



Dissertation

ANALYSES ON TECH-ENHANCED AND ANONYMOUS PEER DISCUSSION AS WELL AS ANONYMOUS CONTROL FACILITIES FOR TECH-ENHANCED LEARNING

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'Tell me and I forget, teach me and I may remember, involve me and I learn.'

Benjamin Franklin



ABSTRACT

An increasing number of university freshmen has been observable in absolute number as well as percentage of population over the last decade. However, at the same time the drop-out rate has increased significantly. While a drop in attendance could be observed at the same time, statistics show that young professionals consider only roughly thirty percent of their qualification to originate in their university education. Taking this into consideration with the before mentioned, one conclusion could be that students fail to see the importance of fundamental classes and choose to seek knowledge elsewhere, for example in free online courses. However, the so acquired knowledge is a non-attributable qualification. One solution to this problem must be to make on-site activities more attractive. A promising approach for raised attractiveness would be to support students in self-regulated learning processes, making them experience importance and value of own decisions based on realistic self-assessment and self-evaluation. At the same time, strict ex-cathedra teaching should be replaced by interactive forms of education, ideally activating on a meta-cognitive level. Particularly, as many students bring mobile communication devices into classes, this promising approach could be extended by utilising these mobile devices as second screens. That way, enhanced learning experiences can be provided. The basic idea is simple, namely to *contribute to psychological concepts with the means of computer science*. An example for this idea are audience response systems. There has been numerous research into these and related approaches for university readings, but other forms of education have not been sufficiently considered, for example tutorials. This technological aspect can be combined with recent didactics research and concepts like peer instruction or visible learning. Therefore, this dissertation presents an experimental approach at providing existing IT solutions for on-site tutorials, specifically tools for audience responses, evaluations, learning demand assessments, peer discussion, and virtual interactive whiteboards. These tools are provided under observation of anonymity and cognisant incidental utilisation. They provide insight into students' motivation to attend classes, their motivation to utilise tools, and into their tool utilisation itself. Experimental findings are combined into an extensible system concept consisting of three major tool classes: anonymous peer discussion means, anonymous control facilities, and learning demand assessment. With the exception of the latter, promising findings in context of tutorials are presented, for example the reduction of audience response systems to an emergency brake, the versatility of (peer) discussion systems, or a demand for retroactive deanonymisation of contributions. The overall positive impact of tool utilisation on motivation to attend and perceived value of tutorials is discussed and supplemented by a positive impact on the final exams' outcomes.



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CONFIRMATION OF AUTOGRAPHIC WORK

I confirm that I independently prepared this dissertation and that I only used the indicated references and auxiliary means. Contents based on contributions of others are clearly marked. The utilised prototypes were in part programmed by Tommy Kubica and Huangzhou Wu. The experiments and results on user interface designs related to audience response systems are based on Alexander Martin's master thesis [[Mar15](#)], which I supervised.

Dresden, 18 March 2016

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INTRODUCTION AND MOTIVATION

'Any fool can know. The point is to understand.'

Albert Einstein



The way students learn has been and continues to be changing with each generation. Today's challenges lie not only in the way how one learns, but also in when one learns as well as when and how one teaches: the entirety of education is at a crossroads. Traditional and established education principles collide with modern technology. How is one supposed to overcome these challenges? The answer should be and is actually simple: rather than perceiving an avertible collision, the inevitability should be embraced. The *problem* then shifts to the question of how one can *enhance* education with the means of modern technology. For example, take cognitive activation. How can cognitive activation be accomplished and fostered by computer science? Or as another example, take audience response systems. How can audience response systems be applied and utilised in different educational scenarios like readings and tutorials?

Learning and acquiring knowledge has always been imperative to humankind. In the beginning motivation was survival, today it seems to be success, which of course correlates with survival in some way or another. However, the way one learns has changed with the technology available during the times. Be it the imitation of skills and hence mastering of the skill oneself, or the intensive theoretical study of a science and application of knowledge, there always needs to be a source of knowledge from which one can derive. Omitting antiquity and starting the argument in the middle ages, this is the reason why masters of trades founded the earliest universities. They wanted to bring together as much knowledge as possible in one location, making vast distance travels for journeymen unnecessary. Before that, once an apprentice achieved journeymen status, they would have to leave their master and travel the country/countries in a journey of knowledge (hence journeymen) in order to acquire knowledge of different skills and derivatives of conduct in their craft from other masters. Taking the ancient world into consideration, too, having scholars congregate at selected locations allowed students from all over the (known) world to learn from these scholars without having to follow them through the countries, respectively finding the scholars therein at first.

For as long as humans were able to communicate in a distributed manner, distributed learning has been used, allowing a source of knowledge to be at a location physically separated from the learners. Open universities have made higher education available to students who are not able to attend lectures at their university. The way open universities offer distributed learning has however rapidly changed. Starting with books and papers being mailed in the late 1900s, gramophone records and stereophonic discs in the 1930s, to television broadcasts in the late 1960s, the distribution of knowledge was primarily unicast and reply channels were –if offered– asynchronous and bound to mail-in services. Since the rise of the Internet, more synchronous approaches for interactions between teachers and learners have emerged. Having discussion forums and mailing lists emerge early in the very young history of the Internet, on-demand lecture videos, video chats and live discussions are available today. Recently, special forms of online learning have emerged that have been designed especially for the Internet, rather than merely adapting offline material to the online medium. One example are micro lectures on specific topics, or massive open online courses (MOOCs). The success of these distributed learning approaches is overwhelming and positive for the ones offering these types of lectures. However, the classic university has to cope with hardship based on the others' success. Therefore, an interesting question is how a classic university can benefit from the new types of online learning while maintaining classic offline courses, especially giving the offline courses an advantage against online courses so that students feel invited to actually enrol in regular university curricula. As this question is currently heavily investigated, a more focused analysis of how to maintain offline university courses in their classic setting while enhancing them with collaborative online features seems to be valuable. Especially when considering university courses being provided as readings, tutorials, practicals, studios, or combination thereof. Thus, investigations currently focus on technology-enhanced learning scenarios that are aimed at a broader scope than just blended learning.

Didactics concepts not relying on technology-enhancement should be investigated for amendability, and –if amendable– be amended in the before-mentioned sense. For example, *peer instruction* [Maz97] (↪ [subsection 2.1.2](#)) is a proven in-course, non-techy concept to increase exam success. However, if students don't attend courses, it is rendered less useful. Hence, students need to be supported in other ways, ones paying respect to their means of learning today. Supporting self-regulation [ZBPZ00] (↪ [subsection 2.1.1](#)) is imperative, thus support of online media should be aspired (blended learning is a related concept). Keeping that in mind and returning to peer instruction, peer instruction can be divided into three main phases: presentation, ConcepTest and peer discussion. Each of these phases should be supported in the online media, and it can be easily realised for the presentation and ConcepTest phases with existing solutions such as Moodle, OPAL with ONYX, et cetera. However, peer discussion is elusive for the online media as it is impossible for the teacher to physically roam through the classroom and listen in on students' discussions. An amendment or modification of the peer discussion phase is required.

Speaking of self-regulation, motivation should be considered, too. Considering explicitly being able to influence your surroundings [HH06], the ability to affect one's learning surroundings with control facilities (for example ARS ↪ [subsection 2.2.2](#)) on a [second screen](#) should provide good incentives for motivation. Extrinsic factors such as group perception can be significantly reduced or even eliminated that way. Provision of anonymous utilisation can boost the effect. However, to date such tools were only intensively investigated in readings; other educational settings such as tutorials still remain to validate the observations.

To facilitate the required investigations, a set of four hypotheses was conceived. These hypotheses will be introduced in [the next chapter](#) and were utilised to focus the conducted research on four distinct problems: integration of tools into the curriculum, transferability of didactics concepts, incidentalness of tool utilisation, and requirements with respect to anonymity. Based thereon, an experimental approach to the challenges outlined earlier was followed. By implementing a limited set of representative tools into a platform, which was then made available to students in an actual course (testing under real conditions), a setup allowing for targeted questioning of students participating in the experiments could be arranged. Recognition of benefits and unforced usage patterns could be achieved by making platform usage voluntary. Within the setup, utilising or ignoring the provided tools had no direct impact on grading, for example by

rewarding extra point, et cetera. Instead, students were to realise the benefits or disadvantages based on their own perception thereof. Additionally, no further incentives were provided but the ones originating from the platform itself. The participating students were regularly asked to provide feedback for evaluation purposes. The results gained allow for positive appraisal of the experimental setup, however the initial hypothesis on anonymity could be falsified. In [chapter 5](#) short descriptions of the conceptual idea as well as intended methods of verification and/or falsification will be provided with the tools' introductions.

This dissertation is divided into three main parts: at first a propaedeutics part containing three chapters, second a proceedings part of five chapters, and lastly an appraisal part with three chapters. The dissertation concludes with the appendix.

The propaedeutics commence with the working theses on which the research presented in this dissertation is based. After a brief overview of existing concepts starting page [16](#), the part is concluded by an overview of important related work in the pages following [36](#).

In the proceedings an experimental entry point based on the first part is described by provision of a global picture ([~> page 66 et sqq.](#)) and system architecture ([~> page 69 et sqq.](#)) in order to conceive some initial assertions that lead to a proof-of-concept implementation ([~> page 72](#)). The assertions, experiments and results for the investigated tools are then described iteratively ([~> page 78 et sqq.](#)), providing insight into anonymity ([~> page 80](#)), learning demand assessment ([~> page 83](#)), discussion system ([~> page 88](#)), virtual interactive whiteboard ([~> page 99](#)), audience response system and emergency brake ([~> page 104](#)), as well as evaluation system ([~> page 112](#)).

Based on the experimental findings of the second part, the appraisal part starts off by discussing important lessons learned ([~> page 142 et sqq.](#)). The potential impact of these results on the community is then briefly discussed ([~> page 148 et sqq.](#)) before completing the part and the main contents of the dissertation with a research conclusion on the concept ([~> page 154](#)).

Finally, the appendix presents the experimental arrangement ([~> page V et sqq.](#)) and the questionnaires that were used as part of the ascertainment ([~> XIII et sqq.](#)). Thereafter, a comprehensive list of references and auxiliary means utilised for ([~> page XLI et sqq.](#)) and scientific contributions arisen from ([~> XLIII et sqq.](#)) this dissertation is provided. A glossary defining some additional terms ([~> page XLVII](#)) as well as an index containing a page reference list of the important terms of the research conducted ([~> XLIX](#)) are provided before concluding with important milestones set for the conferral of the doctorate ([~> page LI](#)).

This dissertation contains original work of undergraduate and graduate students at TU Dresden who under the author's supervision have contributed to this dissertation with the results of their assigned papers and theses. The reader shall note that the author will not highlight entire sections in quotation marks, hence such work will be marked by a comment in the introducing words of the respective sections.

Iff not unsuitable, each chapter will begin by foreclosing its results or core message. This is intended to allow readers to immediately grasp contents and decide whether to read or skip parts at their comfort.

The contents of this dissertation are written in (simplified) British Standard English. This especially means that commas are not set in some sentences if they separate subclauses of five or fewer words, even if grammatically required. Also, for the benefit of readability, the abbreviations 'e.g.' ('for example') and 'i.e.' ('that is') are intentionally not utilised. As there are conflicting policies and theories about how to show possession when writing nouns ending on the letter *s*, it shall be declared that for possession purposes such nouns are added an apostrophe without trailing *s*; that is 'class' instead of 'class's', 'ARS' instead of 'ARS's', et cetera. This declaration shall prevent occurrence of verbalised 's-ses'.

Some terms are explained directly within the footer of a page as a footnote¹, while others – mostly less important ones – are briefly explained in the glossary² at the end of this dissertation (→ page XLVII). If there are at least five non-academic sources for data, information, specifications, assertions, declarations or definitions, this dissertation will either consider them as part of general knowledge and not provide further reference, or provide a summarised version thereof. For all other – to the best of the author's knowledge – not in general knowledge, references are provided in the list of references in the appendix (→ page XLI). Additionally, it shall be noted that some chapters and/or sections may provide a set of references in their introducing paragraph, hence only important references will be marked as such. Should a statement not be referenced explicitly within a paragraph, the reader is kindly requested to refer to the references given in the introduction of the chapter and/or section at hand.

To shorten sentences and enhance readability, the term 'if and only if' is abbreviated by 'iff'.

For easier readability the phrase 'learning and/or teaching' shall be considered replaceable by 'education', or be omitted in context of scenarios, situations, as well as settings. However, the reversal, namely 'education' being able to be replaced by 'learning and/or teaching', shall not hold.

The terms 'tutorial' and 'exercise' will be used synonymously throughout this dissertation.

As commonly agreed on, the phrase 'without loss of generality' is abbreviated by 'w.l.o.g.'.

By times, images/figures will be provided in order to illustrate something. For optimal flow of text, the typesetting tool utilised (L^AT_EX) will place these near the point of reference, but this might not always be possible, hence images/figures may appear on one of the next or preceding pages if not intuitively near the point of reference. It should be noted that all screenshots of the prototype implementations are in German as the exercises in which they were utilised were conducted in German. Translating the contents would have been possible, but were decided against as it would falsify actual occurrences.

Iff no explicit access date is provided with a [URL](#), the date of last successful access prior to compiling this document is 1 September 2015.

Finally, the reader shall be alluded to the fact that each part of this dissertation presents its own table of contents on the reverse of the part's separator page, therefore it is not necessary to refer to the general table of contents on page [i](#) when seeking for specific contents within a part.

¹ For example, this is a footnote.

² In the electronic version of this dissertation the first occurrence of any glossary item is highlighted in colour and implemented as an intra-document hyperlink.

PART I PROPRAEDEUTICS

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1 WORKING THESES

'There are millions of hypotheses for a single hidden truth.'

Daniel Melgaço



WORKING THESES

The starting point laid out in the motivation earlier fosters a set of working theses that shall serve as guideline through the course of this dissertation. Without any further ado, these theses are:

Working Thesis 1 (Integration):

Iff integrated into the curriculum, tools yield a unique feature to distinguish university courses from (free) online courses.

Working Thesis 2 (Transitivity):

Encouragement of autonomy can be easily transferred into the online medium iff didactics concepts are preserved in tools selection and/or implementation.

Working Thesis 3 (Incidentalness):

The impact of tool utilisation correlates with the feasibility of incidental tool utilisation.

Working Thesis 4 (Anonymity):

While capability of anonymous tool utilisation provides additional incentive for *regular* tool utilisation by students, provision of anonymity is required for *intensified* tool utilisation.

These working theses are focused on enhancement of university courses and are at this point disputable. However, it is in the best of all intentions to prove or disprove them with suitable assertions and findings in the later course of this dissertation. The general research area is technology-enhanced learning (TEL).

Working Theses 1 and 2 focus on didactics aspects that may have to be considered. They primarily address the issues of whether the intended users of a tool selection will or will not utilise the selection. Thereafter, Working Theses 3 and 4 address the influence of tool- and self-perception. Iff the utilisation can be achieved incidentally in conjunction with awareness of anonymity, the willingness of students to actually use the tools may significantly increase.

As mentioned in the introduction, classic university courses are suffering from the concurring online choices. General availability and flexibility of *when* and *where* to learn make online courses very attractive for persons eager to learn something. While more and more people decide to pursue a university degree, the share of drop-outs rises, while at the same time attendance decreases [BBF14]. When offered by professionals (that is by universities), online courses can benefit both, students as well as the universities. For example, universities are able to reduce costs as they do not have to supply lecture halls, or they do not have to allocate as much man power as they would have to for on-site courses. Assuming these professional choices are all educating, then a subset of them are qualifying. And of the qualifying ones, a subset is accountable.

Considering what a student may learn from educating courses, they are not necessarily able to apply qualified knowledge in their future line of work. However, once they achieve qualifying knowledge, their contributions to their future workplace *may* turn out to be very valuable. The problem for employers resides in assessing the potential of this '*may*'. Will the future employee be a valuable addition to the workforce? A means of easing the decision-making process is accountability of qualifications. Traditionally, universities certify their graduating students with credentials and/or diplomas; for online courses such accountability may not be given. Even some professional online courses do not certify after successfully passing the curriculum.

In general, there are two simple possible solutions to the problem outlined: on the one hand, online courses could conclude with an accountable certificate; on the other hand, classic university courses could include online aspects while maintaining their certification process.

Problems with the simple solution for online courses are manifold. How can a certificate be accountable? Are online course certificates also an indication of secondary skills such as social skills? There are very few accreditation standards and procedures as they can be found for classic university courses. In the United States the majority of senior year university students spend time on social engagement, bonding, or tutoring juniors and sophomores, so a degree from such a university *can* also prove some level of social capability. And, talking about juniors, sophomores and seniors, university degrees certify knowledge in several divisions of studying in an integrated one- or multi-tier programme. This is hardly true for online courses. Compared to other university settings like German diploma courses³, similar aspects must be taken into consideration, but even if the accountability was given, the qualification remains questionable. Most university curricula include some sort of practical course (such as placement or laboratory), or demand or encourage external placements. This is by no means given for online courses, meaning that theoretical knowledge may have been acquired by the students, but the application thereof is very probably insufficient. –As the problems outlined only scratch the tip of the iceberg, online courses shall not be further investigated. Instead, the focus shall be put on enhancing classic university courses.

For classic university courses, the simple solution described earlier proves difficult in practice. Introducing freely scheduled online aspects to classic courses challenges accountability. The easiest solution is the typical exam at the end of a term, but this contradicts free scheduling. Hence, also allowing exams in freely scheduled online context would be a solution. However, equal and fair exam conditions can hardly be provided. Also, guaranteeing that specific persons actually take an exam themselves is very challenging: any remote-based identification system can be circumvented more or less easily. Software tokens (password, ...) and hardware tokens (RFID chip, ...) can be shared, optical verification requires references (state issued biometric ID, ...) and liveness verification (counter still pictures, ...), post-verification swapping is still possible (person actually taking the exam sits next to verified person outside of camera view, ...), et cetera. Regular gatherings seem to be inevitable, as suggested by [LOO11], for example. Facing this type of challenges, the feasible approach is to somehow include online aspects into classic university courses while maintaining accountable certification. Hence, it is even more important to have students willingly choose to enrol in university courses and actually attend. However, this contradicts a current trend of diminishing attendance, so it seems to be of greater importance to have students actually attend university courses in order to address the other improving aspects. Herein the desired target of this dissertation shall be identified: enhance classic university courses by providing means that consciously benefit students and by that encourage to attend.

Beyond obvious aspects such as not conflicting with part-time jobs, et cetera, the only feasible way to get students to actually attend university courses they have enrolled for, is to make the courses sufficiently attractive. This immediately leads to [Working Thesis 1](#). Any enhancement to classic university courses should be a priori directly attached to the course in question. It is infeasible to ask students to utilise any kind of enhancement if it is not benefiting the course success, which in return is only achievable iff the enhancement is integrated into the curriculum. As the goal is to make attendance beneficiary in comparison to online courses, enhancements on a technical level shall be further investigated here; enhancements in means of didactics, scheduling or teaching staff shall not be investigated within this dissertation. For the remainder such technical enhancements shall be summarised by the term 'tool' (↪ [Definition 1.1.5](#)).

