, so that teachers can visualize differences in the description and highlight parts of it.

As described in the task and sensor data chapter, the teacher needs to be able to select what data should be measured and saved during task execution. The interface has to offer selection possibilities, and a blank space reserved for specialization. Affordances about the selection possibilities and the need to define them have to be perceivable to the users. If a required field is left blank, the sensors cannot measure, so a task should respond with an error message prior to saving.

There is a critical factor about how the task dependencies are integrated into the interface and how the teacher can interact with them. As described before, the interaction possibilities need to be limited, but also kept quite open in terms of combinations. This implies, that the sensor usage, what is constantly measured and saved by the sensors, is limited and has to be pre-defined. From these pre-defined options, in theory, the teacher should be able to select as many as necessary for the task to show up. The dependencies do not only feature what is perceived as sensor data, but they can also build upon components of (day) time, hours spent, location reached (GPS) or (previous) tasks done. All this information must be saved for every student to allow its usage during the self-training part of the teaching for individual task triggering.

5.4 ADDITIONAL REQUIREMENTS

Creating location-dependent tasks must be supported visually. Teachers expressed the need for a map integration to pick start and end location for their tasks. For this, the integration of Google maps was done, since it is commonly used and known by most users (Figure D.7, part 3 and 4).

The teachers expressed a need for enriching the task with multimedia content, such as pictures, gifs or videos for demonstration or explanation purposes. In skiing

and snowboarding, the learning progress highly depends on observing and understanding the correct techniques. Most teachers explicitly mentioned that speed and acceleration are not in focus within the original teaching approach. The most important thing is how students move their body and for that, a teacher demonstrating how it is done, or a video is helpful. It is about the practicing of the correct technique and that students realize the difference between what they think they are doing versus what they are actually doing. This led to the requirements about integrated recording of videos as feedback to the teachers, as well as self-evaluation, demonstration and explanation material for the teachers.

Another aspect, that the system could support would be about finding lost students and checking up on missing team members. One snowboard teacher expressed that “Using the drag lifts is a test. Usually, I lose at least one student during that task.” Having marked locations, meet-up points or being able to check the location of students would help in situations like that.

5.5 LEARNING TASK LOCATION

After the first user testing, we realized that the location of the learning task is central in this project. Therefore, in the updated prototype, we implemented optional start and end locations for tasks. The location (GPS) is the most used and understood sensor during the testing of the teachers’ task creation process. By clicking on a button to add the start location, users are sent to Google maps, showing their current position. The experience of selecting a position on the mobile device was different from how it can be done on a PC. The map has to be moved directly under the shown selection marker, whereas on the PC solution the marker can also be moved. Participants were confused because they had prior knowledge of using Google maps. The end location was selected the same way, using a different button next to the start location in the interface. To confirm that a selection was done, the buttons showed the coordinates of the selected location as feedback. We found the following issues and requirements from user testing.

- The marker should be movable.
- The end-location selection should show the map of the start location, not again the user’s current location.
- Both start and end-location should be visible on the final map.
- Start and end-location should be movable within the same map.

- The selection should be visually shown as a map in the task creation interface, instead of its GPS coordinates.

Since there is a difference between the sole function of informing the students about a task location versus creating a hidden task that shows up upon reaching a specific location, the interface must provide understandable guidance to create both. If the start and end-location (or only the start) is chosen, an additional interaction possibility must enable to show/hide a task. Further on, optionally another marker can be used to indicate where and in which radius the task should pop up at the user's task list and as a notification on the watch.

Another possibility is to enable automated task starting/ending and tracking based on start and end location. If the teacher is interested in the data, it must be possible to automatically start and stop the task based on the students' GPS. It also lessens the requirement of direct interaction with devices for the students, but increases the risk of wrong data due to connection issues and lack of GPS data.

5.6 STUDENTS' OPINIONS ON LEARNING TASKS

In order to know what students may see as important regarding the learning tasks, we asked them about their experiences during the courses. 21 students provided written feedback about their course, skill level, the best, worst and most surprising experience in learning with the tasks on the day. Students from alpine skiing (5 in total, 4 beginners, 1 advanced), telemark-skiing (7 in total, 7 beginners, 0 advanced) and snowboarding (9 in total, 6 beginners, 3 advanced) answered.

Students in every discipline could identify basic tasks from their course days. They agreed on the positive impact of feeling the progression of learning new skills based on the tasks given by the teacher. Other positive aspects include learning a surprising new technique, understanding and mastering techniques based on the feedback and theoretical input from the teacher. There are indications that even advanced students got a new insight into techniques they have used for a long time. The challenge of learning something new in a short timeframe, connected to the progressive tasks by the teacher, was appreciated by most students. Directly related to that, the individual feedback, if any, was described as very helpful and positive. One student described a challenge given by the teacher as "almost impossible", but then managing with encouragement from the teacher as an impressive experience. Additionally, it was appreciated that advanced students were challenged to get out of their comfort zones, to try new things in an active learning environment.

Negative experiences were mainly reported as being connected to long waiting times during very cold and windy weather conditions. With students group sizes

up to circa 15 students, there could be some waiting before using a lift (waiting for everyone) or after using a lift (regrouping). There could also be waiting times during the practice, since students (especially the beginners) needed to go one by one, after each other. Even on the sunny days, the long time in the lifts left everyone freezing. Long waiting times during practice are especially problematic for the snowboarding beginners. They must sit, whereas skiing students can easily rest and wait while standing. Other problems occurred when there was a mismatch between the skill level of one student, the groups' overall level and the tasks a teacher chose for them (based on the group). One student described his experience to be sent to the advanced group. "I should have realized my own limitations. He [the teacher] wanted us to ollie [a snowboard technique for jumping]. That was the worst."

Generally, the tasks given by the teacher were seen as interesting and helpful. The teachers from the same discipline started with the same basics and progressed to more advanced tasks differently depending on the group, location and weather. The challenge that came with specific tasks, to try out new techniques, was very appreciated. Without the guidance of a teacher, most students would not have tried new and challenging tasks, sometimes perceived as scary tasks.