³ In general, 4.5 to 5 year long one-tier programmes.

1.1 DEFINITIONS

Establishing a common ground on terms often used ambiguously, a few definitions shall provide the basis of term utilisation within this dissertation.

Definition 1.1.1 (General Tool):

Any technological enhancement to classic university courses aiming at raising student attendance, providing unique features in comparison to online courses, and benefiting the courses' success rates.

As it is impossible to comprehensively cover all possible derivatives of general tools, the scope shall be narrowed down to tools supporting technology-enhanced learning, that is learning enhanced by utilisation of technology rather than learning depending on utilisation of technology. The narrowed scope yields [Definition 1.1.5](#).

Definition 1.1.2 (Technology-enhanced Learning/Teaching/Education):

Utilisation of education technology yields iff the utilisation aims at providing

- an enhanced learning process and/or an enhanced overall learning experience: *Technology-enhanced Learning* (TeL) – from the learner's perspective,
- an enhanced teaching process and/or an enhanced overall teaching experience: *Technology-enhanced Teaching* (TeT) – from the teacher's perspective, and
- an enhanced education process and/or an enhanced overall education experience: *Technology-enhanced Education* (TeEdu) – from both perspectives.

As already announced in the introduction, the term education can be used synonymously for learning and teaching, now [Corollary 1.1.3](#) provides the foundation to that announcement.

Corollary 1.1.3 (TeEdu Inclusion):

Assuming at least one TeL or TeT aspect is applicable, TeEdu includes all or selected aspects of TeL and all or selected aspects of TeT:

$$\text{TeEdu} = \mathbb{L} \cup \mathbb{T} \neq \emptyset \quad | \quad \mathbb{L} \subseteq \text{TeL} \cup \emptyset, \mathbb{T} \subseteq \text{TeT} \cup \emptyset$$

In the broader scope of education, the influence of technology becomes more and more important. The impact of technology on educational conduct can be summarised in *scenarios*.

Definition 1.1.4 (Scenario):

A scenario is any (education) environment with all of its underlain (education) situations and/or (education) settings.

The so defined scenarios can span from technology-free to technology-overflowing environments with or without technology-utilising situations and/or settings. The first end of the span shall be denoted as *technology-free* (*tech-free*), while the latter shall be denoted as *technology-driven* (*tech-driven* or *tech-full*). Any scenario within the range, especially those considered not fully relying on technology, shall be denoted as *technology-enhanced* (*tech-enhanced*, *techen* or *techy*). This correlates with [Definition 1.1.2](#).

W.l.o.g., scenarios can be described by their learning aspects even though they always include learning **and** teaching aspects.

Definition 1.1.5 (TeEdu Tool (Tool)):

Any general tool feasible for utilisation in TeEdu scenarios that are applicable without yielding dependence on the tool. The term 'TeEdu Tool' shall be abbreviated by 'tool'.

The tools investigated in this dissertation should all be considered to be TeEdu tools as they all share learning as well as teaching aspects. Without proof, the existence of any tool that is solely a TeL or TeT tool is doubtful in general.

As the scope of readings and tutorials vary, therein the ratios of TeL and TeT aspects vary sufficiently to warrant different subsets of tools. However, the subsets are not disjunct. Depending on the individual TeL/TeT aspect ratio of considered tools, the intended use differs.

Definition 1.1.6 (TeL/TeT Aspect Ratio (LTAR)):

The ratio of learning aspects to teaching aspects in the context of TeEdu.

As the LTAR can hardly be measured without defining hard discriminators, a more general approach would be answering the question, whether the focus in question is aimed more toward learning or teaching.

1.2 CONTEXT OF WORKING THESES AND DEFINITIONS

The primary objective of readings is knowledge presentation, whereas tutorials aim at knowledge consolidation. Hence, readings should be considered from the presenting point of view for docents, and the observing point of view for learners. In tutorials the points of views are the consolidation for the learners and guidance for the docents. That is, the LTAR in readings depends on the weight the docents put on the relation between presentation and observation, while in tutorials the LTAR depends on the relation between guidance and consolidation. Another aspect influencing the *perceived* LTAR is the degree of free development of the individual learner. Let higher degree yield higher LTAR, a key to such degree is the individual perception of variance, which strongly correlates with the strictness of the learning environment. The more autonomy is provided to the learners, the higher the perceived variance and thus free development. This immediately yields [Working Thesis 2](#) as contradicting degrees of autonomy in the learning environment and the supporting tools presumably negatively influence each other. However, once autonomy is consistent between learning environment and supporting tools, actual utilisation of tools should blend into the learning environment. Hypothetically, the lesser the aware tool utilisation, the better for the learning process. This idea is reflected in [Working Thesis 3](#) since less awareness should yield more incidentalness. The final considerable influence on the LTAR is considered in [Working Thesis 4](#), as anonymity provides a good means for both, [Working Thesis 2](#) and [Working Thesis 3](#). Let the learner be aware of it being provided while tool utilisation, anonymity eases the mind of thoughts of the impact of decisions that could be perceived negatively by others, hence allowing swifter achievement of incidental tool utilisation. Additionally, anonymity may provide an incentive as students could perceive themselves to be valued as responsible persons, since anonymity could also be misused in various ways. In the positive sense, the perceived value should encourage autonomy as learners are given more room for free development and exploration. – In the sense of this paragraph, Working Theses [2](#), [3](#) and [4](#) are strongly interwoven.

As seen in this chapter, many aspects and ideas are subjective and unproven. Hence, the four theses presented shall be investigated, and proved or disproved in the remainder of this dissertation. As tech-free scenarios shall be deemed sufficiently under investigation in classic didactics research, and tech-full scenarios shall be deemed under heavy investigation by tool developers, the focus of this dissertation shall be on the intermediate tech-enhanced scenarios.

2 EXISTING CONCEPTS

'Self-education is, I firmly believe, the only kind of education there is.'

Isaac Asimov



EXISTING CONCEPTS

Before the focus can shift to the alluring aspects of TeEdu to be introduced in [part II](#), some fundamentals have to be considered. Therefore, classic didactics concepts of learning phases, on-site class structures, as well as learning platforms shall be briefly recollected. Also, some aspects of motivational psychology should be touched as they help lay foundations for users' perception and utilisation of TeEdu tools.

From the vast field of didactics (which is more than a subset of educational psychology), only a selected range shall be investigated in order to position this work within the field. Hence, a center point for lecture and class design shall be provided by Eric Mazur's *peer instruction* concept. The continuation of peer instruction into the TeEdu area shall be triggered by an extended overview of self-regulation. Thereafter, a brief investigation into motivational aspects of (online) learning platforms shall prepare a concept of tech-enhanced, combined on- and off-site as well as anonymously usable tools, enhancing on-site university tutorials⁴.

2.1 PSYCHOLOGY

Comment

Please note the usage of technical terms from psychology. If uncertain, please refer to the glossary (↪ [page XLVII](#)) or specialist literature since some terms can be ambiguous as their meaning differs in computer science and psychology contexts.

2.1.1 Self-Regulation and self-regulated Learning

Comment

This section closely reflects on Zimmerman's original publication on self-regulation as a social cognitive theory of behaviour. ↪ [\[ZBPZ00\]](#)

The aspects that are going to be presented on peer instruction (↪ [next subsection](#)), learning platforms (↪ [subsection 2.2.1](#)), and motivation control (↪ within [subsection 2.2.1](#)) can be woven together by deriving from the same psychological concept spanning them, namely self-regulation. However, this is to be taken very loosely. Let each aspect be a conceptual set, then self-regulation *can* span a selected set union of subsets of the conceptual sets.

Self-regulation was a buzz word in psychology in the 1980s and since has had contributions vastly spread over all areas of psychology. Appositely, self-regulation has been under investigation in the field of education since the 1990s, so a parallel development to peer instruction is cognoscible, even though both do not share much common ground at first glance. Nevertheless, when engaging a vantage point focused more on behaviour, certain aspects of peer instruction fall in line of self-regulation, especially when taking into consideration behaviour as part of motivation control. As is true for volition as an inner state of a person, Zimmerman argues self-regulation to be a 'self-directed and feedback controlled [. . .] part of a general social cognitive theory of behavior' and that 'regulatory skills, or lack thereof, are the sources of our perception'. From a social cognitive perspective, self-regulation is a triadic process interaction of personal, behavioural, and environmental nature. The triad of self-regulation forms is depicted in [Figure 2.1.1](#).

⁴ University readings shall be taken into comparison in the following [chapter 3](#).

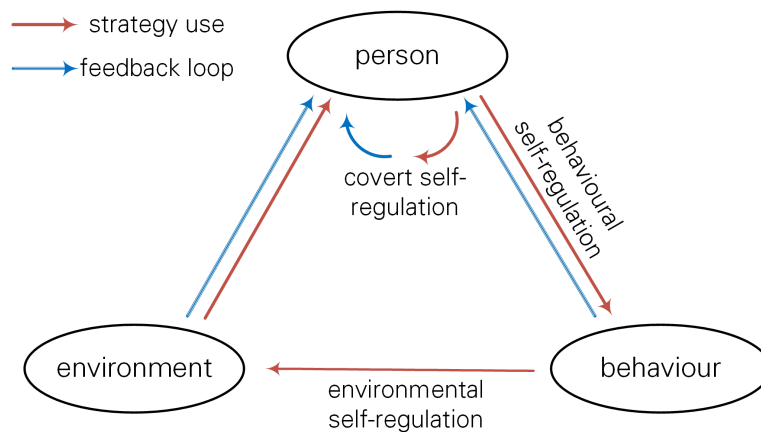


Figure 2.1.1: Triadic forms of self-regulation (revamped from [ZBPZ00]).

Beyond behavioural skills, self-regulation includes a priori knowledge of [agency](#) to enact skills in relevant contexts, as well as a deterministic sense thereof. With respect to (personal) goals (→ [subsubsection 2.2.1.1](#)), self-regulation includes self-generated thoughts, feelings, and especially planning and conduct of actions aimed at fulfilling those goals. Zimmerman argues cyclical adaptation, which falls into conjunction with revolving learning phases (as to be seen later; → [Wah13]).

Similar to the aspect of motivation being a personal process, self-regulation also depends on each individual's motives, traits, abilities, and competence. The self-regulatory process is internal and hence covert, but – as is true for motivation – can be observed in its results through the individual's actions. However, self-regulation is not instantiated in itself, but it depends on a person's conscious or unconscious decision to self-regulate. Therefore, from the exterior observer's point of view, some of the individual's performances may be self-regulated, while others are not.

Comment

The statement on observability and (un)conscious decision to self-regulate or not, engages a computer scientific vantage point of one form of self-regulation to be not to self-regulate. The conceptual idea is similar to error processing: the simplest type of error processing is not to process errors, that is ignore errors.

As is true for learning phase revolutions, self-regulation is dependent on cyclical processing. However, a better fitting technological analogy would be an open loop control: feedback from a prior (self-regulated) performance is utilised in order to adjust the next, or if applicable the current, iteration. W.l.o.g., improving adjustments are considered. As is true for control loops, self-regulation thereby relies on observation and evaluation of the current performance, allowing strategic planning of adjustments based on an idealised condition. The idealised condition is best compared to the idealised (and often simplified) system model in control loops. This type of self-regulatory control loop can be identified in all forms of the triadic self-regulation, namely there is a behavioural control loop, an environmental control loop, and a covert (inner) control loop. For example, behavioural self-regulation can be found in a student who may self-regulate by rearranging topics along an importance discriminator like due-date⁵. An example for environmental self-regulation can be found, when a person is introduced into a new clique and starts adapting their language,

⁵ This should also be considered as an example of self-regulated learning.

clothing, et cetera. However, behavioural and environmental self-regulation restricts the reflection on observable actions. On the unobservable side, covert self-regulation is also possible. It is based on (internal) monitoring, evaluation and adjustment of cognitive and affective states. Continuing the technical analogy, the underlying system model dictates the quality of the self-regulation: the more accurate, the more frequent, and the more constant the self-monitoring can be matched to the model, the better the effectiveness of planning and adjustments. Also, the higher the ratio of adjustments with positive outcome to ones with negative, the better the expected influence on individual self-beliefs. In this sense, failed self-regulation can be demotivating and lead to dysfunctional outcome. As each iteration of self-regulation changes not only the internal state of individuals, but also influences the measurand thresholds benchmarked against, the self-regulatory control loop may never be considered closed. Hence, the technical analogy adapts an open loop control, not a closed loop control. Such measurand thresholds can be any type of variable goals and tasks. For example, self-regulated learning can (and should) influence the set learning goal; if the self-regulation process is successful (unsuccessful), the goal should be adjusted to more advanced/complex (regressive/simple) topics.

The cyclical self-regulation process follows a repetitive parsing of forethought, performance or volition control, and self-reflection (~ Figure 2.1.2). The forethought phase involves processes preceding efforts to act, building up volition and moving toward a fiat tendency. The performance or volition control phase involves any motoric process affecting attention and the action itself. After concluding an action, the self-reflection phase becomes active and influences the individual's perception of and response to the outcome of the action. Lastly, closing the self-regulation cycle, the results of the self-reflection phase influence forethought on follow-up processes.

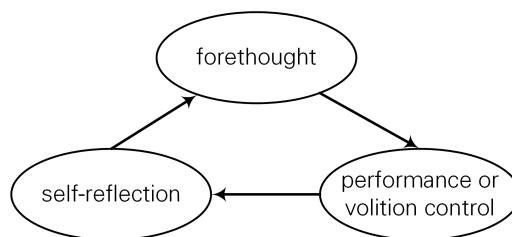


Figure 2.1.2: Cyclical phases of self-regulation (revamped from [ZBPZ00]).

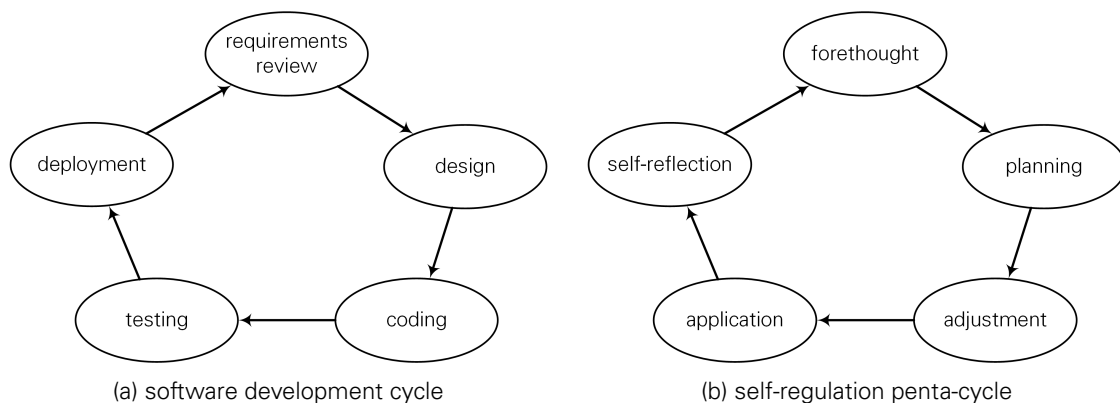


Figure 2.1.3: Comparison of the software development cycle to an expanded self-regulation cycle.

Interestingly, the self-regulation process can be easily compared to the software development cycle. The comparison to the software development cycle (~ Figure 2.1.3a) becomes obvious

when expanding the classic cyclical phases of self-regulation into a penta-cycle (→ [Figure 2.1.3b](#)) by splitting the performance or volition control phase into planning, adjustment, and application.

Continuing the comparison, the forethought phase (requirements review) can be divided into two types of sub-processes: the analysis of the task at hand, and the analysis of the own skills. Next, the planning phase (design) involves imagery as well as developing (designing) and following success or error avoidance strategies. Within the adjustment phase (coding), experimentation and focussing are required, and if need be, an instruction set needs to be adapted. In the subsequent application phase (testing), the results of the preceding phases are applied, or at least it is attempted, and the performance is observed and recorded for future optimisation. Finally, self-reflection (deployment) is triggered, wherein the results are judged (evaluated) and possible reactions (customer satisfaction) are triggered.

Comment

One should note that the comparison fails to match the phases one on one. Actually, the software development cycle should be shifted by half of a phase counter-clockwise, and even then testing and deployment don't properly align. However, the intention of the comparison is to make the self-regulation cycle better accessible to computer scientists. Therefore, this comparison shall be accepted as it is presented.

Re-contracting the self-regulation penta-cycle into Zimmerman's original tri-cycle, the before-mentioned sub-processes can be summarised into [Table 2.1.4](#).

cyclical self-regulatory phases		
forethought	performance or volition control	self-reflection
task analysis goal setting strategic planning	self-control self-instruction imagery attention focussing task strategies	self-judgement self-evaluation causal attribution
self-motivation beliefs self-efficacy outcome expectations intrinsic interest/value goal orientation	self-observation self-recording self-experimentation	self-reaction self-satisfaction and associated affect adaptive or defensive inferences

The original table can be found in [ZBP200].

Table 2.1.4: Phase structure and sub-processes of self-regulation

It becomes obvious that the forethought includes two intersecting, however distinct types: task analysis and self-motivational beliefs. Task analysis involves setting personal goals or wishes, namely desired outcomes to actions such as learning. Often, goals build on each other hierarchically, having lower goals act as multipliers for higher goals (reaching a goal is an incentive for higher goals), allowing progress observation for individuals. Aside from setting goals, task analysis also involves strategic planning, outlining a clear path of actions required to fulfil a desire. Such strategies are purposive and aim at acquiring, enhancing, and displaying specific skills. Pressley argues that appropriately selected and applied strategies aid cognition, control affect, and direct motoric execution, thus enhancing performance [PW95]. This induces individual outcome for each person, hence no self-regulatory strategy is applicable for all persons in the same way. However, also no single strategy is applicable for all tasks and processes an individual may face. As mentioned earlier, self-regulation is an open control loop process, thus no single strategy is able

to endure any set of subsequent tasks unmodified. This especially yields that all self-regulating individuals are continuously forced to adapt their strategies with progress. Zimmerman argues that 'self-regulatory skills are of little value if a person cannot motivate themselves to use them'. Of course, this is true with respect to motivation control, hence once again a parallel can be drawn. Coming from that vantage point, self-motivational beliefs therein produce the second type of forethought, including self-efficacy, outcome expectations, intrinsic interest or valuing, and goal orientation (↔ [Table 2.1.4](#)). Self-efficacy is part of the model of one's own abilities to effectively plan, adapt and perform; basically providing thresholds for self-benchmarking. Outcome expectations are part of the extended model including known or assumed statements on possibilities for outcomes of actions and processes. These model assumptions for themselves allow Zimmerman to propose evidence for self-regulated learning, as – on an academic level – self-efficacy and outcome expectations influence time management, peer pressure, self-monitoring, self-evaluation, and goals as well as desires. Considering learning as a life-long process, self-motivational beliefs are also applicable over the boundaries of single self-regulatory cycles, thus potentially having intrinsic interests or values surpass extrinsic influences. Based on such a value system, the goal orientation is subject to self-motivational beliefs.