VI. DISCUSSION AND LIMITATIONS

The teaching supporting tool should, in the end, not only support skiing and snowboarding teaching. There are many different subjects taught in outdoor education and we would like to have a core concept that can be useful beyond specialized courses. It is easy to get lost in too specific user needs and requirements. In this scenario, teachers repeated the need for video analysis of the students' performance (recording, slow motion, saving and sending between the different parts). That is beyond the scope of this project, being too specific because of the use case.

The exchange of data between mobile devices requires the use of a cellular network connection. Areas for outdoor teaching are in most cases not covered by wireless local area networks (WLAN), and in some cases, there is no mobile connection either (for mobile data usage). It is important that the devices save the measured data until a connection to the cloud can be established.

In many ways, teaching skiing and snowboarding meets extremes. The weather conditions demand a lot from technology. For example, many batteries discharge quickly and touch screens stop working due to very low temperatures. In addition, users prefer to keep on their gloves because of the same reasons, hence being unable to "naturally touch" the devices' screen interfaces. In general, the users (teachers and students) are heavily packed in clothes which restrict movement and interaction

possibilities. Additionally, the storage for equipment is limited. During training, it is preferable that students do not carry backpacks. Therefore, the technology gadgets should only be carried in the worn clothes; such as a mobile phone is most likely to be. To enable a safer and quicker interaction, we propose the usage of smartwatches (or similar), which could be worn over the clothes as well. The interaction through touch has to be straight forward, since complex gestures just worsen the user experience. Possible interaction through voice can come in handy, when the temperature is too cold to remove the gloves.

Another critical dimension is about the creation of tasks for a whole course. Teachers created tasks during testing using mobile phones only, which caused frustration during the writing process and resulted in using short words in text descriptions. There is a need for a desktop version of the application, to create all tasks needed to support the whole course, with possibilities to copy text from other sources. Generally, easier solutions for formatting and a better overview of long texts would be desirable, to address the lack of overview on a small mobile device screen. However, the teachers expressed that the mobile version is needed to create flexible tasks on the go, during the teaching, in breaks or generally spontaneously anywhere. Some teachers referred to tasks as reminders, or had ideas to use them as general broadcast of information. “Please restrain from training on that slope because of avalanche danger! Use the slope as pointed out here instead.”

VII. CONCLUSION AND FUTURE WORK

In the end, this research tries to solve the problem of technology, especially mobile and sensor technology, not being used and not being considered useful by teachers in higher education. One of the main factors of the low usage is missing usefulness and a lack of context-fitting technology in hard- and software. However, we found that there are many possibilities, considering the dynamic and flexible environment of outdoor education. The interaction richness and context- or environmental factors can be used, supported and enhanced by the usage of wearable devices. They can provide the needed input to personalize mobile educational technology in a meaningful way and to encourage learning and teaching. In many fields of research about sensor data, it is all about accuracy and optimization, sensor fusion and finding the best outcomes. In this learning and teaching based research, the focus is on finding simple but powerful additional helpers, like sensor data, to provide meaningful feedback for the teachers and students and create the additional possibility for task personalization through dependencies. These little sensor helpers can be as simple as the overview of average speed of a given class, activity time or number

of tries. Sensor data in this field should be seen as supportive tool, not as a purely analytic instance. Still many analytic aspects and optimal data representation must be considered in future work.

The main next steps involve the shaping of interaction techniques for the teachers to create tasks, meaningful sensor measurement and presentation, as well as usability testing. We also think about the usage of the xAPI standard and how to modify it to save mobile context sensor data.