Following the self-regulatory cycle to the next phase, performance or volition control processes can be either of self-controlling, self-observing or mixed nature. On the one side, self-control basically involves self-instruction, imagery, attention focussing, and task strategies, on the other side, self-observation involves self-recording and self-experimentation. The latter two are aimed at (c)overly describing task execution by tracking specific aspects of one's own task execution, while the prior four aim at focussing and optimising the task execution itself. Within the type of self-control, self-instruction aims at (c)overly describing proceedings of task execution (the 'how to'), while imagery aims at mental pictures of task execution (the 'how could'). Attention focussing aims at gating external events and covert processes, maximising available attention resources toward the task at hand. Reducing tasks to their essentials and reorganising those parts into a result maximising order is involved in task strategies. For the type of self-observation, self-recording aims at 'increas[ing] the proximity, informativeness, accuracy, and valence of information at the point it occurs, structur[ing] it to be most meaningful, preserv[ing] its accuracy without need for intrusive rehearsal, and provid[ing] a longer data base for discerning evidence of progress' [ZBPZ00]. This means an individual is able to realise and recognise progress within a task or process, as well as in a successive set of tasks or processes. Specifically, this allows pattern recognition and adequate adaptations in order to enforce (make use of them), or cease and desist certain patterns (terminate bad habits). Of course, such enforcement/ceasing *can* lead to extended or cycled self-experimentation. Adapting behaviour may not immediately lead to determined changes in expected outcomes (for example within the before-mentioned hierarchically arranged subgoals), however a winning strategy may be to systematically change specific aspects of behaviour one at a time, and observing the influence on the outcome. Of course, this induces a certain immediacy of the entire self-observation and self-control processes, thus temporal proximity, informativeness, accuracy, and valence of behaviour feedback is imperative. – Please refer to Zimmerman's list of references in [ZBPZ00] for more details.

Finally, in the last untouched phase of self-regulation, namely self-reflection, once again two types can be identified: self-judgement involving self-evaluation of one's own performance and causal attribution of result significance, and self-reaction involving self-satisfaction and associated affect as well as adaptive or defensive inferences. Both types are highly correlated with self-observation as it provides the data base for reflection. Self-evaluation therein is the process of comparing the (self-observed) outcome of an action with the preset goal or desire, while causal attribution links the outcome to potentially responsible factors within one's planning or conduct, may they be promoting (positively influencing) or penalising (negatively influencing) the outcome. Judgement is based on four distinct criteria: mastery (scaling from novice to expert), previous performance (benchmarking current outcome to previous outcome(s)), norm (comparing to social surrounding and performance of others), and collaboration (benchmarking role fulfilment within a team). Once judgement has been passed, self-reaction emerges. First of all, self-(dis)satisfaction and the associated affect directly influence one's future basis for similar decisions, especially in the next forethought phase. As is true for dopamine ('happiness hormone'), the degree of influence

on future decisions as well as future reception of the same is variable, but in general decreases for the same discharges of the same magnitude. Hence, conducting the same task or process repeatedly (that is reaching the same goal) becomes less fulfilling over time. This is why people in general tend to seek positive outcomes and strive for higher goals once a (lower) goal has been accomplished. Of course, this requires tasks and processes to be valued along an intrinsic importance scale. On that scale, different but however similar tasks may have significantly different intrinsic value. Once an individual has reached a conclusion on the value of the outcome of an action and is (dis)satisfied, conclusions on adaptations for future conducts are considered. These conclusions for modifications to the self-regulatory cycle of subsequent actions are adaptive or defensive inferences. The before-mentioned striving towards higher goals is a typical adaptive inference as it modifies the self-regulatory process toward a potentially even better outcome. On the other side, defensive inference aims at protecting oneself from future (especially *to be expected*) dissatisfactions.

It is obvious that the described self-regulatory process can be applied to educational settings by replacing the universal terms 'action', 'task', and 'outcome' with terms associated with learning and teaching. Teachers and students can (and should) adapt their conduct on a self-regulatory basis in order to maximise efficiency of education. However, for the remainder of this dissertation the aspect of self-regulated learning on the students' side shall be considered, whereas the teachers' side shall not be investigated in further details (but not ignored).

2.1.2 Peer Instruction, Peer Discussion

A well-established method of designing on-site lectures, namely peer instruction, was conceived by Mazur et. al. in the 1990s and has been continuously researched ever since [Maz97, CM01, FCM02, CWFM07, LMW08]. It is applicable in a wide range of situations and for a large scope of different class sizes [FCYM00]. The basic idea is to not have students in an ex-cathedra teaching situation, but to allow frequent recollection of material during classes. Starting from the classic tiers of learning, for example the 'bonbon model' and similar constructs [Mar03, Sis12, Mie07], a principle of interlayering learning phases like a sandwich has emerged [Wah13]. Mietzel, Martens and Sistermann's approaches can be summarised into a tier model like:

- *introduction* into the topic,
- *motivation* for the topic,
- *identify challenge* within the topic,
- *intuitive, uninstructed solution* to the challenge,
- *constructive, instructed solution* to the challenge,
- *autonomous reconstruction* of the solution,
- *training and consolidation* of the solution method,
- *expansion* of the method context and *transfer* on similar contexts,
- *construction* of further knowledge within the topic, and finally
- *ability to explain and discuss* within the topic.

In shorter terms LRCT(E): listen, reproduce, construct, and transfer (and if applicable: explain). Wahl's idea takes the LRCT tiers and rearranges them into revolving phases, taking also into consideration aspects such as attention span or motivational varies. Basically, attention spans call for regularly changing the students' activity (for example [B_R01]), and motivational varies call for regularly providing new incentives (for example [HG87]). Hence, rearranging into revolving phases allows for timely changes of activity while providing opportunities for appropriate incentives. The interesting question at hand is whether the revolving phases are designed as LRCT, or if the students are forced into carefully considering what they have learned by trying to convince their fellow students of what they think they have understood, namely revolving LRCTE. Mazur's peer instruction concept follows revolving LRCTE.

A good application example of peer instruction is provided in [LMW08] and can be summarised as in Figure 2.1.5. The goal is to involve all students as good as possible in the lecture by tasking each individual a mandatory explanation of their understanding of the presented concepts to their fellow students. Application of the concept demands a prior structured test that is addressed at all students, hence preventing only involving highly motivated strivers and nerds answering, as informal direct vis-à-vis questions would. Aside from challenges with strivers/nerds, diffident and/or insecure students could be demotivated by being exposed to direct questioning, openly visible to all fellow students.

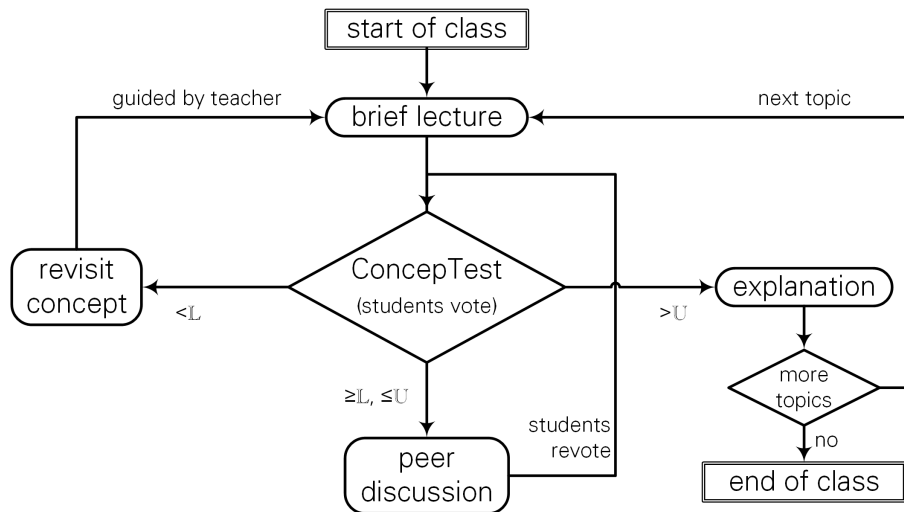


Figure 2.1.5: Basic flow chart of peer instruction. The thresholds L and U need to be determined, but can be adjusted dynamically.

In order to apply peer instruction in a class, the traditional linear presentation needs to be replaced by a division into a series of short (self-contained) topic units, therein following a defined set of rules known to the students. Each unit commences with a presentation highlighting one specific aspect of the class' topic. Each short presentation is followed by a directly related conceptual question ('ConceptTest' in Mazur's original work). All students should submit an answer within a minute or two. The answers are not graded and do not influence the students' assessment, but are utilised to benchmark their (current) understanding of the topic's aspect in question. Let the benchmark be B , then with respect to the percentage of correct answers, three possible outcomes are designed: a lower threshold L is not surpassed ($B < L$), the benchmark performs within L and an upper threshold U ($L \leq B \leq U$, $L < U$), and U is exceeded ($B > U$).

For the two thresholds the next step is easily determined: the topic is revisited under supervision of the teacher iff $B < L$, and the next topic is introduced iff $B > U$. However, iff the students perform within the thresholds ($L \leq B \leq U$), the students are ought to discuss their answers with their (direct) neighbours in *peer discussions*. The values for L and U must be adapted to the context, topic, goal, et cetera, however as a rough rule of thumb, Mazur's research findings suggest $L \approx 30\%$ and $U \approx 70\%$.

The idea of peer discussion is for the students to try to convince each other of the correctness of their own answer. This addresses the learning tiers expansion, construction and mainly the ability to explain and discuss. The discussions are not supposed to last longer than two to four minutes. During the discussions, the teacher is supposed to roam through the class room and listen to as many discussions as possible, memorising the arguments used. After the discussion time has concluded, the teacher ends the discussion and calls for the students to answer anew. Students can change their answers in response to the discussion, especially if their position has

changed based on the arguments of their discussion partner(s). Afterwards, the teacher explains the answer and moves on to the next topic.

In Mazur's original design of peer instruction, students are not assessed based on their ConceptTests results. However, they can contribute a credit to their final grade by consistently participating over the semester. A strong incentive to participate is provided by having the midterm and final exams include a significant number of questions verbalised identically or similarly to the ConceptTest questions.

It should be noted that the time required for the conceptual questions needs to be skimmed from the fixed class time available. Generally, this is only realisable by outsourcing parts of the lecture, namely by having the students read on the topics before class. As Mazur states '*learning from reading is a skill well worth developing, particularly because after college a great deal of ongoing learning takes place through reading*'. The problem herein is the progress in studies of the students: juniors may not be as aware of the importance of reading as sophomores or seniors. In order to provide an incentive to read, the students receive credit for answering a few control questions. These questions include the key aspects of the material and are designed to help the students immerse into and think about the material.

The concept of peer discussion shall be revisited later. In combination with aspects of learning platforms (→ [subsection 2.2.1](#)), a new concept for tech-enhanced peer discussion outside of the restrictions of peer instruction will be introduced in [part II](#).

2.1.3 Learning Process Supervision: Learning Demand Assessment

Comment

This subsection is a shortened German-to-English translation of [Bau07]. Additional material from [BEH+96] is used for explanations.

Nowadays, traditional forms of instruction are more and more replaced by a learning process supervision (LPS) in which teachers exacted more than ever. LPS consists of several (learning) steps: demand assessment (LDA), path determination, task design, progress observation and support, result evaluation, and result documentation. The first two yield equally shared activities for teachers and students, the latter four a fortiori involve the teachers since students are incapable of passing them on their own. After a short discussion of the phases, the focus shall be set on the LDA. Nevertheless, the entirety of LPS as well as all steps therein are demanding for the teachers as LPS is a type of supervision requiring a high degree of methodic, social, and personal (mental and emotional/empathic) presence.

The six steps of LPS roughly represent the ideal chronological execution, but the boundaries are vague. They rely on each other and are never clearly separable. In the first step, LDA, the student's individual learning goals are determined together with the teacher. Based on these goals, individual learning demand is defined. Based on the learning demand teacher and student then stipulate a learning convention as well as a learning path within this convention. Focussing more on the teacher, the third step then requires selection of tasks suitable for the learning path and, if needed, adaptation of the tasks as well as rearrangement into individualised learning sets that can be handed to the student. In the following fourth step the teacher needs to observe the student's learning with the given tasks, probably assisting with learning barriers. After the student has solved the tasks, the teacher should evaluate the results together with the student rather than only presenting a mark. Finally, the teacher needs to assist the student in documenting their results in order to allow and foster consolidation and dissemination of the acquired knowledge. In many aspects these steps are methodically similar, all requiring situative, alert and empathic cognition of the topical requirements. For example, LDA may be demanding in early phases of degree programmes, but revisiting and adjustment/redefinition of learning demands during the

conduct of the programme is imperative as interests may shift, but also the requirements may alter with each newly assigned task.

Regarding content and methodology, the spine of LPS is the orientation toward individual development of each student. Rather than a static or at most selectively adapted curriculum, this requires a systematic and continuous redefinition of learning goals in order to match the changing learning demand over the entire programme, ideally with each new task. The redefinition as a per-demand adaptation has to respect any influencing factor, especially those individualising each student. Static factors influencing all students include but are not limited to: desired degree, programme regulations, pre-defined learning goals, reference projects, task analyses and requirements, training philosophy, bad (prior) experiences, peer expectations, et cetera. Beyond the scope of the static factors, individualising factors dominate the redefinition process. Individualising factors include but are not limited to prior knowledge, personal experience, fears and proclivities, personal conduct, et cetera. Therefore, students and teachers together must determine what adaptations are personally required in order to maximise success with the current learning goals. In general, this includes personal strengths as well as weaknesses, allowing for shifting focuses in tasks, but also targeted learning in order to address weaknesses. This also allows early identification of possible learning barriers. Additionally, teachers are enabled to attribute further education goals, so-called *soft-skills*. During the demand assessment they can identify key skills and competences correlated with the learning path. This is important, as modern education is expected to not only provide students with knowledge in their field, but also to help them learn important desirable conduct such as being autonomous, reliable, responsible, flexible, team-minded, et cetera. In general, such soft-skills are not part of the general curriculum, but they are part of the education assignment. In order to foster them, they need to be included in the best possible fashion, mainly by integrating individual adaptations of the learning tasks.

Another imperative part of individual learning demand assessment is the learning behaviour. In order to optimally adapt a student's learning path, the teacher must understand how (and when) a student learns best. They need to understand with which methods their student succeeds, with which they apply avoidance strategies, and with which they can be successfully motivated. Ideally, the teacher supports their student's self-reflection capabilities, enabling them to identify their learning patterns and adapting them on their own. In short, students and teacher together need to know how they can optimally encourage learning processes.

The very practical application of learning demand assessment relies on the following three areas of experience and perception.

- Experiences with learning and working conduct, learning and working results, and all as-sertable learning and conduct deficiency therefrom (from the teacher's perspective). This includes mistakes, mishaps, scheduling problems due to repetitive failure, handling of criticism, information policy, quality defects, et cetera.
- Perception of insecurity, helplessness, hesitation, frequent questions, attempts at getting around tasks, plenty of misunderstandings, symptoms of excessive demands, et cetera.
- Perception and experience with reactions of others toward the conduct of the student (for example peer conflicts, discontented practice partners, et cetera).

All of these are symptoms of learning demand, but in part also of learning desires. Students may not have mastered a learning aspect yet, or they are insecure about their mastery.

Of course, an LPS aimed at fostering self-regulated learning processes (↪ [subsection 2.1.1](#)) must focus on the question of what is necessary in order to enable the student to autonomously identify their own learning demand. Sadly, teachers often develop an attitude of imposing assessments on students, thus being solely responsible for the assessment. With young adults this type of imposition is equal to an incapacitation and most generally leads to a betrayal of trust. The LPS degrades to a manipulative conduct in which the teacher dominates the student into a certain direction. Of course, such manipulation can lead to a total loss of trust and confidence of the student in their teacher, ultimately refusing to learn with and from them. In contrast, when

fostering the student's autonomy, having them understand the learning process as their own responsibility, a trustful learning partnership can develop. The student learns to learn what they have understood not to have learned, yet. Any decision concerning the learning path is made conjointly as forcing a certain path would lead back to the negative effect described earlier. On the opposite, any consequence resulting from the path taken is within the student's responsibility, which can either foster their self-confidence (positive self-regulatory effect), or demotivate them (negative self-regulatory effect). The teacher's assignment is to ensure a positive outcome by providing effective learning means and support whenever required (as described earlier). In order to facilitate a maximum of positive incentive, the teacher must disclose all observations and conclusions when discussing learning goals and paths with the student.

It is imperative to support students in their individual learning demand assessment in order to foster their development to autonomous persons, especially enabling them to confidently approach self-regulated learning.

2.1.4 Cognitive Activation

As seen in the previous subsection, cognitive processes are an important part of decision making and motivational processes. Therefore, the critically discussed term of *cognitive activation* shall be briefly discussed here, even though it is hard to provide a brief description for cognitive activation, as this concept is rather new and of topical interest. However, the coarse idea is, as learning requires constant linking of new information to already present information, that students are able to learn more efficiently when they are enabled to use incoming information to activate information they have already consolidated. The new information then is more integrally linked to the consolidated information. In this sense, any form of teaching is *cognitively activating* when it stimulates students to actively engage new information in a personally optimal fashion (for example [BK00]). A source of dispute is the level of stimulation required; this remains an open research question. Nevertheless, as long as teaching methods are able to encourage students to engage the learning process on a cognitively higher level, they are able to engage newly learned information with their own ideas, concepts, symbolism, et cetera, based on their previous knowledge. This can be considered evolutionary learning [HPR07], but requires consideration of learning processes to be constructivist. Therefore, solving problems or exchanging solutions with peers seems to be better suitable than knowledge derivation along open questions. This should not be mistaken for the presence of competence [Leu11] (for example the competence to solve a mathematical problem); rather, activation and competence are complementary concepts. While activation aims at effective knowledge transfer, competence aims at knowledge consolidation. Thus, activation is a means for effectively achieving in all areas of competence:

- Declarative and procedural knowledge – compare mastery
- Strategic knowledge – compare problem solving and modelling
- Beliefs knowledge – compare utility and quality of consolidation
- Personal and social knowledge – compare acceptance and distribution

For didactics, this means that learning goals must be devised in context of desired competence. Based on these desired competences suitable activation strategies must be considered. Not referencing strategies to goals is dangerous and can have negative repercussions, for example improper focus on certain aspects. Therefore, current research attempts to respect all four competence areas when considering cognitive activation. An increase in technical knowledge is fostered by cognitive activation aimed at effective and sustainable consolidation, problem solving competence is fostered by cognitive activation aimed at application, et cetera. However, it should be noted that the third and fourth area are often only considerable in broader context of technical didactics, especially extended educational objectives.

As students are supposed to actively engage new information in a personally optimal fashion, the definition of cognitive activation means must respect the students' individual preconditions. This requires adaptive learning scenarios capable of serving homogeneously mixed student groups.

2.1.5 Note on Gamification

Gamification is closely related to motivational and self-regulatory aspects of learning. It focuses on combining aspects of games (fun activities one is voluntarily willing to spend time with) with non-game activities. The focus of this dissertation does not align with gamification as the intention is not to conceive and develop yet another gamified learning platform. Motivational and self-regulatory aspects are appreciated, but the entire concept of games shall be clearly confined. Therefore, gamification shall not be investigated beyond what is presented in [section 3.2](#), and it shall be assumed that the reader is familiar with gamification. If this assumption is wrong, please refer to Sebastian Deterding's definition [[DDKN11](#)], and Philipp Herzig's work on recent formidable applications [[Her14](#)]. Further details on gamification within [section 3.2](#) are described in detail by Lars Beier [[Bei14](#)].

2.1.6 Note on Blended Learning

Blended learning is a type of learning environment design. It aims at replacing traditional learning environments; a goal it shares with the focus of this dissertation. However, in blended learning students are supposed to learn in part exclusively in a digital or even online environment. This especially means that certain learning material is accessible outside of on-site activities only. Conversely, this also means students have (limited) control over time, location, pace, and path of their curriculum. In general, on-site activities are combined with activities relying on computer support. Therefore, blended learning shall not be investigated within this dissertation beyond mentioned shared goal, as the desired focus is amending traditional learning environments – having students' utilisation of such amendments voluntary, not compulsory – without departing from them, especially making learning success not depend on utilisation of amendments, but merely increasing it by doing so. It shall be assumed that the reader is familiar with blended learning; if not, please refer to Norm Friesen [[FH10](#)] for a brief discussion and a very comprehensive list of references.

2.2 COMPUTER SCIENCE

2.2.1 Learning Platforms

Comment

This subsection is based on an undergraduate pro-seminar research contribution provided by Sebastian Fehrs. ↪ [[Feh14](#)]

Interactive learning platforms, e-learning tools and interactive tutorials benefit from a growing impact in day to day situations, for example visiting a modern art exhibition often is accompanied by a special guidance app. Especially the loose coupling of time and space, options for own learning speed, progress-independent selection of topics, repetition of topics, as well as low costs make such platforms and tools attractive. However, they can have a negative impact on the learning process if few or no instructor feedback is provided, especially by lack of instruction, correction of errors, and especially motivating feedback [[CM01](#)]. Therefore, strategies for controlling of learner motivation must be developed, aiming at positive incentives [[CJ10](#)] and maintaining high motivation levels, while at the same time considering manifold factors such as (graphical) user interface design, phrasing of tasks, learning goals/targets, or even topic scope. Regardless of the type of incentives targeted, their usage must be well considered time-wise as well as count-wise. Too often, too seldom, too early, too late; slight derivations can have huge impact and negatively influence the outcome. In order to come to an educated decision, the first focus must always aim at

the concept of the platform (and with that the type, of course). The concept dictates the means for motivational incentives [LLY10]. Research in motivational psychology is applicable here.

In general, learning platforms can be split into two categories of software systems: learning management systems (LMS) and e-learning systems (ELS) [Sch05]. LMS include management and distribution of lecture material, but differs from simple collections thereof by adding functionality with respect to (encrypted) user management, course management (lectures, content, files, ...), role and right management, community and communication tools (chat, forum, ...), or learning aids (annotations, bookmarks, ...). In the other category, ELS are designed to contribute to or replace location- and/or time-dependant lectures, hence they include tools and/or digital media in order to support interactivity (allowing users to influence their learning process), multimedia (learning contents are presented in different media), multi-modality (aiming at different senses, especially auditive and visual), as well as multi-coded content (aiming at accessibility, barrier-free content). With respect to LMS and ELS, Schulmeister concludes that the so designed learning overcomes the barriers of location and time, making the learning process and experience more flexible and valuable for the learners [Sch05]. Of course, similar conclusion may apply to the teachers. Further, barriers regarding analogue/digital content can be overcome, allowing easier distribution, visualisation and linking of learning objective. Finally, the norm barrier can be overcome due to individualisation of the learning process, which takes into account for each individual learner, but is not limited to, personality, diversity, participation, disabilities, et cetera. This is not possible in classic group-based education settings. However, the disadvantage of learning platforms can be found in lack of instruction as the role of the teacher is reduced to maintaining the platform and indicating its usage, hence didactic instruction must be presented within the platform, allowing the learners to regulate themselves. Considering this, motivation and incentives become eminently imperative even more.

Excursus: Motivation Control

Examining learning platforms from a motivational psychological perspective, all fundamentals of motivation theory still hold true. Traditionally, these fundamentals are divisible into motive, motivation, volition, and action. Each fundamental is based on the preceding.

Starting with the motive, it represents an (internal) attitude toward an objective a person is aiming for. Attitudes can spread a large range, but commonly agreed motives span from instincts such as self-preservation to achievements like a certain desired life style. Independent of the motive itself, motives are not directly observable in general; they can only be deduced from behaviour and actions. Hence, any motive may induce an action readiness. Such induction is called motivation and is always strongly correlated with a definable situation, restricting its occurrence to a very narrow time frame. As it is restricted in that manner, motivation is commonly defined as either intrinsic or extrinsic. On one hand, intrinsic motivation arises from the prospect of internal gratification, namely having a person's own actions lead to achieved fun, satisfied curiosity, or accomplished challenges. On the other hand, extrinsic motivation arises from the prospect of externally induced gratification or lack of punishment, namely having the acting person anticipate from a situation either a direct or indirect advantage, or fewer disadvantages. Such (dis)advantages can be of material or immaterial nature. In this sense, extrinsic motivation can also yield negative stimuli. Regardless of type of motivation, once motivated, a person may develop an intent to act. Such intent is the first step in the process of volition, which – besides the intent – includes planning the action itself, and finally an impulse that leads to overcoming underlying action thresholds and initiating the actual action. Finally, this action is any type of observable behaviour in (interpreted) context of the prior three fundamentals; as a reminder, a planned, subjectively reasonable and purposive behaviour.

In order to influence a learner's motivation positively, the process leading from motive to action shall be investigated a bit further. This is necessary as motivation directly influences concentration and hence also receptiveness, which is a key to successful learning. In [HG87] a volition

model with significant pre-decisional and post-decisional phases is suggested. It provides a starting basis as the model allows envisaging four phases, each underlaid by one or more motives, leading to an action and/or follow-up actions: consideration, planning, action, and assessment.

Within the first phase, *consideration*, motives are analysed with respect to their potential (subjective) value as well as their prospect of success. Basically, consideration can be described by expectation/value ratios (EVRs) as suggested as early as in [Atk75] (1975). In didactics, one can argue that students' motivation is observable in their readiness, endurance as well as their respective choice of tasks (if applicable), and is directly correlated with the students' expectations toward success and their subjectively estimated value of the tasks at hand. In the end, they will formulate a desired outcome that in return triggers an intention as described above. In [HG87] this first step toward overcoming the action barrier is literally compared to crossing the Rubicon, hence the suggested model name is 'Rubicon model'.

Once consideration concludes in an intention, planning follows seamlessly. The concluded intention is considered an irrevocable commitment, therefore pre-action volition is inevitable. During planning the volition is used to develop a strategy for how to actually succeed with the actual action and how to potentially maximise the estimated positive outcome⁶. The result of planning is the fiat⁷ tendency, which is a subject-dependent decision container based on situation and personality factors. It represents the resolution of beginning an action in the pre-determined value context. The value can (and should be) derived from the container.

As soon as the fiat tendency has kicked off the execution of the action, the pre-decision volition is replaced by the actional volition. In order to successfully conclude the action, the magnitude of the volition needs to be sufficiently high in order to establish enough momentum to continuously consider the effort worthwhile. In this sense, the volition can be considered a measurand for the commitment mentioned earlier.

Once the action has concluded or is about to conclude, post-actional volition emerges in form of the assessment. Within assessment the action's outcome is evaluated and weighed against the initial desired outcome. The outcome is considered to elevate positive primarily iff the outcome overall is beneficial for the acting person, and secondarily iff the outcome envisioned during planning matches the actual outcome, ideally congruent with each other. The primary evaluation helps value the outcome itself and provide direct positive stimuli, whereas the secondary evaluation helps future planning by benchmarking and fine-tuning the knowledge on which planning strategies are based on. In this sense, assessment is imperative for future motivation and aids electing realistic intentions.

Motivation Control in Learning Platforms

Application of the before-mentioned on learning platforms is straight forward. One may assume that the learner's motive to successfully internalise learning contents is a priori present as the learner has already concluded into first action by utilising the learning platform. Therefore, learning platforms should focus on supporting the following transition of motive into motivation to continuously utilising the learning platform. In order to develop successful strategies for learning platforms, the following important factors should be considered: target audience, contents, education objectives, didactics methods, and design patterns. The target audience must be defined in order for the learning platform to successfully meet the learners' expectations toward the learning environment, as well as addressing the learners' familiarity with computers, et cetera. Next, the contents are to be curtailed and structured with respect to their information, tasks, learning questions, et cetera. By doing so, the education objectives can be set at the same time by especially defining properties the learners must have acquired after successful learning experience.

⁶ Of course, when considering actions aimed at potential negative conclusions, planning allows potential minimisation of expectable negative repercussions.

⁷ Latin *fiat*: 'let it be done'

Commonly, the so set education objectives purport appropriate didactics methods of instruction and presentation, but also reproduction. Often a selection of design patterns (approved scenarios, education methods, rework techniques) can be applied to the learning platform based on the purported didactics methods.

In combination with the motivation control phases described earlier, these factors allow conceiving a concept for positive motivation control. From the Rubicon model the therein focused phases shall be consideration and assessment, as these inevitably impact motivation within the context of learning platforms. One such model is presented in [Atk75] with the risk-choice model (an expectation-value product model); it is directly applicable to learning platforms. As discussed earlier, motivation arises from consideration of (subjective) value of the objective and/or task, and the (subjective) probability of a successful productive action. Hence, any difficult tasks must adhere a higher value than a simple task. However, this is subjective to the character and motive of each learner, hence the applicable incentives are subjected to fluctuating impact on motivation gain. Therefore, it is imperative to have consideration yield an attractive value-expectation product that imposes a definite intention at the end of consideration. Only if planning is initiated, the incentive was a success. A key toward a successful realisation *can* be having platforms dynamically adjust to an individual learner's demands and allowing self-regulated learning.

2.2.2 Audience Response Systems (ARS)

The best conceptual ideas on self-regulation are useless if students have no means of influencing their learning environment. Often, knowledge presentation is a mono-directional process with a docent presenting and students listening. However, it is desirable to increase interactivity in order to give students a fulfilling learning experience. Amongst a vast range of possibilities to influence learning environments, systematic approaches are promising. Such systems range from simple 'clicker' systems [BSR13, Dun06, Lan10] for voting or polling, to complex 'personal response systems' (PRS) [MC11] for individual responses, and 'audience response systems' (ARS) [Cal07] for group responses. ARS provide feedback to the lecturer during classes by having the audience vote on questions or poll on topics. By providing this feedback channel students get more immersed in their learning environment. The lecturer in return receives valuable information about the audience's knowledge and attitude. The basic functionality of all systems is similar: in a first step the lecturer (or an assistant) prepares the regular teaching material, but then amends it by preparation of one or more questions that shall be presented to the audience at defined times during their educational activity (for example readings; in the following 'class'). Of course, these points in time should also be defined by the lecturer (or their assistant). The students are introduced into the system at the beginning of class and are asked to submit answers to the questions when they are displayed. For reasons of automated processing of feedback, feedback must be handed in via defined means, namely technical devices physically distributed in the room or handed out at the beginning of class (the clickers), or other technical means available to the students, for example their own smartphones with an installed feedback app that connects to the system. Due to this requirement all submissions can be aggregated and processed automatically and immediately. Processed results can then immediately be presented to the audience via the regular presentation screen or a dedicated presentation screen. This allows for the docent to react to and upon the audience's answers by including results of polls into the lecture, choosing the group progress based on the audience's knowledge (for example adapting the lecture to special needs), or providing timely feedback on misconceptions, et cetera. By this, ARS are capable of increasing the interactivity [MSD+09] and hence, help students in learning. As mentioned, polls and questions are the main means of ARS, however research conducted strongly suggests that the core instructional component is built up of questions correlated with the learning topic (learning questions) [MSD+09, WB13]. With respect to students being provided with means of influencing their learning environment, features for live and real-time feedback on parameters of class' conduct have shown great potential [FWB13]. Inclusion of ARS over the course of an entire semester can lead to increased motivation, higher attendance rates, and better exam performance [PB09, Dun06]. However, the level of success of the ARS is strongly dependant

on the quality of the learning questions, their coordination with class content, and their content goal [Cal07, BGLD06]. Such coordination can demand different types of learning questions, for example aimed at directing attention, raising awareness, increasing interactivity, stimulating cognitive processes, evaluating progress, or assessing preparation. Especially [Cal07] argues that learning questions provide means to find out more about students' situations, do formative and summative evaluation, guide thinking, or work on practice problems and experiments. They suggest lectures to be *more* fun with learning questions. This in return increases motivation and achievement [PB09, Dun06] and thus, has a positive effect on attention, attendance, preparation, empathy, and processing depth [Lan10].

2.2.3 Virtual Interactive Whiteboard Systems (V-IWB)

As definitions on virtual interactive whiteboards vary, a clarifying definition shall be provided for the context of this dissertation. Alas, it is imperative to clearly separate from regular [interactive whiteboard \(IWB\)](#) solutions. – The following shall be defined:

Definition 2.2.1 (Virtual Interactive Whiteboard (V-IWB)):

An [interactive whiteboard](#) utilising a virtual display area (website frame, second screen, ...) instead of a physical display is defined as *virtual interactive whiteboard*, or *V-IWB* for short. V-IWBs are discriminable into ($m : n$)-type collaborative systems:

- Let $m = 1$ and $n = 0$, then a V-IWB has one content creator share created content only with themselves. The V-IWB then acts as a 'personal notebook' type.
- Let $m = 1$ and $n \in \mathbb{N}_{\neq 0}$, then a V-IWB has one content creator share created content with at least one other person. The other person(s) access the content in read-only mode. The V-IWB then acts as a 'personal bulletin' type.
- Let $m \in \mathbb{N}_{>1}$ and $n = 0$, then a V-IWB has multiple collaborative-parallel or collaborative-serial acting content creators share created content only with themselves. The V-IWB then acts as a 'shared notebook' type.
- Let $m \in \mathbb{N}_{>1}$ and $n \in \mathbb{N}_{\neq 0}$, then a V-IWB has multiple collaborative-parallel or collaborative-serial acting content creators sharing created content with at least one other person. The other person(s) access the content in read-only mode. The V-IWB then acts as a 'shared bulletin' type.

For obvious reasons all types of V-IWB are suitable for learning platforms as they help students organise their (virtual) graphical work space. However, the bulletin and especially the shared types encourage group activities, which are important for self-regulated learning regarding performance in comparison to peers.

As V-IWB do not require a physical whiteboard with limited space for students, utilisation is not limited to a few representative students, but open to all attendees. Furthermore, students not in the same physical location – that is the same classroom – are able to partake in whiteboard activities. On the downside, V-IWB require real-time capable infrastructure, especially devices providing own or shared access to the V-IWB system. These devices can either be loaners or the students' own. However, for the latter barrier-free access should be facilitated. In our case 'barrier-free' does not only reference access for students with disabilities, but – in more general terms – access independent of operating system or application availability. Commonly agreed upon, access created this way is facilitated by provision of the V-IWB as a web application that can be run within the web browser. If this includes the absence of plug-ins, even if they are freely available, is disputed. Nevertheless, manifold implementations exist.

2.2.4 Cognisant Incidental Utilisation (CIU)

Comment

The term *second screen* herein references the trend of using a mobile device (tablet device, smartphone, et cetera) to provide an enhanced, often interactive or immersive, experience for content of another perception focus, for example the television. In context of tutorials the term is used analogously to describe the utilisation of technical display devices such as laptop computers, smartphones, or tablet devices, but without having the tutorials being designed for or relying on these devices. The devices are meant as an amendment to tutorials conductible without them, however providing additional functionality to those tutorials, for example by providing students a more interactive and immersive tutorial experience.

Assuming the main means of tutorial conduct remains to be the black- or whiteboard, second screens provide an additional interaction means for students and tutors and are supposed to be cognisant incidentally utilisable (CIU), namely by students making the voluntary but cognisant decision to utilise their device when they incidentally want to, not when the device calls for their attention. The phrasing consists of two separate concepts combined into one action concept, namely *cognisant decision making* and *incidental utilisation*. The basic idea is to have all phases of decision making described in [subsubsection 2.2.1.1](#) be cognisant, especially meaning they take place on a conscious level, and combine them into the utilisation (the action) in a way that it becomes incidental on a conscious level, that is while the utilisation may not be considered incidental on a global level, it *is perceived* as incidental on the conscious action and decision making levels. In principle, a person engaged in an activity consciously decides whether they are willing to engage in a second (in-parallel) activity, and are aware of the consequences of that second action's conduct on the primary action. They decide if they can afford to split their attention on two (ore even more) activities.

As the computer science concept describes a type of utilisation of a technical means, the underlying 'incidental' differs from what psychology defines. Thus, it is imperative to clearly separate the two even though the computer science concept often is conjunct with psychological concepts of education (as is true within this dissertation). Psychology mainly focusses on 'incidental' in the context of *incidental learning* [Liv01, Cro11]. Incidental learning has no curriculum and is not organised. Instead, learning effects originate in coincidental learning situations (that is learning by accident). Therefore, by definition, it does not take place in dedicated learning environments such as schools or training camps, and cannot be planned, yet systematically organised to meet learning goals from different subjects or qualification demands. The learning situation is unforeseeable and inseparable from normal life activities. Hence, the knowledge obtained is entirely problem-related for real-life situation management. In short: a learner has no control of their learning and remains unconscious about learning taking place until the learning effect has arisen, if at all.

The core aspect of unconsciousness separates psychology's 'incidental' from computer science's version. In computer science 'incidental' is more closely related to decision making and motivation (in the sense as for example described in [HH06]) as well as the capability of consciously redirecting all or part of one's attention toward an HCI process (in the sense as for example [Kah73]). Following the single and multiple resource model, humans only possess a limited amount of cognitive resources they can distribute to different processes or interactions. This limitation can be addressed in two ways: not at all or cognisant. In the first case, attention may be deviated involuntarily, yielding potential risk of insufficient cognitive resources for important processes or interactions. However, attention focus breaking interactions are possible. For example, the user interface of a control device may require urgent user interaction in order to prevent a disaster. If it is able to redirect the controller's attention toward the critical information directly, risk of disastrous outcome can be minimised. If the controller would have to make a conscious decision to check the corresponding control interface aspect, the second case would be at hand. Users have

at all times complete control of their attention focus and are hence able to consciously divert all or part of their cognitive resources to certain processes or interactions. However, this type of interaction design holds a risk of important information being ignored. Therefore, in practice a suitable compromise of both cases is considered in interface designs.