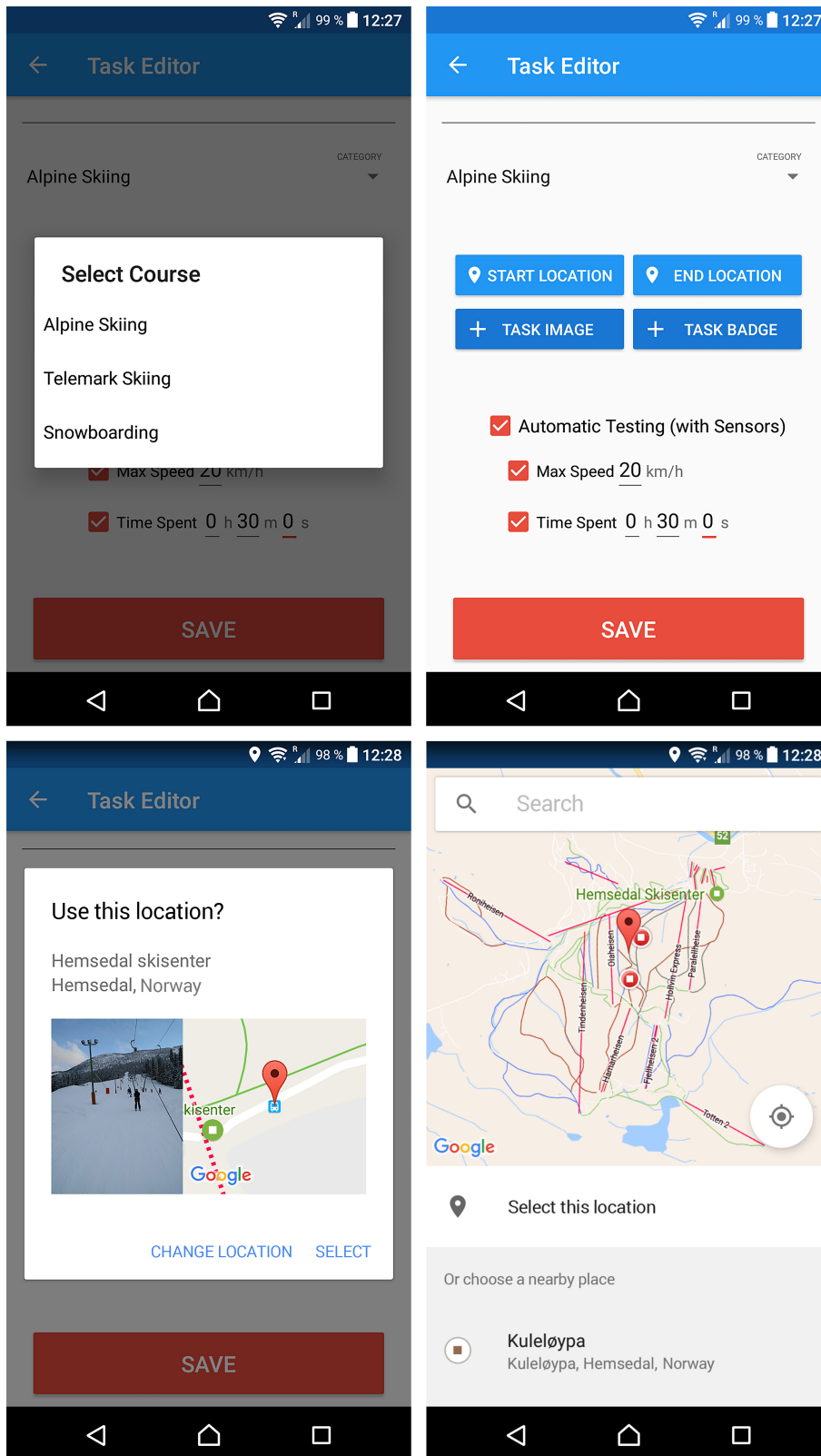


Figure D.7: (1) Course selection screen, (2) location and sensor selection screen, (3+4) location selection with google maps.

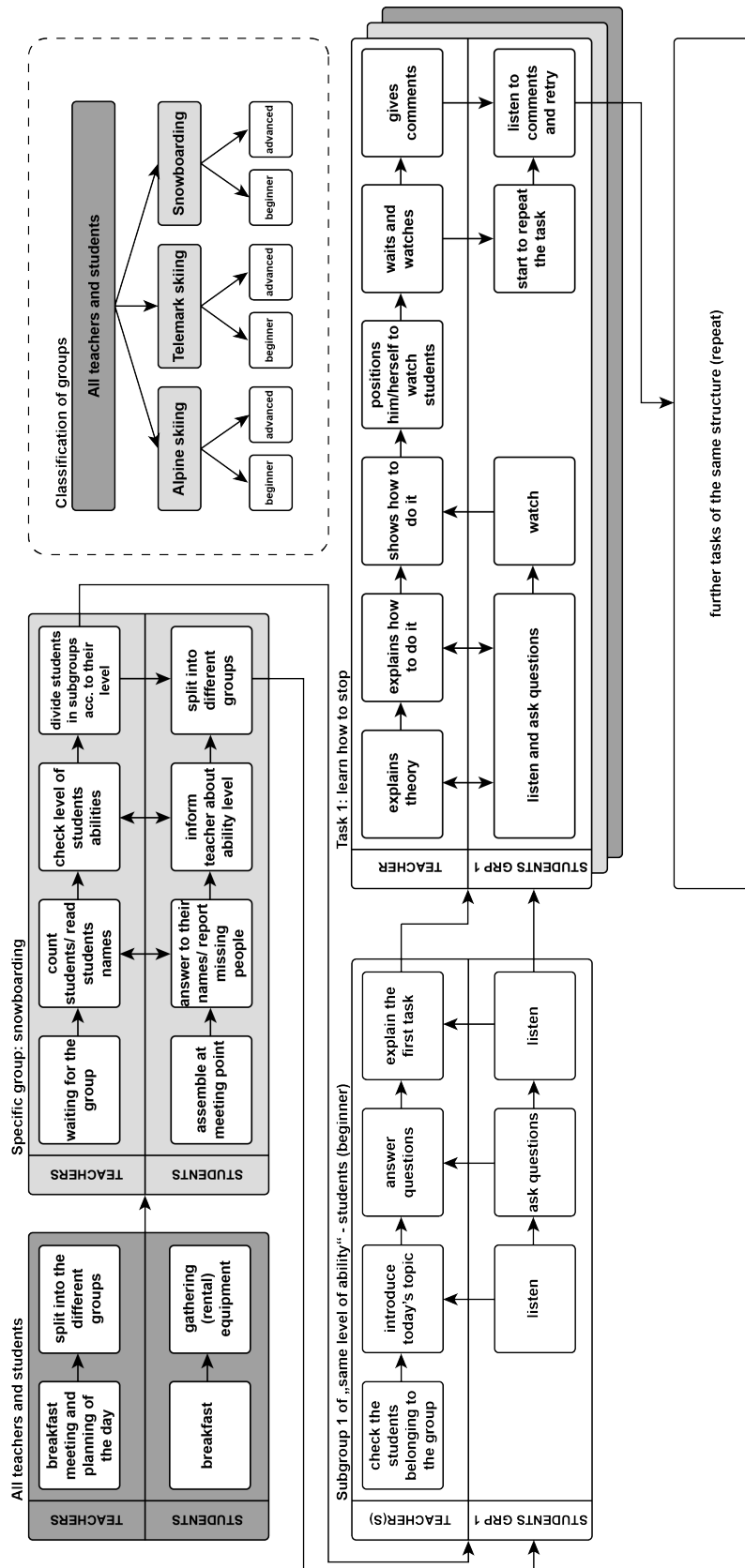


Figure D.8: Structure of the course taught in Hemsedal.

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Paper H:

Higher Education Teachers Meet Mobile Technology: Application and Acceptance

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Higher Education Teachers Meet Mobile Technology: Application and Acceptance

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and Andreas Prinz

Abstract—New technology-supported teaching concepts require validation through user testing and evaluation. This applies to our task-based mobile teaching support application, which introduces the concepts of dynamic tasks and feedback. It requires the teachers to design tasks and to identify appropriate sensors for meaningful feedback generation as well as to personalize tasks. The personalization is achieved by dependencies between tasks and sensor measurements. Different selections of tasks would lead to different students experiencing personalized paths in learning. Our prototype of this application was designed mainly for outdoor sports teachers in Norway. This paper reports about a user test of that dynamic task concept with sports teachers from Uganda, aimed at an improved design and user experience. We found several challenges connected to the concept itself, as well as technological issues. Finding meaningful sensors, and especially thinking of task dependencies is a challenge for most teachers. The paper presents an updated design to handle the issues found.

Keywords—Human-centred Design, Task-based teaching, Higher Education, Content Analysis

I. INTRODUCTION

Supporting teachers in a meaningful way is one of the goals of this project. We want to support teachers in their teaching process with technology that fits their needs. We want to motivate them to use recent technology within higher education, in particular mobile and wearable technologies. We found that teachers hesitate to integrate technology in their teaching and the usage of technology in teaching is in most cases limited to presentation materials, interaction and exchange of files between teachers and students [1].

Conducting research about what technology is motivating for teachers to integrate, and what support is missing, we found the area of task design, distribution and task feedback is not sufficiently addressed. Teachers create tasks in almost all subjects, and many teachers claimed their motivation to teach being generated through

seeing the students learn and getting feedback on the tasks students are working on [2]. We focus on task design and distribution since it is one of the most common overlapping points in many teaching approaches.

The use case we follow in this research is outdoor and sports education at higher education level. Previous testing was conducted with skiing and snowboarding teachers. From that testing a concept to support the task creation process was designed, using available technology like mobile and wearable devices. Mobile sensor technology and wearables are increasingly emerging in sports and fitness [3], however, there is still a lack of extensive research about wearables in the field of sports education [4]. Mobile devices are equipped with sensors to measure the context of the person wearing them. This enables to design tasks with consideration of additional user context information. From that, it is possible to design for personalized and more dynamic learning.

To evaluate the concept of dynamic tasks, the following research questions should be answered.

1. Can the concept of dynamic tasks be easily understood?
2. What challenges do teachers have in designing learning tasks using the concept of dynamic tasks?

To answer these questions, this paper reports on an evaluation of our concept and prototype for task-based teaching with a focus group in Uganda. The context and circumstances for technology in teaching is a lot different in Uganda than it is in Norway, where most of our user involvement and testing is done. Including teachers with different backgrounds, culture and experiences, and technology acceptance [5] also challenges the requirements we gathered and provides us with new insights.

The paper is structured as follows: First, the concept and prototype we designed is introduced in Chapter 2, including sample tasks from previous user testing. After that, in Chapter 3 the methodology within this study is described, including how and why we used qualitative content analysis. Chapter 4 groups the results within the categories we deductively and inductively found for the qualitative content analysis. The last chapter concludes the paper and describes future work.

II. DYNQ: THE DYNAMIC QUESTING APPLICATION

To explain the underlying issue and why this user study had to be conducted, we introduce our task-based teaching concept and prototype. The development of the prototype used in this research followed the human-centered design process according to ISO 9241-210 [6], in order to design a solution that is perceived as useful.

For that, an understanding of the user's context, especially the teaching situation and teaching approach is needed. A context analysis provided user needs and requirements for a supportive teaching tool. From the start, we found task-based teaching to be one of the central areas in which teachers expressed a need for technology support. The main areas of support are task design, task distribution and feedback [2]. To refine requirements, users (teachers) were involved at every stage of development, keeping it design-based, highly interactive, iterative and flexible [7].

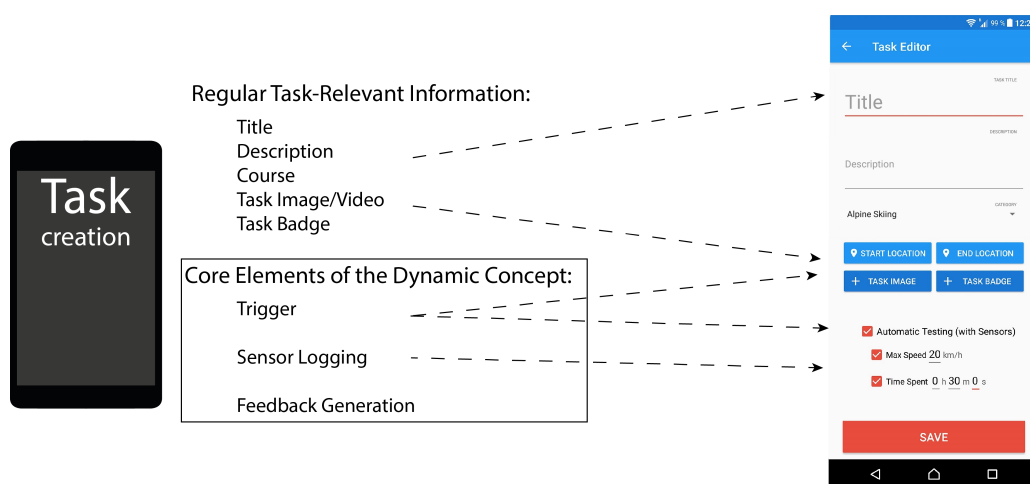


Figure H.1: Task components and their representation in the prototype.

To design for a solution supporting teachers in outdoor education within their task design, task distribution and feedback processes, we developed a concept of dynamic tasks based on mobile and wearable technology. Sensor technology allows teachers to add new variables to their tasks, making them log the progress of the students as well as having tasks appear based on previously defined variables. The task design in dynamic questing (DynQ) supports the same task structure as teachers would use without mobile system support, but it adds the flexibility of dynamically providing tasks if needed. In addition to regular known task elements (task title, description, notes, resources), its added new core elements consist of dynamic task dependencies (**triggers**), **sensor logging** and **feedback generation** (Fig. H.1.). The elements of tasks in DynQ are shown on the prototype (Fig. H.1, right side). If a teacher adds a trigger to a task, it enables dynamic flexibility of when tasks appear for the individual students. Triggers determine when a task is shown for a student. Triggers can be data obtained by sensor logging, specific location (GPS) or time set by the teacher. There are several types of triggers: context information of the student (e.g. the student's location) or an achievement (e.g. reached a certain speed), or a combination of both. An example for an achievement can be reaching an extraordi-

nary speed during a task. The **sensor logging component** can provide measurable data, such as speed, acceleration, physical location, and time. This sensor-based data can feed a trigger's condition which can then be met (achieved) anytime during the training process. A trigger could also be the fulfillment of a certain task or task combination. In addition, sensor logging provides data for **feedback generation** for teachers as well as students. Collected data can be visually shown in the interfaces of both user groups.