When TeEdu tools are supposed to only amend scenarios (as considered within this dissertation), it is important to make the scenarios not depend on the tools. Even more, tools shall be designed in a manner that they *never* interfere with the conduct of the considered scenarios, maintaining the scenarios' principal educational means as the sole important attention focus/foci. In this context, it is imperative to have learners consciously decide whether they wish to divert attention to a tool, or not. And if they decide to utilise a tool, the utilisation should not distract from the scenario in a way that no more cognitive resources are attached to it. In this sense, workflows and interactions must be designed to allow cognisant decisions and incidental utilisation, hence *cognisant incidental utilisation*. The *cognisant-ness* aspect is achieved by clear definition of possibilities and consequences, supporting decision making processes and the motivation to utilise (→ [subsubsection 2.2.1.1](#)).

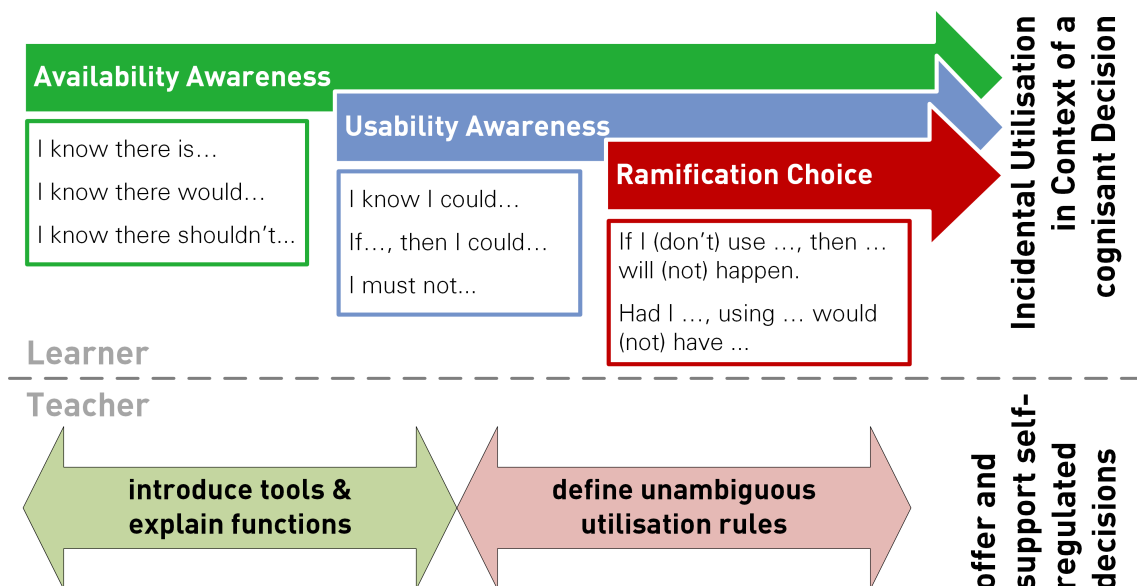


Figure 2.2.2: Cognisant Incidental Utilisation: three columns of CIU from the learner's perspective (top) and associated teacher's tasks (bottom).

It is fatuous to assume CIU in the described fashion is achievable. However, CIU as a design principle that should be observed is practical. As visible in [Figure 2.2.2](#), proper introduction to tools and clear announcement of utilisation rules support achievement of a maximum of CIU contingent. The required separation of the involved roles, one on the CIU supporting side, one on the CIU striving side, is easily achieved in TeEdu as there are two distinctive roles anyway: teachers and learners. The essential points of role separation is included in [Figure 2.2.2](#), as well.

2.3 APPRAISAL

The presented concept of peer instruction is to some extent combinable with (online) learning platforms and both include motivational and self-regulatory aspects. However, the aspect of peer

discussion needs further investigation, for example even as late as 2014 –circa twenty years after peer instruction was originally conceived– Greg Wilson⁸ advertised a reward for successful implementation of an online version of peer instruction. Most of peer instruction's tasks and phases are not hard to implement into an online platform⁹:

- *Have students read material on the topics before classes.*
Easily done by making digital distribution of reading material available to the students via the platform, for example as PDF files.
- *Have students answer questions (ConcepTest).*
Multiple choice and single best choice questionnaires are a standard tool for assessment in online platforms. Even specialised extensions are available, for example ILIAS, the OPAL extension ONYX, but also research prototypes such as eAssess⁺.
- *Assess the outcome of the ConcepTest.*
In general, this is part of the teachers' backend of the assessment tools.
- *Have teacher reveal and explain correct answer.*
Can be achieved by pre-recorded or real-time video explanations or slide shows, both of which are available in the standard set of tools in common learning platforms.

The only unsettled task is to *have students discuss among their peers and have the teacher roam through the class room*. This in particular proves to be a tough task as the very fact of having the teacher physically roam is infeasible in an online setting. Nevertheless, a conceptual similar idea should be feasible and will be addressed in [part II](#).

The aspect of motivation remains important in on-site and off-site learning situations. Mazur addresses this issue peripherally with respect to having the students read material on topics *before* classes. Assuming a certain fiat tendency when having students attend on-site classes, it is imperative to reward this behaviour in order to provide positive incentives for further attendance. The idea is simple: make on-site learning attractive and reward attendance. However, no pressure should be exerted; especially off-site learners should not have any disadvantages from not attending – that is, courses must be passable without attending and utilising provided tools –, but on-site learners should be rewarded with benefits.

Self-regulated learning as a concept to be supported in modern education should be considered in any learning platform. Of course, being able to decide when and how to utilise a platform is derived from self-regulation, however a certain instruction is required in order to positively stimulate students. For example, leaving the entirety of a topic open to students' self-regulation may prove fatal as the students may get lost in the vastness of the topic without finding any structure. As soon as instructions are provided at crucial decision points, a subliminal structure can be provided. Therefore, any type of learning platform should not naïvely allow self-regulated learning, but support an instructed, motivating aspect of self-regulated learning. Especially appropriate learning process supervision is imperative. However, learning platforms do not allow for all steps of learning process supervision to take place within them, so a focus on initial incentives should be considered. Mainly, this should be addressed by including individual learning demand assessment, directly assisting students in autonomously determining suitable tasks and learning paths, which can then be followed in a self-regulated fashion. This proves to be challenging and must be considered in [part II](#).

Another aspect to be considered in a suitable platform design is pairing the learning platform with the on-site activities. If the learning platform respects cognisant incidental utilisation, on-site activities do not suffer from platform utilisation, but are amended, providing valuable additions to classic settings. Having students decide whether to utilise provided tools on- or off-site supports their development to autonomous and accountable persons. It should benefit the trust between (adult) students and their teachers.

⁸ Park Forest Middle School, State College Area School District, State College, PA, USA

⁹ Moodle and OPAL shall provide benchmark.

3 RELATED WORK

'Be nice to nerds. You may end up working for them. We all could.'

Charles J. Sykes



RELATED WORK

Continuing the considerations of the previous chapter on existing concepts, some related concepts and implementations shall be investigated. Based thereon in conjunction with the concept appraisal (→ page 33), foundations for a modified application, or an extension as the case may be, shall be derived. The idea is to present important locum tenens for certain aspects of the concepts discussed earlier. That way, a distinguished representative covering conceptual aspects is provided, that can then be applied for the research problem at hand. An overview of the relations of concepts and examples is provided in Table 3.0.1 (farfetched relations in parentheses).

example	self-regulation	peer instruction	LPS	learning platform	ARS	V-IWB	CIU
Visible Learning	✓	✓	✓	×	×	×	✓
auditorium	✓	×	(✓)	✓	×	×	×
Auditorium Mobile Classroom Service	✓	×	(✓)	✓	✓	×	✓
ARSnova	✓	×	(✓)	✓	✓	×	×
Google Classroom	×	(✓)	✓	✓	×	×	×
StackOverflow	×	×	×	✓	×	×	×
AwwApp	×	×	×	✓	×	✓	(✓)

Table 3.0.1: An overview of the relations between concepts and examples.

Comment

All content material and appraisal thereof presented within this chapter represents state of the art by 1 September 2015 (Google Classroom: 1 April 2015). All web-based references were verified to be accessible by 11 January 2016.

3.1 VISIBLE LEARNING

Visible learning is not a solution or product in the sense of an application of the concepts presented earlier. It actually represents facts of current education aspects derived from results on a vast set of meta-analyses related to education. Hattie presented these results [Hat09, Hat13], and they have been subject of topical discussions and research ever since. Hattie's results are a synthesis of more than eight hundred meta-studies conducted over fifteen years. Data on over eighty million students and more than fifty thousand smaller studies is included in the visible learning data-base. It is one of the largest, if not even the largest, collection of research about efficiency in education based on actual data.

Hattie drew the conclusion that almost anything can improve student achievement as long as it is other than not doing anything in class. The conclusion is based on a comparison of effect sizes of different educational aspects within their respective context. From the conclusions a comprehensive list of strategies and innovations with their best working scenarios can be derived. As visible learning focuses primarily on student achievement, Hattie argues that visible learning

‘occurs when teachers see learning through the eyes of students and help them become their own teachers’.

Effect sizes considered by Hattie are provided as a numerical values, where

- an effect size of .5 is equivalent to a one grade leap at GCSE¹⁰,
- an effect size of 1 is equivalent to a two grade leap at GCSE¹⁰,
- an effect size is the result of a normalised and averaged value of a *number of effects* from well-designed studies, and
- an effect size above .4 is above average for educational research.

It should be noted that Hattie does not clearly define some of the considered effect sizes, hence some effect sizes contain more than one education strategy. This Matryoshka-effect *can* be troublesome, but as is typical for education, a clear distinction between effects is not possible; some even correlate so strongly with each other, they need to be considered as a set, but are sufficiently disjunct to not be considered as one. Effects can be considered within one set, or –as often conducted– a combination of intersection subsets thereof. Considered subsets are: student, school, curriculum and teacher. However, the set conjunction of the subsets is not congruent with the overall effects set as some effects cannot be attributed to any of the four subsets. Tables 3.1.1 to 3.1.5 provide the top ten of each (sub)set.

effect	size
proficiency level self-assessment	1.44
cognitive development stage (Piaget)	1.28
formative assessment of class	.90
micro-teaching	.88
acceleration (for example skipping classes)	.88
influence class behaviour	.80
interventions for special demand students	.77
clarity of teacher	.75
inverse teaching	.74
feedback	.73

Table 3.1.1: Top 10 effect sizes overall.

effect	size
proficiency level self-assessment	1.44
cognitive development stage (Piaget)*	1.28
prior proficiency level*	.67
birth weight*	.54
concentration, stamina and engagement	.48
motivation	.48
infantile promotion*	.47
preschool programmes*	.45
self-concept	.43
angst reduction	.40

Table 3.1.2: Top 10 effect sizes in the *student* subset.

¹⁰ General Certificate of Secondary Education – Used primarily in England, Wales and Northern Ireland, but also in other current and former member nations of the Commonwealth of Nations.

effect	size
acceleration (for example skipping classes)*	.88
influence class behaviour	.80
class cohesion	.53
peer influences	.53
class management	.52
learning in small groups	.49
'school effects'	.48
'school size'	.43
extra activities for highly skilled students	.39
'school heading'	.36

Table 3.1.3: Top 10 effect sizes in the *school* subset.

effect	size
inverse teaching	.74
promotion of vocabulary	.67
repetitive reading	.67
promotion of creativity	.65
Lautier method	.60
tactile stimulation	.58
promotion of reading understanding	.58
promotion of visual perception	.55
outdoor/experience education	.52
promotion of reading	.50

Table 3.1.4: Top 10 effect sizes in the *curriculum* subset.

effect	size
micro-teaching	.88
feedback	.77
clarity of teacher	.75
teacher-student relationship	.72
teacher's advanced training and qualification	.62
non-labelling of students	.61
perceived teacher quality	.44
teacher's expectations	.43
'teacher effects'	.32
teacher's education	.11

Table 3.1.5: Top 10 effect sizes in the *teacher* subset.

Effects set in quotation marks within the tables shall be excluded from further considerations as their meaning is too unclear, and effects marked with an * shall be excluded as they cannot be influenced in university scenarios. From the remaining effects a clear correlation with existing concepts is discernible. For example, peer instruction works great in the context of visible learning because it provides, ordered in descending order of effect size, the following effects from the top tens (other effects omitted):

- proficiency level self-assessment – ConcepTest and peer discussion,
- micro-teaching – short presentation and peer discussion,
- influence class behaviour – peer discussion,
- feedback – ConcepTest and peer discussion,
- inverse teaching – pre-class reading and short presentation,
- repetitive reading – pre-class reading,
- promotion of vocabulary – pre-class reading and peer discussion,
- promotion of creativity – peer discussion,
- non-labelling of students by the teacher – ConcepTest does not influence grading, however peer discussion can lead to labelling by peers,
- promotion of reading understanding – pre-class reading,
- promotion of visual perception – pre-class reading and peer discussion,
- class cohesion – peer discussion,
- peer influences – peer discussion,
- class management – peer instruction itself,
- promotion of reading – pre-class reading,
- learning in small groups – peer discussion,
- extra activities for highly skilled students – short presentation by students instead of teacher, and peer discussion,
- motivation – pre-class reading, ConcepTest and peer discussion, as well as
- angst reduction – ConcepTest and peer discussion (though, these can have a negative effect if the student regularly fails in the ConcepTest or peer discussion).

Similar considerations on effects and impact can be derived for any other education concept. This is based in the data-base of visible learning as it is founded in actual education scenarios. Thus, any concept in use will somehow correlate to the visible learning results. W.l.o.g., addressing the following set of visible learning effects shall be considered desirable for the purpose of this dissertation when investigating tools (ordered in descending order of effect size):

VLE01: proficiency level self-assessment,	VLE10: promotion of visual perception,
VLE02: formative assessment of class,	VLE11: class cohesion,
VLE03: micro-teaching,	VLE12: peer influences,
VLE04: influence class behaviour,	VLE13: class management,
VLE05: clarity of teacher,	VLE14: learning in small groups,
VLE06: feedback,	VLE15: motivation,
VLE07: promotion of vocabulary,	VLE16: perceived teacher quality,
VLE08: promotion of creativity,	VLE17: angst reduction, and
VLE09: non-labelling of students,	VLE18: extra activities for highly skilled students.

3.2 AUDITORIUM

At TU Dresden¹¹ a deployment of a specialised educational discussion system is in use, namely *auditorium*¹² [Bei14, BBH14]. Other than functionality to be considered standard for a discussion system or forum, *auditorium* includes specialised features: contributions in form of questions, comments, answers, and announcements, up- and down-voting on contributions, gamification functions in form of a point system, leader-board and badges [Bei14], as well as tagging function

¹¹ Technische Universität Dresden, Dresden, Germany

¹² Lower case diction is intended. <https://auditorium.inf.tu-dresden.de/> – accessed 15 March 2016.

for grouping and consolidation of contributions. Or in other words, auditorium is a knowledge exchange hub amended by announcements and gamification. –More on knowledge exchange hubs in [section 3.6](#).

Simply said, auditorium aims at preserving solutions to recurring knowledge issues. It is organised into courses (groups) and allows topic specific discussions. Especially student questions that regularly arise are meant to be asked within auditorium. At the same time, any user –but especially docents– owning¹³ a group is able to make announcements. Another type of contribution are open topics, stipulated for providing for any contribution not a question or announcement, but worth discussing. Questions, announcements and topics can be commented on or be answered. Any contribution is modifiable in content as well as type afterwards, for example when an answer proves to actually be a comment. Regardless of type of contribution –question, announcement, topic, comment, or answer–, all users are able to vote on the contribution by giving it a ‘thumbs up’ or ‘thumbs down’ (↪ [Figure 3.2.2](#)). Votes are aggregated and a score is computed for each voted-on contribution, for example three up-votes and one down-vote compute to a score of +2.

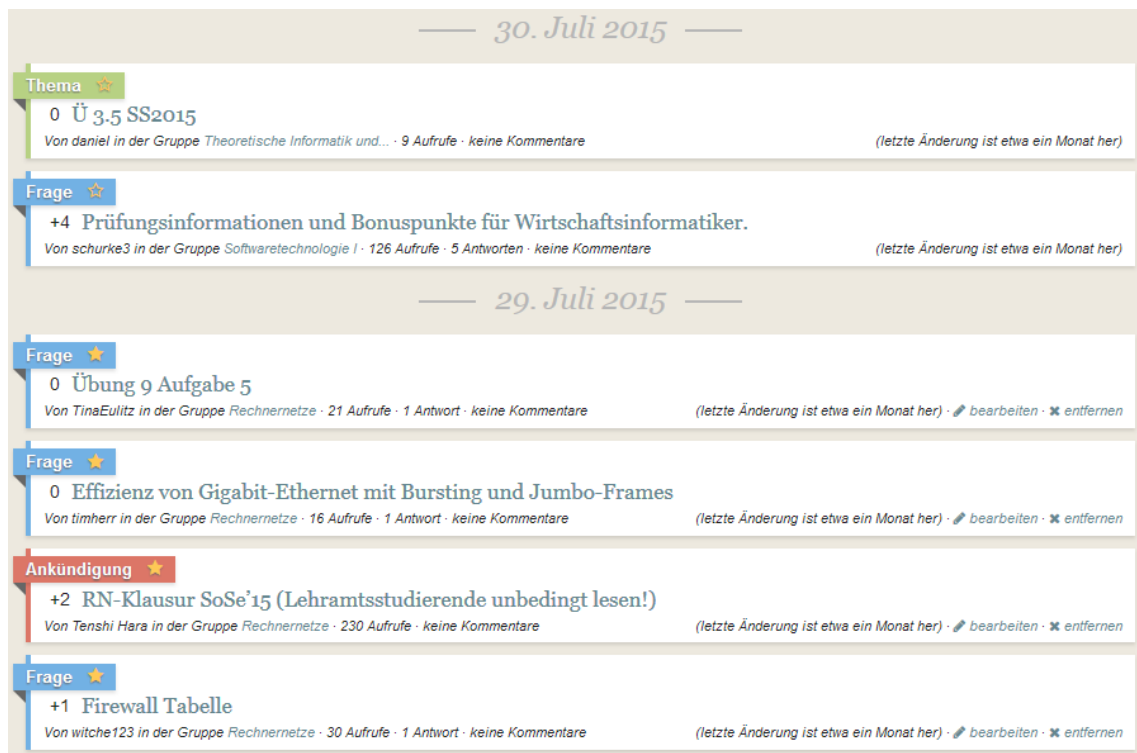


Figure 3.2.1: auditorium’s landing page activity feed. Top to bottom: topic, +4 scored question, two starred questions, starred and +2 scored announcement, starred and +1 scored question.

The original creator of a question as well as the owner of the group the question was posted to can mark an answer as helpful. Depending on up-votes and helpful markings, topics (that is, collections of associated contributions within a group) can be prominently highlighted in the contribution flow on the landing page or the group overview, namely by a ‘star’ marker. Refer to [Figure 3.2.1](#) for a screenshot of the actual deployment, showing contributions in the landing page flow, including stars and scores. Additionally, this screenshot –as well as [the previous one](#)– illustrates usage of different colours for different types of contribution for easier identification by the users, namely blue→question, red→announcement/comment, and green→topic/answer.