A sample task in the context of skiing and snowboarding is shown in Table H.1. The task belongs to a certain course, has a title and a description. Our prototype uses a combination of a mobile phone and a smartwatch, where a short description can be shown. The adding of visual media was a requirement to support the task description. A level of task difficulty can be assigned by the teacher. For example, in case of a specific beginner task, students should not get in danger, but some incline of the slope is needed, therefore a gradual or beginner slope is chosen. Before the students go to an actual slope, they are training to skate with the board with one foot out of the bindings and get used to the movements of the board. Specific tasks that must be achieved are named "skating" and "stopping with one foot out". Basic tasks should be shown even if the students have not met the requirements, but it should be visible which tasks need to be completed before enhancing to the advanced basics. For this example task, teachers indicated that it could be useful to see the number of accelerations and stops, hinting to number of tries and possible falls.

The DynQ concept enables teachers to design tasks for varying and different conditions, for different skillsets, locations and times (example shown in Fig. H.2). Tasks are prepared before the teaching, so that students can freely discover the appropriate tasks within the teaching process or during self-practice, depending on when the system is used. Students can take different paths through the tasks pre-defined by the teacher, depending on the number and the complexity of the designed tasks. This not only supports personalized learning, it also aligns with creating knowledge through experimentations, as a part of experiential learning. In addition, it follows the gamification approach of creating motivation through exploration and the discovery of the unexpected [8].

III. METHODOLOGY

This research uses a human-centered design process. It is part of one user testing phase, leading to a new iteration of the process. This study serves the purpose of testing an existing concept in a new and different context. The above-mentioned, task-based teaching tool DynQ and its applicability to different areas should be

Table H.1: Sample task using the task elements for snowboarding beginners.

Course:	Snowboarding
Title:	How to stop using heel press
Description	Stand with your entire body facing downhill and your board across the incline. Stand with your knees bent, and stay low. Concentrate on what edge control and stopping feels like. Press your heels into the back of the board and lift your toes off the ground very steadily.
Short Description:	Press heels, lift toes.
Difficulty:	Easy
Media:	<image>
Location:	On a gradual or beginner slope.
Dependencies:	Task “skating”, Task “stopping with one foot out”, Location.
Hidden/Shown:	The task should be shown, even if the dependencies are not met.
Badge(s):	-
Which sensors to log:	Number of accelerations, speed.

analyzed. The main goal is to find out if the concept is applicable and accepted by teachers from different areas.

Previous rounds of design and testing were conducted with teachers mainly in Norway. In the beginning, teachers with various backgrounds were involved, but the refinement, application, and most user testing was done in outdoor sports education. For a better design solution and user experience, we wanted to analyze the specific problems stated by Ugandan teachers (related to sports education) within their environment and we wanted to see if this other group of teachers can understand and apply the concept and make tasks for their own teaching after a quick introduction. Thus, a focus group interview as part of the human-centered design process gives us insight about their context of use as well as additional requirements for several different use cases within the area range of outdoor education. We want to expand our views in the direction of multiple sports in higher education (not only skiing and snowboarding), including related courses such as nutrition, sports theory and sports injuries.

The focus group interview was conducted with six higher education teachers from Makerere University, Uganda. The teachers with a background in sports education or a related field were chosen randomly. Two female and four male teachers participated in the focus group. Prior to the interview, we collected basic demographic information and handed out a questionnaire aligning the main topics that



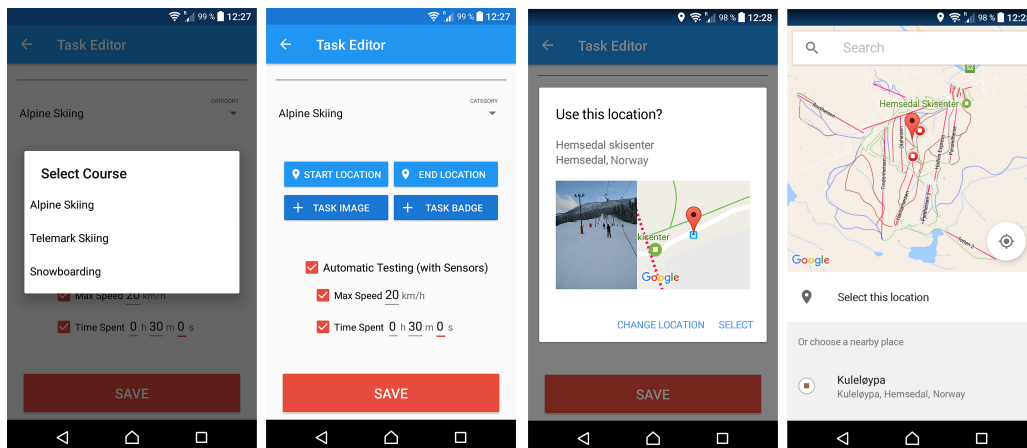


Figure H.2: Example of how the task creation can look like with start and end location.

were discussed in the focus group discussion. The participants were between 31-50 years old with 5 teachers in the range of 31-40 years and one in the range of 41-50 years. Their teaching subjects include sports science, sports sociology, exercise health and age, outdoor activities, sports pedagogy, swimming, motor learning, sports psychology, biomechanics of sports and exercise, strength and conditioning, sports coaching, practical aspects of sports, soccer, basketball, tennis, volleyball, aerobics, nutrition, growth and development to research methods and epidemiology. All participants teach at least one subject connected to sports education.

For the analysis, we chose qualitative content analysis. Since the purpose of this analysis is testing our concept, we explicitly search for occurrences of concept parts, making it mainly a deductive analysis approach. Prior to the interview, the participants received a short questionnaire and sheets for additional notes, which were also taken into consideration during the analysis.

3.1 FOCUS GROUP

The important part that we were particularly interested in was about applying the concept to the teachers' own teaching, meaning they formulate existing or new tasks according to the DynQ concept (using triggers and sensor logging). That requires the participants to build on the concept idea and to be creative about the problem to fit in or create new tasks for the dynamic concept. Our use case is quite particular for the Norwegian outdoor teaching situation, since we used skiing and snowboarding as a use case, user testing and observation scenario. During one to one interviews with teachers in Norway, we found that it takes time to introduce the teachers to the task concept, even though the use case of skiing and snowboarding was known to them. Given that Ugandan teachers are from a different teaching and technological

background, we wanted them to be able to build on each other's knowledge within the discussion, so that we can reach a state of creativity, despite of the fact that the concept is newly introduced and includes snow sports as the example scenario. We wanted them to be encouraged by the possibility to discuss among themselves, build on their applicable ideas and see where it takes us [9]. We found the focus group to be the best approach because we were interested in how and why they think in a particular way, to explore their attitudes and needs and let the group dynamics take us to new and unexpected ideas [10].

Besides the demographics, the questionnaire asked the teachers which subjects they are teaching. The next question asked if the teachers use tasks and in which situations. They could choose from three options (tasks to be done during lectures, tasks to be done at home, and tasks for laboratory work) and it was possible to describe other options. Further, we asked if the teachers create tasks spontaneously depending on situations. In addition, they could specify the types of situations in which they need to create or adapt tasks spontaneously.

3.2 QUALITATIVE CONTENT ANALYSIS MODEL

The focus group interview was video-recorded and transcribed, providing a textual base for analysis. Using DynQ requires a basic understanding of its concept and how to use these possibilities within a certain area and approach to teaching. That is why we decided to use a qualitative content analysis model [11] [12]. The DynQ concept consists of at least three steps (Fig. H.3). To use the concept in teaching, teachers must understand or know about conditional tasks, to understand the concept of task triggering (that something leads to a new task) and what triggers could be used in their specific field of teaching. In an optimal case, the teachers could connect triggers and tasks and they would understand which sensor information about their students would be useful for them. In the task design process, teachers must think about the creation of a trigger, insert the usual task information (content) and decide which sensors to track throughout the task for receiving visual or numerical feedback about the students' progress. The sensor tracking and the summative idea of the teacher's feedback needs can generate meaningful triggers. For example, a student can pass a location during a task, and the location triggers a task specific for that location. Further on, after finishing a task, a student can trigger another task with a specific requirement such as a summative result of having reached a maximum speed of 30 km/h.

From the concept stated above (Fig. H.3), the categories for analysis were designed. We were explicitly looking for the mentioning of these areas, and interested in the understanding and application of those. Therefore, the main category for

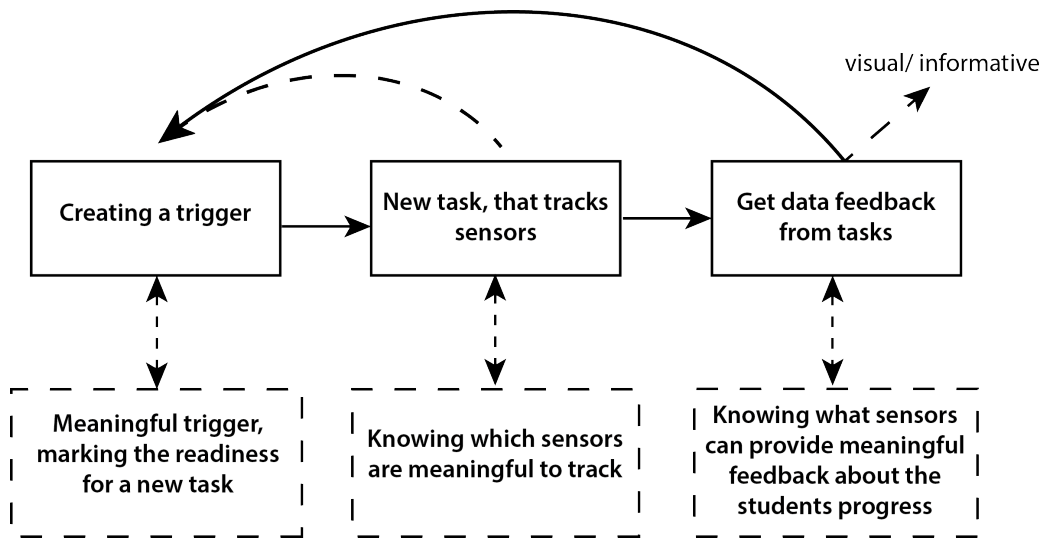


Figure H.3: Steps used in the Dynamic Questing Application when designing tasks.

qualitative content analysis is “understanding of the dynamic questing application concept”. The explicit DynQ concept steps serve as the basis for our categories. The first one is “identify tasks”, since it is easiest to understand. From our experience, most teachers can identify and describe tasks they use in their teaching. The second category “identify sensor-logging and feedback” is connected to the sensor-logging concept. It is about what sensors are logged during execution of tasks and what teachers want to see as feedback. Only what is selected for logging during task creation will be logged later when a student completes a task. When teachers state their needs of specific feedback, we can conclude which sensors would be required for that. That is why we combine the sensor logging and the feedback idea in this category. The third category “identify triggers for tasks” is important to the concept, since it determines the possibilities for personalization. Triggers are the core concept of dynamically appearing tasks, but they are hardest to identify. (Fig. H.4).

IV. RESULTS

The results of the questionnaire (“Do you make tasks spontaneously?”) suggest that all six teachers agree that there are circumstances where tasks must be created spontaneously, or where they must be adapted to specific circumstances. Teachers could describe the situations in a free text field. We found that reasons for spontaneous tasks or the adaption of tasks include: students’ skill level, weather changes, blockage of facilities (“when we cannot use the pool”), progress and assessment specific reasons, and available materials and resources. But it was also stated that teachers

adapt tasks based on class discussions, where students express a need for certain tasks or adjusted group activities.