¹³ A group may have multiple owners, and ownership is transferable as well as inheritable.

Overall, recurring questions and discussions on certain topics can be aggregated and preserved for future generations of students, hence shortening the time students need to spend in order to acquire knowledge through discussions with docents and fellow students, as they can access recaps of previous incarnations of the same problem solving iterations.

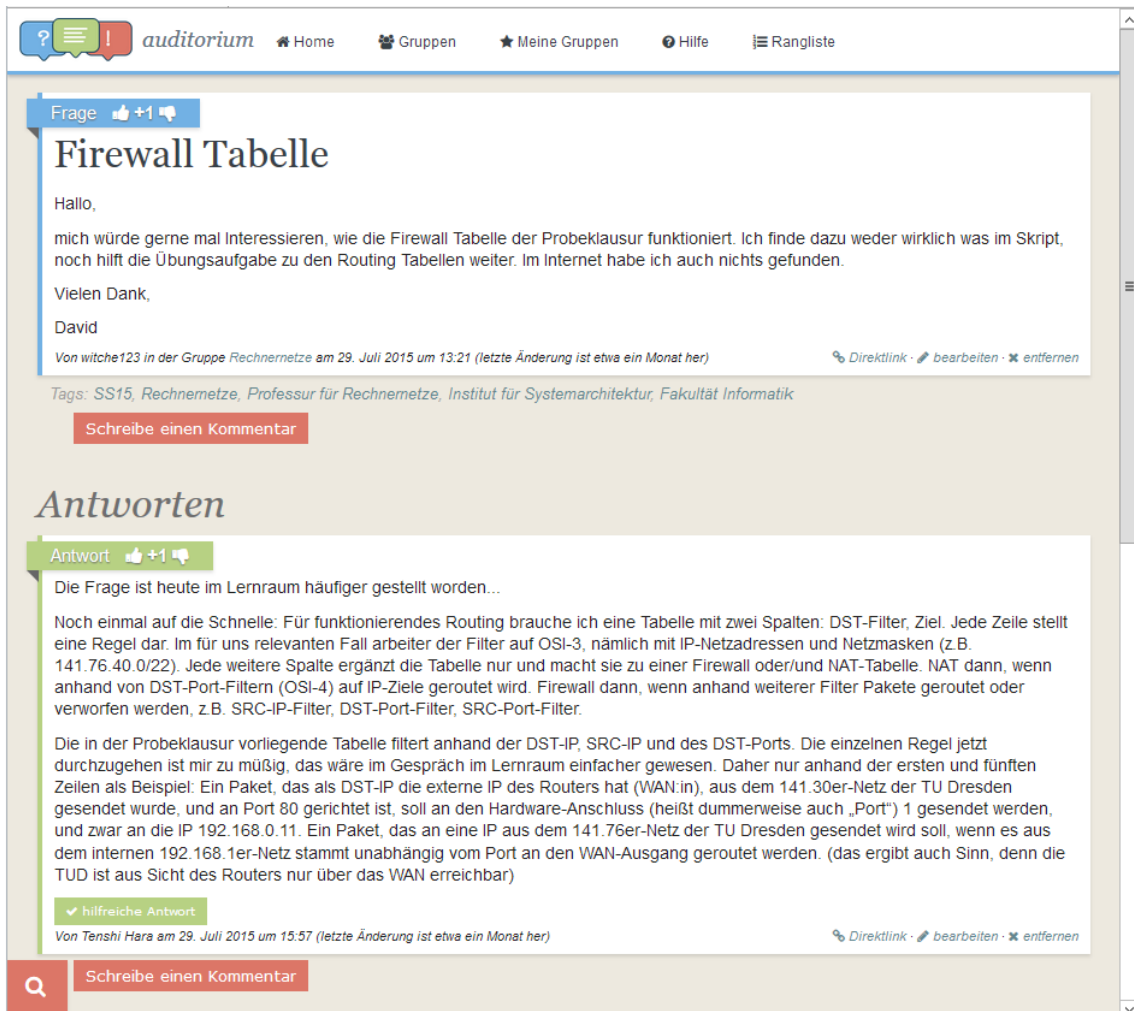


Figure 3.2.2: A question posted to auditorium and an answer provided. Both have received votes accumulating to +1 scores, and both are open to comments (red 'Kommentar' box). With an answer form below the visible area of the screenshot further answers can be provided.

Another aspect giving great value to auditorium is the inclusion of gamification. Through any action certain flags in the workflow can be triggered. For example, asking or answering questions triggers gamification events. The same is true for up-votes and down-votes. All triggered gamification events attribute to a user level which can be matched against others in a global high-score. The prominently placed hyperlink to the high-score can be seen in the upper right area of Figure 3.2.2 (the 'Rangliste' hyperlink). Adding bonus, users who prefer not to be listed in the high-score can make their ranking invisible to other users. This helps motivation as users with a bad ranking can hide it, or vice versa users with high ranking – mostly teachers due to plethora of answered questions and received up-votes – can choose to be invisible in order not to demotivate other users, or not to be presented as over-achievers, strivers respectively. Also, users can be displayed in the high-score either in relation to the top and lowest performers (↔ Figure 3.2.3a), to

#	Name	Reputation
1.	Alice	456
2.	Bob	320
...		
287.	You	280
...		
1323.	Jasmin	2
1324.	Jason	1

(a) absolute position

#	Name	Reputation
285.	Alice	456
286.	Bob	320
287.	You	280
288.	Jason	230
289.	David	182

(b) relative to vicinity

#	Name	Reputation
1.	Friend	456
2.	Friend	320
3.	You	280
4.	Friend	230
5.	Friend	182

(c) relative to friends

Figure 3.2.3: Conceptual types of motivational high-score displays within auditorium. [Bei14]

their relative vicinity (\leadsto Figure 3.2.3b), or to their friends (\leadsto Figure 3.2.3c), that is user accounts specially marked with a ‘friend’ relation to one’s own user account.

Aside from the high-score, triggered gamification events attribute to a badge collection. Badges are organised in three levels (bronze, silver and gold) and are grouped into categories aimed at increasing platform utilisation, for example helpfulness for answering questions, assessment for up-votes and down-votes, et cetera. An example for a user’s badge collection is provided in Figure 3.2.4, also displaying the user’s level, their points, as well as motivational hints (remaining points to next level, greyed out badges still to be achieved). Another core concept of the implemented gamification aims at easier initial access to the auditorium platform by providing a set of easily achievable badges for exploration of platform functions, for example completion of the user profile, editing a contribution, asking the one’s first question, et cetera. The motivational control and self-regulation aspect of striving toward higher goals after successfully meeting a (sub)goal is supported by having subsequent badges and levels be harder and harder to achieve.

Even though currently only deployed as a website to be browsed and displayed by a web-browser, auditorium is programmed with an open API that would allow potential addition of other types of client interfaces, for example smartphone apps.

The core concept of preserving knowledge and providing a discussion platform as provided in auditorium is noble and should be retained. However, auditorium in its design is loosely coupled with the university courses it is amending. Utilisation during a reading or tutorial is not designed. Even though such utilisation would be possible, it would not be well integrated into the curriculum and some aspects may provide distractions, for example gamification could distract from tutorials, decreasing learning success even though providing motivational incentives. A further item of criticism is the enforcement of real names in combination with mandatory registration using a university e-mail address¹⁴. Especially students with low self-esteem are prone to not ask questions or provide answers they consider to be ‘stupid’ or simply false. Providing anonymity would greatly improve involvement of these students as other platforms show. However, anonymity also involves the risk of over-boarding trolling and very bad user experience (atmosphere), for example Hick’n’Hack¹⁵ was designed by students of TU Dresden’s computer science programme for students of that programme, but due to anonymous usability insults, defamations and other hostilities are a daily occurrence, and especially new users are often alienated and discouraged as even earnest questions and answers are often defamed by trolling.

¹⁴ For the existing deployment of auditorium, users are forced to provide an @tu-dresden.de or @*.tu-dresden.de e-mail address. These addresses either contain the user’s name (givenname.surname@), or a user identification token (s1234567@). Additionally to their real name users are therefore also biuniquely identifiable via their e-mail address.

¹⁵ <https://tud.hicknhack.org/forum> – accessed 15 March 2016.

auditorium Home Groups My groups Help Leaderboard Search Tenshi Hara 635 | 14 0 Sign out

Dipl.-Inf. Tenshi Hara (635 Points)



[Change profile image](#)

Achievements Settings

Achievements

Level 4 Visit the leaderboard
635 of 1000 Points
Only 365 Points to level up!

Introduction to auditorium

100%

If you accomplished every guide you will gain the achievement "Curious".

- Introduction
- Groups overview
- A Group in Detail
- A Question in Detail

Information about you

100%

If you provide all information from above you will gain the achievement "Biographer".

- First name
- Surname
- Username
- Role at the university

[Settings](#)

Achievements

Bronze Achievements

Bronze Achievements are easy to get. Every Bronze Achievement adds 25 Points to your reputation.

Learning
 Commenter
 Cooperative
 Helpful
 Significant
 Something to Say
 Modern Browser
 Rewarding
 Critical
 Editor
 First Step

Silver Achievements

Silver Achievements are challenging. Every Silver Achievement adds 50 Points to your reputation.

Learning
 Commenter
 Cooperative
 Helpful
 Significant
 Something to Say
 Moderator
 Party
 Biographer
 Curious
 Rewarding
 Critical

Gold Achievements

Gold Achievements are the most challenging. Every Gold Achievement adds 100 Points to your reputation.

Learning
 Commenter
 Cooperative
 Helpful
 Significant
 Something to Say
 Rewarding
 Critical

Navigation

- Home
- Groups
- My groups
- Search
- Leaderboard
- Profile
- 0 unread notifications waiting for you.
- [Sign out](#)

Support

- Visit our support group
- Find us on github
- Write us an email
- German | English

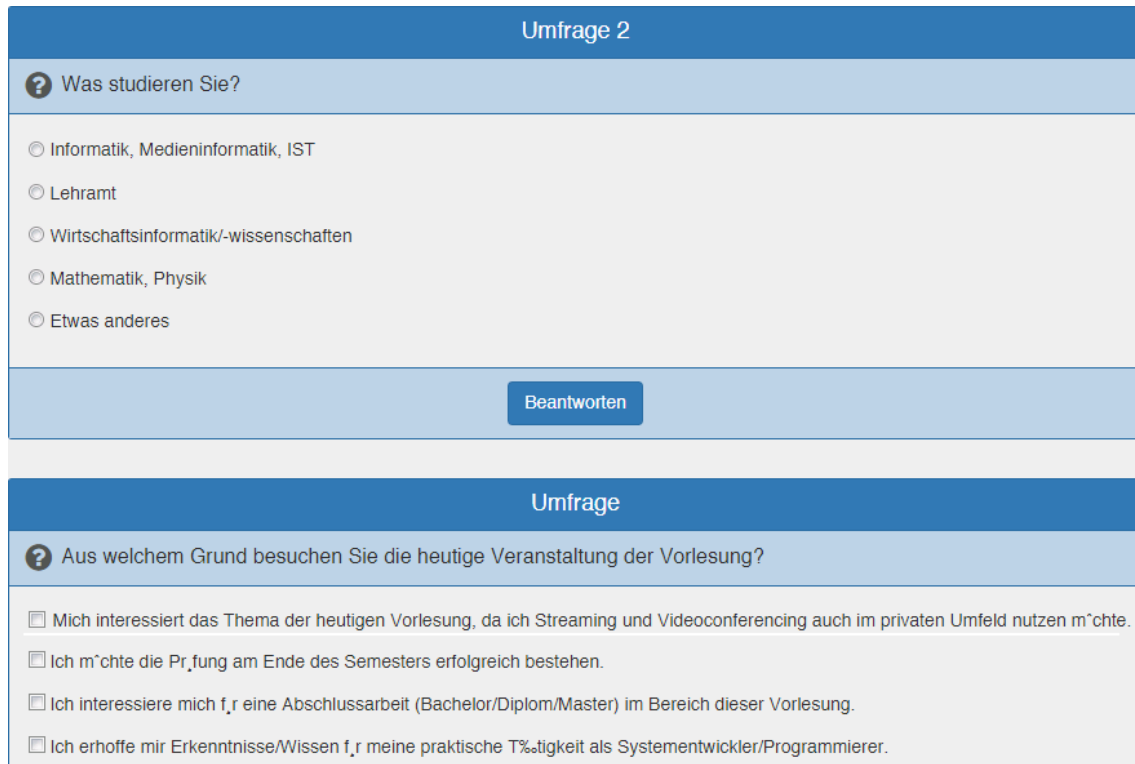
About

- Imprint
- Privacy

Figure 3.2.4: User profile within auditorium. Top: header navigation with current points and badge count next to user's name; centre: profile information including degree (if applicable), points and level information, as well as achievement information on badges already received (emphasised) and still achievable (shown greyed out); far bottom: footer navigation.

3.3 AUDITORIUM MOBILE CLASSROOM SERVICE

A prototype of an enhanced audience response system is in development at TU Dresden with *Auditorium Mobile Classroom Service*¹⁶ (AMCS) [KBK13, KBK14, KDBK14, KBKS14]. Its primary aim is effectively providing students with a means of receiving targeted learning hints during readings. In addition to ARS functionality AMCS also provides evaluation tools.



The image displays two screenshots of the Auditorium Mobile Classroom Service (AMCS) survey interface. The top screenshot, titled "Umfrage 2", asks "Was studieren Sie?" (What are you studying?). It features five radio button options: "Informatik, Medieninformatik, IST", "Lehramt", "Wirtschaftsinformatik/-wissenschaften", "Mathematik, Physik", and "Etwas anderes". A blue "Beantworten" (Answer) button is located at the bottom of the question area. The bottom screenshot, titled "Umfrage", asks "Aus welchem Grund besuchen Sie die heutige Veranstaltung der Vorlesung?" (For what reason do you attend today's lecture?). It features four checkbox options: "Mich interessiert das Thema der heutigen Vorlesung, da ich Streaming und Videoconferencing auch im privaten Umfeld nutzen m'chte.", "Ich m'chte die Pr'fung am Ende des Semesters erfolgreich bestehen.", "Ich interessiere mich f,r eine Abschlussarbeit (Bachelor/Diplom/Master) im Bereich dieser Vorlesung.", and "Ich erhoffe mir Erkenntnisse/Wissen f,r meine praktische T%tigkeit als Systementwickler/Programmierer."

Figure 3.3.1: Example of questions for profiling of users. Top: degree programme; bottom: reason for today's attendance. (Screenshot provided by Tommy Kubica, B.Sc.)

When a reading is to be amended by AMCS, the docent is required to prepare additional information as well as extend the lecture by expected user interactions on [second screen](#). That is, the docent must design content for the second screen workflow. Once second screen workflow has been established, students are profiled according to initial questions. These questions' areas include but are not limited to degree programme, prior experience, interest in topic, importance of exam, or peer pressure (↪ [Figure 3.3.1](#)).

Iff predefined criteria are met and associated events triggered, students receive learning hints based on their profiles through the second screen, so-called meta-cognitive prompts (MCP). For example, an MCP based on the intersection of degree programme and personal interest can be triggered by a specific reading slide on a topic matching that intersection, having the MCP on the second screen include hyperlinks to [URLs](#) with additional information on the topic of that specific slide, or providing decision-making aids on optional required modules (for example a seminar) in the later course of the degree programme. This functionality is aimed at providing students incentives for being attentive, but also for motivational animation.

¹⁶ <https://mobileclassroom.inf.tu-dresden.de> – accessed 1 August 2015

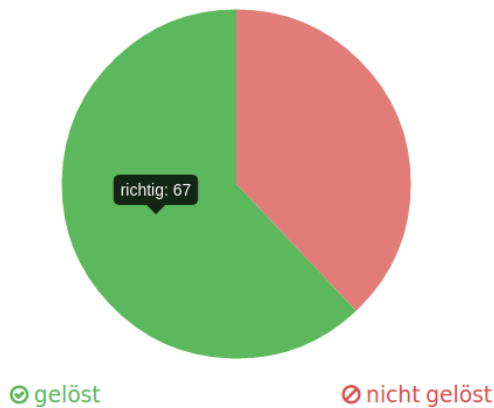
Another functional aspect of AMCS is an automated assessment system. At predefined times of a reading (defined by a slide they are attached to), learning questions (LQ) are pushed to the second screen. Students then have the possibility to answer the LQs. Currently, LQs are designed as single best choice questions, but technically any type of question is possible, that is multiple choice, sortation, arrangement, cloze, et cetera. Provided answers are evaluated in real-time and visualised immediately. The docent *can* share the results of all submitted answers with the audience, as depicted in [Figure 3.3.2](#).

Lernaufgabe 3:

Was ist Information Literacy?

- 1.) Die Fähigkeit einen Text schnell lesen zu können. 2.) Die Fähigkeit Informationen kritisch zu bewerten. ✓
 3.) Die Fähigkeit Informationen mit Anderen austauschen zu können. 4.) Die Fähigkeit Informationen zu verstehen.

Ergebnisauswertung:



Antwortenverteilung:

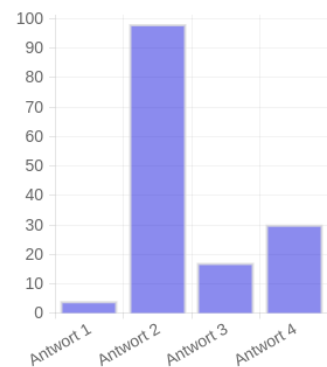
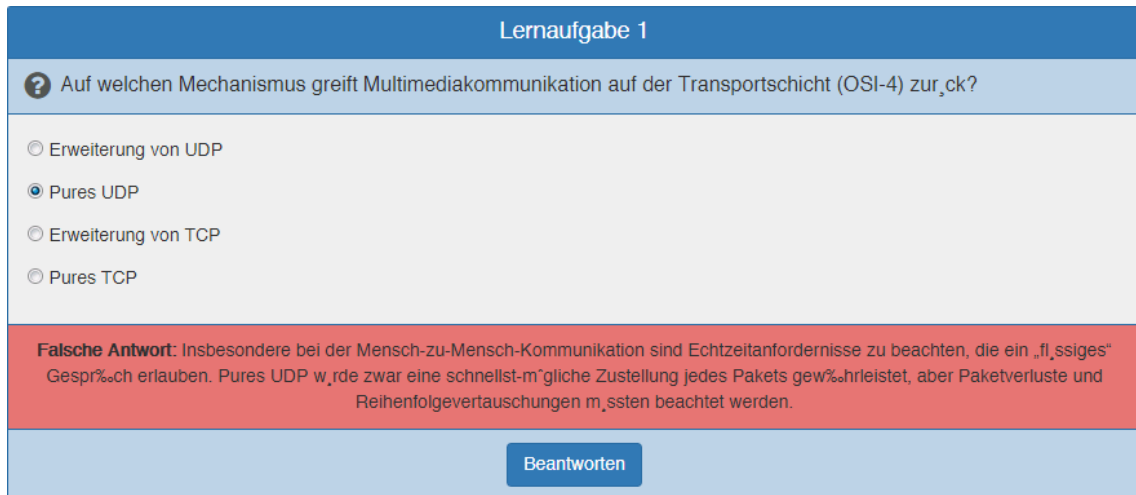


Figure 3.3.2: Example of evaluated results. The example has one correct answer (bold font) and three decoys. Left graphic: ratio of correct to incorrect answers. Right graphic: actual distribution of submitted answers. (Screenshot provided by Tommy Kubica, B.Sc.)