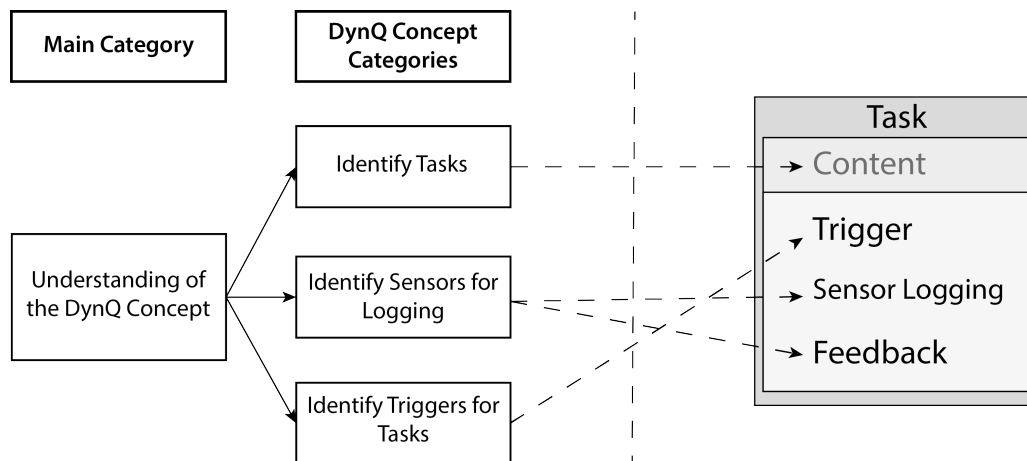


Figure H.4: Deductive Qualitative Content Analysis categories. Modeled after [12].

From the interview transcripts, we inductively found other important categories for the qualitative content analysis. The issue about technology acceptance and attitude towards technology is repeatedly addressed, making it an important category. From the diversity in teaching subjects from this group, we derived the category of general application areas for wearable and mobile teaching tools similar to DynQ. The complete figure of categories is given in Fig. H.5.

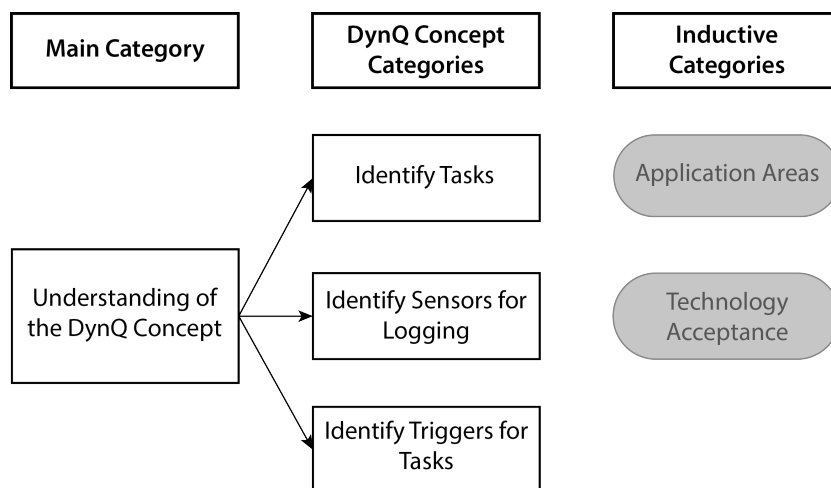


Figure H.5: Deductive and inductive Qualitative Content Analysis categories. Modeled after [12].

4.1 IDENTIFICATION OF TASKS

Tasks were mentioned on a general level, only few concrete sample tasks were given, but a general agreement that sports students need to exercise, train and conduct tasks was expressed. In aerobics, the teacher needs the students to design programs and to record videos for the teacher as feedback. It was mentioned, that “seeing and doing” was very central to their teaching approach as directly expressed by one teacher “for us, learning is more seeing and doing”. Further on, it was specified “when I do a skill [...] show students that this is the way it is supposed to be”. Learning was described as “learning by doing” and “through repetition”. The example of specific hand-movements in basketball was demonstrated. It was clear that tasks build on each other, and have a certain specific order or hierarchy “they can move on to the next level, or maybe they need to reduce [...]”. The teachers expressed the importance of being involved and active during the students’ training process. They need “visuals” showing what a student is doing. It was indicated that a validation of the student is needed “like a selfie, it is showing the student, that the teacher knows” that the correct student really was doing the assignments. Clearly stated tasks related to sensor use and triggers in the discussion were:

- Running a certain distance/ way, with a certain speed or within a certain range of time
- Swimming with a certain stroke rate /frequency or speed
- Group running
- Activities on training stations
- Volleyball activities like: jumping, blocking, hitting the ball, reaction time

From these tasks, the following extra requirements for task design and used hardware can be derived:

- Video recording and sending as feedback to the teacher
- Underwater videos (swimming) and waterproof smart watch for logging
- Possibility for the teacher to attach a video/ picture to explain a skill
- Monitoring of multiple students exercising (e.g. running) without the teachers being co-located. The example of direct tracking of the students’ progress including data syncing to the teacher’s watch was mentioned.

- The distraction from pressing start and stop to begin and end a task must be minimized (especially during short tasks like fast swimming).
- Secure way of informing the teacher who is sending the data/ person validation and verification
- Rating of achievement and progress as a feedback for the teachers

4.2 IDENTIFICATION OF SENSORS FOR LOGGING

Even though our prototype is limited in terms of sensors, we kept the possibilities open to get a wide range of answers. Those answers can lead to new requirements, which could mean that a change in hardware would be needed for the stated application areas and sensor-logging needs. From the task discussions, the following interests in measurements were stated:

- Exhaustion, tiredness, panic, body functions
- Reaction time for jumps, blocking (volleyball), difference in reaction time over training time (hint to exhaustion)
- Monitoring the progress over longer time periods (e.g. 6 weeks within basketball)
- Measure lap count in swimming for distance
- Heart rate, step count, accelerometer (fitness, health)
- Stroke rate and frequency (swimming)
- Jumping height (basketball)
- Specific movements like throwing a ball and technique accuracy (basketball)
- Energy consumption over time (aerobics)
- Time (when are they performing the tasks and how long)
- Speed, distance, pace, acceleration, location tracking (running)
- Activity in general, to monitor if all students are doing the workouts
- Sense difference between running, or using a motorcycle, bus or equivalent