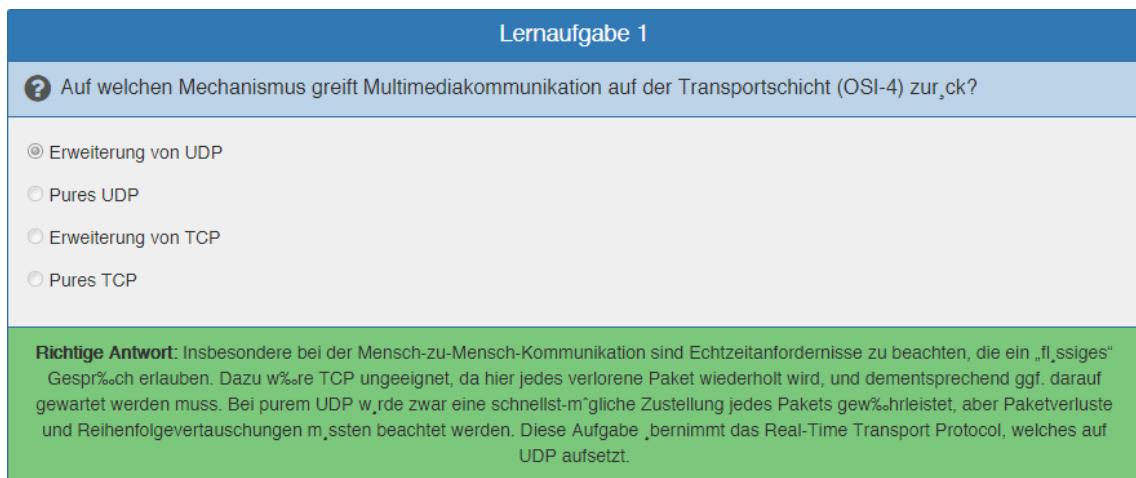
Any single student is presented with immediate assessment of their answers. Generally, students have two attempts at answering an LQ correctly: after the first wrong answer an explanation on why the answer was wrong is given, and after the second wrong answer explanations on why all wrong answers are wrong and why the correct answer is correct are given. Should the student answer an LQ correctly in either the first or second attempt, the explanation on why the answer was correct is disclosed. Examples are provided in [Figure 3.3.3a](#) (incorrect answer), [Figure 3.3.3b](#) (correct answer), and [Figure 3.3.4a](#) (on smartphone displays). This functionality helps students assess their learning progress, or topic comprehension respectively, in a closely time-correlated manner. In the sense of self-regulatory adaptation of their learning environment this greatly supports self-evaluation and causal attribution. Being able to range one's own answering performance within the sum of all answers aids assessment within the group context.

As a by-product AMCS also includes evaluative functionality. If added to the reading slide set, students will be presented with evaluation possibilities on their second screen during the reading. The nature of the evaluative means can be opted by the lecturer, but generally any meaningful evaluation is realisable, that is visibility, clearness, comprehensibility of material, and comprehensibility of the docent's presentation, atmospheric environment, et cetera. This functionality helps the docent to improve their readings, while it also allows students to actively influence

their learning environment, making their feedback valued and timely, as opposed to semestral mandatory pen & paper evaluation, which often led to modifications in the next incarnation of a course, but not in the currently attended. The same functionality can be utilised in order to create in-reading polls (→ Figure 3.3.4b) that allow the docent to quickly gather the audience’s state of mind, or even to show the audience their position distribution respectively.



(a) Incorrect answer; second answering attempt permissible (bottom centre ‘Beantworten’ button)



(b) Correct answer in the ultimate second attempt

Figure 3.3.3: A learning question being first answered incorrectly (a) and then correctly (b). (Screenshots provided by Tommy Kubica, B.Sc.)

Within the dark bar at the bottom of Figure 3.3.4b the frontend of another functionality of AMCS can be seen, namely ARS. Basically, AMCS’ ARS is a simple real-time derivate of the above mentioned evaluation subsystem. Rather than attaching evaluatory questions about speed and volume of the presentation to each slide, and then computing and visualising results to the lecturer, AMCS has a feedback channel for speed and volume decoupled from the slides. This results in the ability to constantly make such feedback available in the frontend. Any feedback is evaluated in real-time (green and red bars in Figure 3.3.4b) and is available to the docent at any time.

From a technical perspective, realisation is simple. AMCS has models of courses, reading within courses, slide sets associated with readings, and students attending readings. Users’ interactions

can be attached to slides within slide sets by creating request-response pushes (RRP). The request herein represents any content pushed from the AMCS server to the second screens, while the response represents any answer transferred from the second screens back to the server. As RRP are designed in this very general manner, this single data entity type is sufficient in order to serve as an initial profiling question, an MCP, an LQ, or an evaluation. This becomes very obvious when considering that an initial profiling question (like 'Why are you attending today's reading?') may allow multiple answers, while an LQ designed as multiple choice test also allows multiple answers. From the system's view, both data entities are **unifiable**. Similar arguments apply for the other derivatives of RRP, as well, for example an MCP is a prompt without a reply.



(a) Example of learning questions.

(b) Example of a poll and the ARS frontend of AMCS (dark bar on the bottom).

Figure 3.3.4: Different AMCS contents displayed on smartphone. (3.3.4a provided by Dr.-Ing. Iris Braun; 3.3.4b provided by Dr. rer. nat. Felix Kapp)

It should be noted that AMCS is implemented as an API-driven project, hence allowing easy addition of client-side applications for different platforms. Currently, a web-app for browsers, an Android app, as well as an iOS app are deployed for students, and docents have access to an OS X slide annotation tool¹⁷, as well as a website with a specialised docent view. However, AMCS is designed to act as a **framework** so that future functional additions are possible. –The AMCS framework will provide the basis for the integration of the tutorial prototypes' functionality into a combined platform serving readings and tutorials (→ **part II** and **section 10.2**).

Even though AMCS is outstandingly suitable for the described scenario, tutorials fall short. The scope of tutorials differs too much from readings to allow AMCS to be utilised in tutorials unmodified. Often tutorials are based on group discussions, collaborative derivation of solution of learning

¹⁷ There is a deprecated Windows version of the docent tool. Furthermore, direct manipulation of the database by an administrator is thinkable.

tasks, and utilisation of blackboard/whiteboard. Usage of (electronic, projectable) slides may be possible, but should not carry the content of the tutorial as opposed to the reading where slides are the main presentation means. The preparation time required to amend a course by AMCS is significant, especially when conceiving learning questions and meta-cognitive prompts. Even though preparation time is worth the effort, the workflow of a tutorial is not as pre-determinable as in readings. Additionally, providing learning questions in a tutorial is ambiguous; tutorials are designed to work on learning questions, to exercise and consolidate knowledge presented in readings. Provision of meta-cognitive prompts in the context of tutorials may also prove infeasible and unsuitable in the manner AMCS does. The ARS aspect of AMCS is interesting for tutorials, too. It provides students with low self-esteem, or those hesitant to provide non-anonymous criticism on the tutor's conduct, a means to provide feedback. However, time correlation proves to be challenging for this type of ARS amendment, especially for tutorials (↪ [Appendix A](#)).

It should be noted that AMCS allows users to anonymously utilise it. User accounts are distinct by means of a pseudonym and password combination freely selectable by the users. In the current implementation *any* non-empty pseudonym is possible, however the often followed recommendation sees users provide the first two letters of the mother's first name, the day of the mother's birthday, and the day of the user's own birthday. For example, 'SA1622' for mother Samantha, born 16 August 1969, and the user born 22 March 1995. This type of anonymous usability was introduced in 2014 after successful user motivation within the first dissertation-related prototypes (↪ [Appendix A](#)). It allows users to easily recreate their forgotten pseudonym, while at the same time allowing system-internal user tracing without giving up anonymity. A positive impact on the users' willingness to utilise AMCS compared to AMCS' old login schema based on e-mail addresses was notable.

3.4 ARSNOVA AND OTHER AUDIENCE RESPONSE SYSTEMS

A modernised approach to ARS is presented with *ARSnova*, currently under development at TH Mittelhessen¹⁸. It follows the principles described in AMCS closely, but derives from a different foundation. As described in [section 3.1](#), Hattie presented vast amounts of result on meta-studies. ARSnova takes the visible learning results on formative assessment as well as feedback and defines them as the most effective actuating variable. Hence, the learners' individual learning progresses as well as the learning group's combined learning progress are determined in real-time. For that, prep questions (beforehand) and in-course questions (during a reading) are presented to the students and are to be answered. Individual progress is visible to each learner themselves only, while the group's progress is visible to all course attendees and the docent.

On one hand, the prep questions are designed to support a 'just in time' learning strategy; strongly time-correlated adaptations of reading contents become possible. On the other hand, in-course questions provide assessment of and feedback from the students, allowing formative evaluation of the teaching process. For example, specific suggestions for improvement can be derived from a closing evaluation (circa 5 minutes at the end of a reading) that presents free text forms for feedback. The idea follows the concept of [minute papers](#). Assessment is possible based on equally weighed questions (in general single best choice) as well as point-based questions (in general multiple choice). Weights range on a 5%-equidistant scale from -10 to +10 points, allowing harsh penalisation of false answers (like selecting a distractor), even obverting mostly positive assessments into the negative. However, the minimum achievable score is 0, as negative scores are rounded up.

The realisation of ARSnova is similar to AMCS, but differs in UI and usability aspects. Of course, the utilised framework of backend and frontend differs, too. The same is true for any other of the important ARS solutions currently maintained. The main difference is of functional nature,

¹⁸ Technische Hochschule Mittelhessen, University of Applied Sciences, Gießen, Germany

namely what type of evaluation and assessment means are supported, for example single best choice, multiple choice, true/false statements, ranking, et cetera. To provide a comprehensive list is impossible, but some web-based, freely usable solutions include but are not limited to the representatives provided in Table 3.4.1. A more extensive list is available within the ARSnova research documentation at <https://arsnova.eu>.

ARS	single best choice	yes/no decision	true/false statement	scaling grades	Likert scale	multiple choice	free text	numeric	voting	learning card	image map	image submission	cloze	drawing	anonymous questions	live feedback	team challenge
AMCS ¹⁹	✓	×	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	✓	×
ARSnova ²⁰	✓	✓	×	✓	✓	✓	✓	×	×	✓	✓	×	×	×	✓	✓	×
FreeQuizDome ²¹	✓	×	×	×	×	✓	✓	×	✓	×	×	✓	×	✓	×	×	×
ILIAS ²²	✓	✓	×	✓	×	✓	×	×	×	×	×	×	×	×	×	×	×
invote ²³	✓	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×	×
Kahoot ²⁴	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
PINGO ²⁵	✓	✓	✓	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×
Quiz Socket ²⁶	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
SMILE ²⁷	✓	×	×	×	×	✓	×	×	×	×	×	×	×	×	✓	✓	×
Socrative ²⁸	✓	×	✓	×	×	✓	✓	×	×	×	×	×	×	×	×	×	✓
StuReSy ²⁹	✓	×	×	×	×	✓	×	×	×	×	×	×	✓	×	×	×	×
TEDzi ³⁰	✓	✓	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×
tweedback ³¹	✓	✓	×	×	×	✓	×	×	×	×	×	×	×	×	✓	✓	×

more extensive list at <https://arsnova.eu>

Table 3.4.1: Functional comparison of a selected subset of web-based ARS.

3.5 GOOGLE CLASSROOM

Aiming at simplification of creation, distribution, and grading of assignments in schools, Google Classroom is a blended learning platform relying on TeEdu means especially in order to be a paperless educational system. Hence, assignments provided via Google Classroom are per definition paperless. Google Classroom relies on Google Docs, Google Slides and Google Sheets – or more generally speaking: Google Drive –, and is an integrated feature of Google Apps for

¹⁹ Even though AMCS is not strictly an ARS (→ section 3.3), it shall be mentioned here with its currently implemented ARS functionality. As mentioned, the data model theoretically allows any type of responses.

²⁰ <https://arsnova.eu> – accessed 15 March 2016

²¹ <https://freequizdome.com> – accessed 15 March 2016

²² <https://iliasnet.de> – accessed 15 March 2016

²³ <http://invote.de/> – accessed 15 March 2016

²⁴ <https://getkahoot.com> – accessed 15 March 2016

²⁵ <https://pingo.upb.de> – accessed 15 March 2016

²⁶ <https://www.quizsocket.com> – accessed 15 March 2016

²⁷ <https://www.smile.informatik.uni-freiburg.de> – accessed 15 March 2016

²⁸ <http://socrative.com> – accessed 15 March 2016

²⁹ <https://sf.net/projects/sturesy> – accessed 15 March 2016

³⁰ <https://www.tedzi.com> – accessed 15 March 2016

³¹ <http://www.tweedback.de/> – accessed 15 March 2016

Education. It was made publicly available for schools in the United States in August 2014. In the beginning, a Google account was required, but this requirement has been removed in June 2015, however an identifiable user account (provided via Google Account API) is still required, but it can be decoupled of a user’s primary Google account. Probably, this change is a result of privacy concerns, as class progress, et cetera was visible via the account (with unfavourable privacy settings), hence making students transparent to the general public, especially their fellow students, other teachers, and potential later employers.

Comment

Contrary to available material on Google Classroom, the company name ‘Google’ shall not be omitted within this section. This shall ease distinguishability between products and actual nouns, for example Google Classroom vs. classroom, Google Drive vs. drive, et cetera.

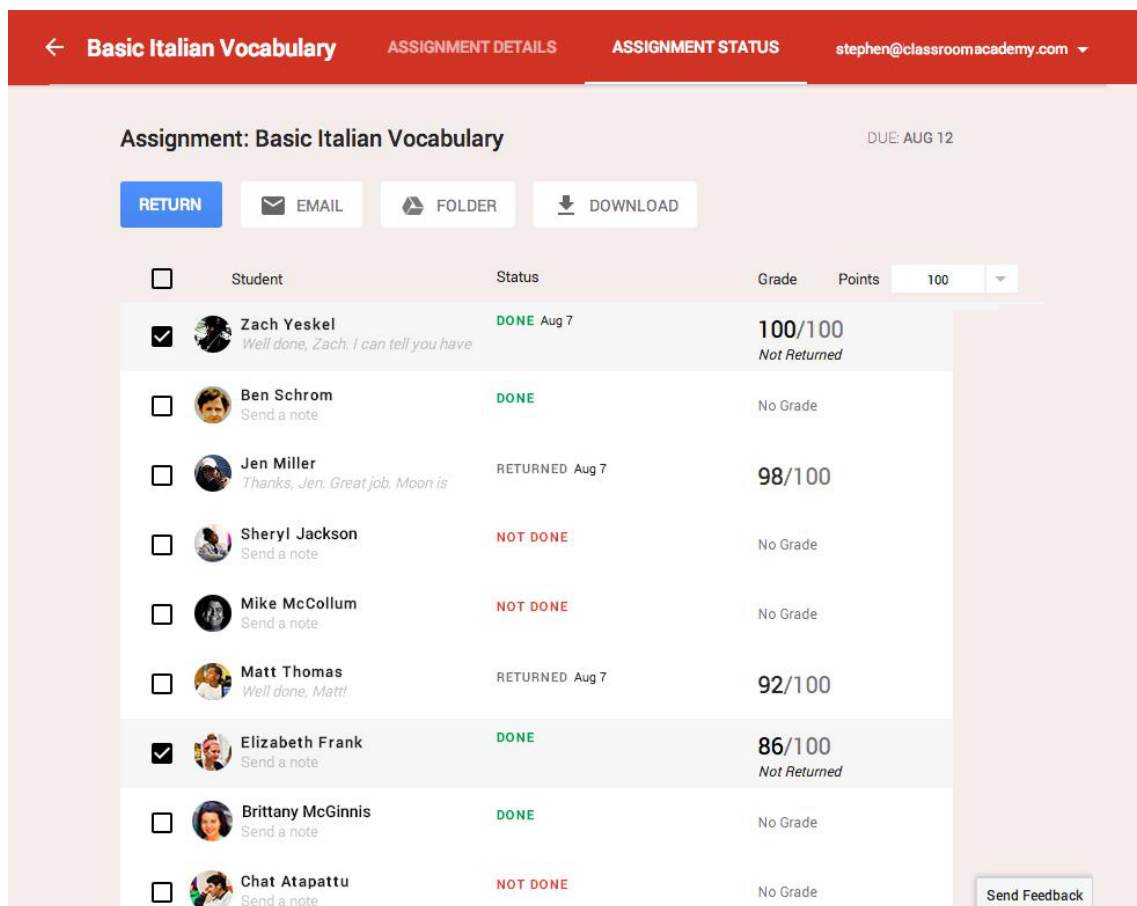


Figure 3.5.1: An example for assignment details in Google Classroom. Note the status and grades of the students. ©2014 by Gabriela Vatu.

Google Classroom acts as a hub with fancy GUI –organised as class streams– to many of Google’s products, that in combination are able to provide schools with the required means to conduct paperless education. The provision is advertisement-free, even for products that normally rely on ads heavily. However, it is strictly limited to software solutions (web-app, Android app, and iOS app), unless extra hardware provision is contracted between school and Google.

Assignment creation, distribution, management, and hand-in are provided by Google Drive. User-to-user communication is provided by Google Mail (time decoupled) as well as Google Hangouts (real-time collaboration). Students' enrolment into classes is achieved via Google API coupled to schools' databases, or by provision of an individualised, private code. That is, teachers are able to directly invite students to courses iff they know the students account identifier (their e-mail address associated with their account), or they can provide a URL and an access code for enrolment. Courses are organised within Google's products in a simple but efficient way³²: creation of a folder for each course within each Google product utilised in the class. For example, a class relying on Google Drive and Google Mail would have a separate folder in both products.