4.3 IDENTIFICATION OF TRIGGERS

The identification of possible sensor measurements to trigger tasks was a challenge, but most teachers could identify what they need their students to achieve before they can proceed with a certain advanced task. Interestingly, negative triggers were also mentioned, like “if the students fail to stay within a certain range”. Analyzing the conditions and dependencies they stated for the described tasks, we found the following possibilities for triggers:

- Previously completed tasks, moving on to a next level
- A certain number of activity repetitions, e.g. on a training station
- Task recommendation based on energy consumption
- Weight tracking for fitness and health related tasks
- Previously achieved running/ swimming distance within a certain amount of time (lap count for swimming)
- Timing, heart rate and reaction time to make recommendations for next tasks (volleyball)
- Achievement of a certain stroke rate, a particular speed using the correct technique (swimming)
- Staying within a particular speed range (running, swimming), stroke frequency range (swimming)
- Too fast movement, overdoing, extreme exhaustion as trigger for breaks and different tasks
- Immediate task adjustment or dynamic recommendations for long distance runners to keep or change the pace in certain locations

4.4 APPLICATION AREAS

As mentioned before, stated teaching subjects within the field of sports education were sports science, sports sociology, exercise health and age, outdoor activities, sports pedagogy, swimming, motor learning, sports psychology, biomechanics of sports and exercise, strength and conditioning, sports coaching, practical aspects of sports, soccer, basketball, tennis, volleyball, aerobics, nutrition, growth and development were mentioned. We expected further discussions of concrete tasks in

the stated teaching subjects. The use cases of running, swimming, basketball and volleyball got further recognition within the focus group discussion.

Regardless of the taught subject, most teachers indicated application areas for such a technology solution could be in the field of assessment and monitoring. For example, monitoring the students' workout, checking on them if they are doing what they are supposed to do, but also checking on their progress. This includes the idea of minimizing cheating, where the teachers cannot check upon the students. The thought was not new. Teachers from Norway mentioned the problem of cheating or especially lazy students as well, however, not to the same extent as it was mentioned by the teacher group from Uganda. There was a clear difference between the concept idea that sensors can be used to trigger tasks for students automatically and the idea of the participating teachers to mainly use sensor logging to check the students work and progress. That gave us insight about possible requirements towards cheating detection and security issues while tracking the students progress.

4.5 TECHNOLOGY ACCEPTANCE

Participants engaged with the prototype from the start of the group discussion and discussed their own usage of smartwatches, showing an interest in the subject and the specific usage of wearable technology. Two of them clearly stated the integration of wearables (smartwatches) into their own training, coaching or research. Teachers stated a specific interest in innovative technology and any kind of technology out of the standard practice: "...if there is anything out of the ordinary, [...] I could actually have an idea of what I can do", "in which range the work(out) has been done, which types of fat were burned", wondering "wouldn't that require a chip in the blood?". Obviously, the teachers were not only positive about the technology: "if it fails, it's useless".

Direct issues with the concept and the technology were expressed as follows.

- Unreliable internet connection, possibility of data loss
- Usage of two devices, placement of both and data loss
- Costs to provide and maintain gadgets
- General uncertainty about what to measure
- Mistrust of people and technology

Teachers clearly stated that they think students would misuse a system, if it is vulnerable. To fake results they think students would try to "shake" the device, "use

a motorcycle” instead of moving themselves, “have somebody else doing [it]” (the task), as well as “record everything on the same day, even if they should work out continuously over multiple days”.

Overall, trust towards the technology within the following areas was mentioned:

- To sort data for the teachers, for example to help coping with large student group sizes, but also on an individual basis (much data from the same person)
- To measure tiny differences more reliably than humans, e.g., reaction time of volleyball players (jump, block)
- To enhance sports education and to make it more valuable
- To help teachers/ coaches to structure sports activities

Overall it was directly acknowledged, that the technology can be of use and support teachers and students, in particular in cases where the teacher cannot be around.

V. CONCLUSION AND FUTURE WORK

The participants of the focus group discussed use cases of a dynamic task application in various fields. Designed and tested with teachers mainly from a background in skiing and snowboarding, new requirements towards the system and concept were found this way. The participating teachers showed a surprisingly positive attitude towards mobile and wearable technology as well as high technology confidence. They had knowledge about sports watches and smartwatches as well as some sensor devices. In any case, the used technology has to fit the needs of the teacher in his/her specific teaching approach. Teachers from Uganda had a different perspective on application areas than we experienced with sports teachers from Norway. The general idea was to mainly use the sensor possibilities for monitoring and checking up on the students. As we found, that is mainly generated from the expectation of teachers to have cheating students. All in all, we could not analyze every category as deeply as we expected. We found that this was the case, not only because of concept understanding difficulties, but it was also influenced by the diversity of teachers (different subjects). Having many different subjects in the discussion combined with limited interview time where each participant’s input needs to be considered, limited the time for concrete discussions to go deeper into specific tasks and possibilities for sensor usage. Even though the teachers had tasks in mind and were able to express those, the concept of task triggering is difficult to grasp and must be explained in a better way. Affordances of the user interface have to match the idea of task dependencies from the teacher’s perspective and mental

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model. That means, task dependencies have to be visualized better for a consistent understanding, for example showing the hierarchy between tasks within the interface, what task follows what, and what has to be done prior to a specific task, which tasks are visible for all students and which tasks have to be discovered by the students. We could experience the transition from not knowing anything about the dynamic task approach to understanding the concept and how to make tasks based on the new concept. Although limited, teachers could identify what would be meaningful to log with sensors and how tasks could be triggered using information about the student's context (using sensor measurements, GPS and time). From the focus group discussion, we found that further considerations for different subjects including non-sports subjects like nutrition, could be using the dynamic questing approach. Sports subjects are one example among various disciplines that employ teaching approaches using tasks. Future work could include further design and development of DynQ to meet teachers' requirements with a focus on specific application areas.

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