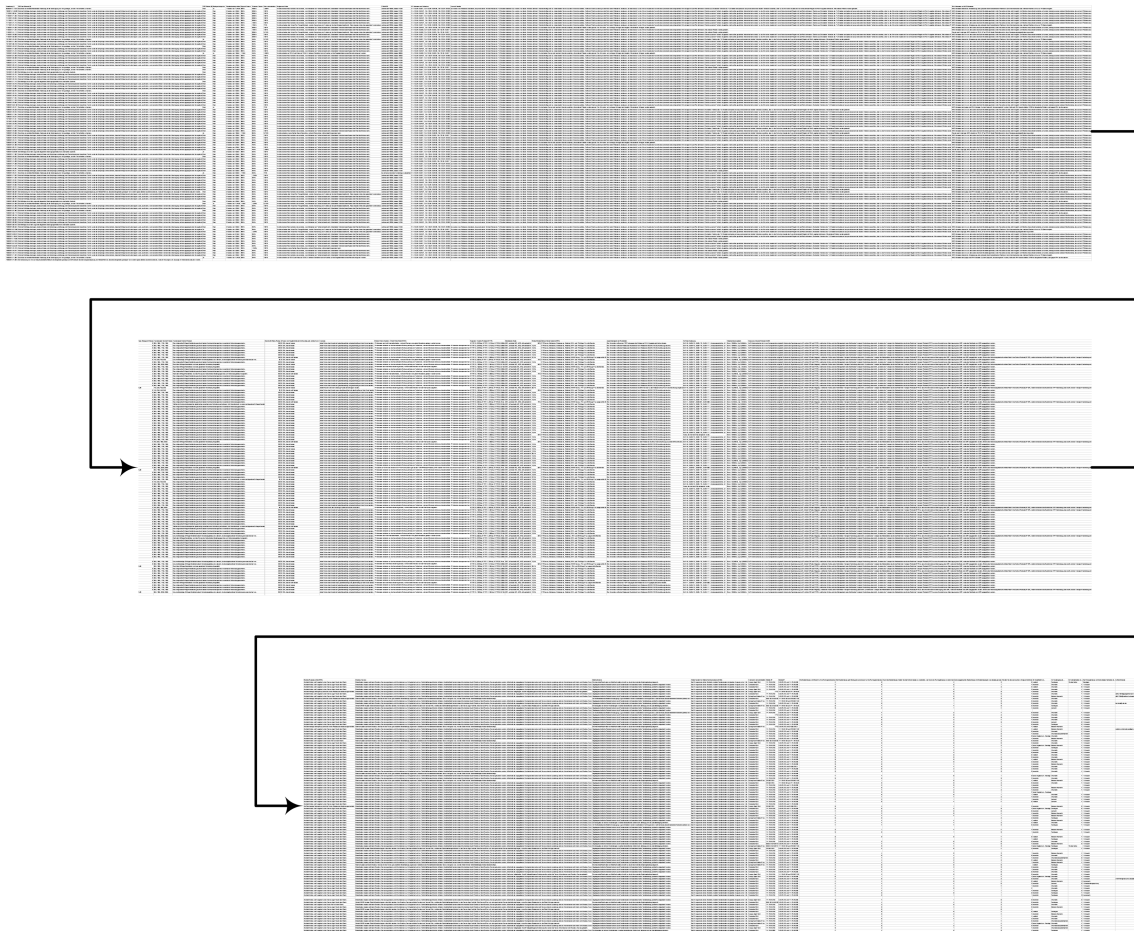


Figure 3.5.2: An example for unserviceable assessment results in Google Classroom. Shown is the list of submissions for a mock exam with 12 knowledge areas and 109 participants. The result set is 'only' 46 columns wide, but each of the 109 rows contains an average of 3300 characters.

The paperless assignments are stored and graded within Google Drive. Instead of actually transferring files (or their ownership), files are shared between teachers' and students' Google Drives, hence teachers can share the 'original' assignment as a template with their students, and vice versa submitted work remains within the students' Google Drives. This way, teachers can provide a submission template that students modify within their Google Drive. The modified versions are then shared back with the teacher. As Google Docs, Google Slides and Google Sheets support real-time collaboration, teachers are always able to monitor students' individual progresses on assignments. Even further, teachers are able to provide comments or help editing together with the

³² The mantra is *KISS*, 'keep it simple, stupid'.

students. Instead of simply commenting turned-in assignments, teachers are also able to provide grades on them (↪ [Figure 3.5.1](#)). Students can be urged to revise the assignment and hand-in further iterations. However, graded assignments can only be edited by the teacher, unless the grade is revoked and the assignment turned back to the students (all or individual).

Teachers and students are able to post announcements to class streams. Announcements are, if not marked otherwise, open for comments. A 'comments disabled' marker only affects students' ability to comment; a teacher can always comment. This allows for documented and reproducible two-way communication between teachers and students. By design, announcements of teachers have highest priority and are immediately visible on top of the class stream, while students' announcements can be subject to prior moderation, and will not have as high of a priority. Announcements may have media attached. Such attachments must be available through Google services, so videos on YouTube (a Google subsidiary) or files stored within Google Drive are possible, but not 'externally' hosted content like videos on Vimeo or files stored in Dropbox. Another type of communication available – also allowing attachments – is usage of Google Mail. However, communication via Google Mail will not show up within the class stream.

Any time, but especially at the end of a term, teachers are able to move active courses into an archive. Archived courses are removed from the list of current courses, hence aiding organisation of the curriculum. However, archived courses are not deleted, only modification rights are removed. Archived courses are accessible as read-only class streams via a special folder.

Integration with Google+ allows for networking and social grouping. Teachers and students are able to keep in touch after courses have concluded via Google+, but also during courses Google+ ensures seamless integration of class activities and social networking.

Due to heavily relying on Google Drive for file distribution (assignments are nothing more than files), Google Classroom assignments are limited to the capabilities of Google Docs, Google Slides and Google Sheets. Especially assessment is primitively difficult with Google Drive and Google Sheets. Tasks need to be clumsily created as single best choice items. Thereafter a flow between the individual tasks with intermediate responses to submitted solutions has to be created. As there is no global configuration, all options (for example having tasks only be processable once) have to be manually repeated for each task. Finally, the created flow has to be attached to spreadsheet within which all submitted solutions are stored. This storing only takes place for completely filled and submitted exams, so partial results of students who do not finish the exam within the defined timeframe are not stored. The spreadsheet containing the result lists all flow elements' contents in the cells, hence it is not immediately useful and confusing (↪ [Figure 3.5.2](#)). An improvement would be to provide simple task-to-answer relations, for example 'Task 5 → Answer d'. There are a few analysis options, but they either generate similarly unclear diagrams or are provided on a pay-per-use basis unsuitable for education running on a strict government budget.

Google Classroom can be utilised for in-course paperless activities as well as distributed learning environments. However, due to its limitations it is designed to be utilised in in-course environments. It is designed to replace pen and paper, therefore nothing beyond the scope of what is possible with traditional pen and paper is possible, especially no ARS features, motivational incentives, et cetera. Anonymity is limited as well. If one trusts Google, everything is fine when utilising a secondary account for Google Classroom. If one is willing to share everything related to school with friends, acquaintances and even strangers, utilisation of the primary Google account allows simple sharing of all related information via Google+. However, if one doesn't trust Google, Google Classroom becomes unusable from a privacy view point. For example, to the best of the author's knowledge there is no information available on whether Google Classroom and all of its underlying services will observe European privacy laws once they become available to European schools. Recent developments in light of Edward Snowden's uncoverings clearly demonstrate that Google did not observe the International Safe Harbor Privacy Principles³³ while they were in place. Now that Safe Harbor has been revoked, nobody knows what happens to European data in the United States of America.

³³ Safe Harbor sees US companies to comply with EU directive 95/46/EC on the privacy and data protection.

3.6 STACKOVERFLOW

There are many representatives of knowledge exchange hubs with community votes (and potentially with pseudo anonymity), for example StackExchange, Reddit, Apple Cake, or Amazon Answers. Due to its nature as a knowledge exchange hub for technical experts, especially computer engineers, the StackExchange derivate *StackOverflow* shall be considered in the list of related work. It allows anybody to register an account either with any name and e-mail address combination – from these credentials only the e-mail address is verified by a link-click verification – for anonymous usage, or by signing up via Facebook, Google+ or OpenID API.

Any question can be asked within the platform as community-driven self-moderation takes place. Any question unrelated to technical topics (for example spam) will receive negative comments and down-votes, hence removing the question from attractive search result positioning. At some point, given sufficiently negative score, questions and comments are removed. Additionally, contributions can be reported to a moderation team and thus be removed faster. It should be noted that users who have received a significant amount of positive feedback are granted moderation right automatically, which fosters the idea of the community-driven self-moderation as anybody can become a moderator.

Questions, answers and comments thereon can be up-voted or down-voted by registered users. These votes represent each individual's attitude toward the contribution. For example, users having the same question may up-vote a question, while bad or incorrect answers can be down-voted by users, signalling others about potential issues with submitted answers. The sets of associated contributions – questions, answers and comments belonging together – form discussions.

The initial poster of a question is able to mark answers to the question as 'helpful', allowing other users easier access to solutions while quickly browsing aggregated question pages or activity streams. Up-votes and down-votes are added and accumulate in a score displayed next to the voted-on contribution. An example for the voting and marking mechanism is provided in [Figure 3.6.1](#). The question (top) has received up-votes and down-votes accumulating to a positive score of 39, that is there is an articulate number of people with the same (or similar) question. However, there also might be persons who disagree on the relevance of the question, that is there might be down-votes. Five answers were submitted by the time the screenshot was created, but the screenshot only shows one and a quarter of them. The first provided answer has an accumulated score of 42, which is very positive. Once again, this score may be the result of up-votes and down-votes. The check mark below the score indicates that the original question poster evaluated this answer as 'helpful'. This first answer has received ten comments, of which the first few are displayed, while the rest is suppressed but available via dynamic reloading utilising an [AJAX](#) mechanism.

Users are able to favourite any question by clicking on a star next to it. Favoured questions are stored and displayed within a list in the user profile. This allows users platform-internal referencing of contributions without having to rely on browser storage such as bookmarks. This means that favoured contributions are available on any client the user decides to use.

The scores of questions in combination with the amount of answers and page views are utilised in order to determine topical discussions. This is helpful for topics that are in high demand at a given time as they are aggregated and prominently displayed on StackOverflow's landing page (↪ right area in [Figure 3.6.2](#)). For example, when Google decided to change their Google Maps API, a vast number of unprepared developers were suddenly confronted with an adaptation task of rewriting their API utilisation. After a brief settling phase developers with that exact issue were able to find related questions and answers within StackOverflow.

Besides having topical discussions prominently displayed and hence easily accessible, all questions are displayed on the landing page in an activity stream reverse-sorted by time (↪ left 75% in [Figure 3.6.2](#)). For easier containment of relevant discussions all questions can (and should) be

how to empty recyclebin through command prompt?

39

I have a requirement. usually we delete recyclebin contents by right clicking the mouse and empty the recyclebin. but i have a requirement where i need to delete recyclebin contents using a command through command prompt. Is it possible? if so how can i achieve it?

asked 3 years ago
viewed 100485 times
active 4 months ago

windows windows-7 command-line batch-file recycle-bin

asked Feb 11 '12 at 8:50
user1016403 2,316 15 54 99

edited Feb 11 '12 at 9:31
Cody Gray 121k 17 235 313

Why do you need this? What problem are you trying to solve? – Cody Gray Feb 11 '12 at 9:21

1 I just let Windows automatically delete the oldest files when the Recycle Bin reaches its maximum size
superuser.com/questions/69284/... – Matthew Lock Oct 8 '14 at 2:25

add a comment

5 Answers active oldest votes

42

You can effectively "empty" the Recycle Bin from the command line by permanently deleting the Recycle Bin directory on the drive that contains the system files. (In most cases, this will be the C: drive, but you shouldn't hardcode that value because it won't always be true. Instead, use the %systemdrive% environment variable.)

The reason that this tactic works is because each drive has a hidden, protected folder with the name \$Recycle.bin, which is where the Recycle Bin actually stores the deleted files and folders. When this directory is deleted, Windows automatically creates a new directory.

So, to remove the directory, use the rd command (remove directory) with the /s parameter, which indicates that all of the files and directories within the specified directory should be removed as well:

```
rd /s %systemdrive%\$Recycle.bin
```

Do note that this action will *permanently* delete all files and folders currently in the Recycle Bin **from all user accounts**. Additionally, you will (obviously) have to run the command from an elevated command prompt in order to have sufficient privileges to perform this action.

answered Feb 11 '12 at 9:30
Cody Gray 121k 17 235 313

10 A few more caveats: • the change in bin status may not reflect in Explorer (the desktop icon) until you actually open the Recycle Bin and/or refresh the desktop, • it only affects that particular volume: recycled files on other drives will not be affected, so you may not be actually *emptying* the recycle bin with this method, and • the directory name can vary by Windows version (and I believe filesystem as well). It may be \$Recycle.bin, Recycled, Recycler, etc. and you may even have more than one if you multi-boot—programs like Norton Recovery Bin have their own directories. – Syntech May 14 '13 at 14:49

This only works in cmd.exe – Casey Jan 22 '14 at 20:40

@Casey, Why do you say that it "only works in cmd"? – Pacerier May 25 at 0:00

@Syntech, How do we figure out is it \$Recycle.bin, Recycled, or Recycler? Is there a variable to do that, or is the only way via catching the exceptions? – Pacerier May 25 at 0:00

add a comment

13

I prefer recycle.exe from Frank P. Westlake. It provides a nice before and after status. (I've been using Frank's various utilities for well over ten years..)

```
C:\> recycle.exe /E /F
Recycle Bin: ALL
  Recycle Bin C:  44 items, 42,613,970 bytes.
  Recycle Bin D:   0 items,  0 bytes.
  Total:         44 items, 42,613,970 bytes.
```

Linked

0 Empty Recyclebin using c program

Related

444 How to pass command line parameters to a batch file?

266 How to get current datetime on Windows command line, in a suitable format for using in a filename?

931 Is there an equivalent of 'which' on the Windows command line?

268 How to sleep for 5 seconds in Windows's Command Prompt? (or DOS)

119 How to create an empty file at the command line?

11 How to send Shutdown command to process through CMD Prompt on Windows

1 How to maximize current command prompt using command

1 How do I move files to a directory that's the create date of the files in Windows Command Line?

0 How to run application from command prompt with arguments?

0 How to make two running command-prompt windows send commands to each other on the same computer?

Hot Network Questions

How can I make my languages structurally less like English?

What is a word meaning "with a low possibility"?

Same time, same height

Two vowels together: "Go out" and "Go upstairs"

Correct Way to Limit Op Amp Output Current

more hot questions

Figure 3.6.1: An exemplary question asked on StackOverflow.

annotated with tags. These tags then allow swift classification of discussions into certain topics. These tags are visible in [Figure 3.6.2](#) as an aggregated item list below each question.

The scores are also utilised to display mastery within user profiles. All delivered and received contributions and votes are accumulated in a reputation score displayed publicly in the user profile (~ top left corner of [Figure 3.6.3](#)).

The screenshot displays the 'Top Questions' section of StackOverflow. It features a list of questions, each with its own set of statistics (votes, answers, views) and a list of tags. The questions are sorted by 'interesting' questions, with a count of 422. The right sidebar shows 'Hot Network Questions' with a list of trending topics.

votes	answers	views	question title	tags	asked/modified	author	score
0	0	2	Why is this declaration of a function in template class invalid?	c++, templates, methods, types	asked 1 min ago	Ruslan	820
0	0	5	JavaFX Self Installer With Inno Setup 5 - Where put the modify .iss file?	java, ant, javafx, inno-setup	modified 1 min ago	Uraeus Oudjat	1
0	2	27	access to azure invoices from API	api, azure, invoice	modified 1 min ago	Andrew	3,953
0	0	2	There is no ViewData item of type 'IEnumerable<SelectListItem>' that has the key 'Practice' - MVC5	c#, asp.net-mvc, visual-studio, razor, drop-down-menu	asked 1 min ago	coto2	41
0	1	14	SQL Second latest date Subselect	sql, sql-server, date, max	modified 1 min ago	Ralf de Kleine	6,308
0	0	2	Lazy loading ignoring Explicit Loading	asp.net-mvc, entity-framework, lazy-loading, eager-loading	asked 1 min ago	Trxplz0	176
0	0	2	How play video on nwjs?	javascript, html5, video, node-webrtc	asked 1 min ago	demenvil	109
0	0	5	Make a view for a table with various conditions	mysql, database	modified 1 min ago	mat7	109
0	0	2	navbar-fixed-top show content behind Navbar	react-bootstrap	asked 1 min ago	Chris G.	2,385
0	0	3	R or Python: Correlation Table	python, r, correlation	asked 1 min ago	Krishna Ram	1
0	0	2	Image Width Height Via AngularJS (ng-file-upload)	javascript, html, angularjs, ng-file-upload	asked 1 min ago	Satyaki	48

Figure 3.6.2: A snapshot taken of StackOverflow's discussion stream on 1 September 2015.

StackOverflow also includes some gamification functions, namely collection of badges. Badges a user has achieved are categorised in bronze, silver and gold levels. The count of achieved badges is displayed for each level near the reputation score in the user profile (~ [Figure 3.6.3](#)). The user profile also includes a self-description (top centre in the screenshot), counts for answers and questions (top right), an impact assessment ('people reached'), as well as statistical information (location, URL, member history, page views, last online). For the knowledge exchange hub functionality, the contents of the lower half of [Figure 3.6.3](#) are of significance: information on top tags and top contributions are provided based on the scores and contribution counts. This allows easy identification of a user's expertise, thus also allowing easy assessment of the (potential) quality of a contribution: rule of thumb suggests a good contribution value if the user expertise is good.

The general concept of StackOverflow (and all other knowledge exchange hubs) is to allow expert discussions on questions, provide a means to collaboratively discuss, allow determination of solutions to problems, and finally to preserve discussions³⁴. This final aspect, namely preservation, can be considered imperative as the same or similar discussions often recur time and again.

The screenshot displays the StackOverflow profile for Cody Gray. At the top, there are tabs for 'Profile' and 'Activity', and links for 'Meta User' and 'Network Profile'. The profile header includes a placeholder image of glasses, the name 'Cody Gray', and a 'Stack Overflow Careers profile' badge. Key statistics are shown: 120,929 reputation (with 17 gold, 235 silver, and 313 bronze badges), 2,029 answers, 9 questions, and ~9.5m people reached. Location is listed as Austin, TX, with a profile link, membership duration of 5 years and 2 months, 20,586 profile views, and last seen 13 hours ago. A bio states: 'Sorry, I don't do chat! I'm not quite sure how that feature benefits a Q&A site. If you have a question that you think I might be able to answer, please post a question to the site so that everyone may benefit and contribute.' It also mentions expertise in Win32 API, C++, C#, and VB.NET, and a 'Fair warning: I tend to be prolix; brevity is not my strong suit.' Below the bio are sections for 'Communities (20)', 'Top Tags (1,235)', 'Top Meta Posts', and 'Top Posts (2,038)'. The 'Top Tags' section lists tags like C# (Score 4,631, Posts 774, Posts % 38), .NET (Score 4,294, Posts 639), WinForms (Score 2,233, Posts 456), Windows (Score 1,520, Posts 291), Visual Studio (Score 1,424, Posts 187), and C++ (Score 1,155, Posts 274). The 'Top Meta Posts' section lists three posts with titles like 'Am I being disrespectful if I address people by their names?' and 'Why do we need to have exactly 3690 rep to be eligible for nomination?'. The 'Top Posts' section lists questions like 'Release generating .pdb files, why?' and 'Declare a Const Array'.

Figure 3.6.3: A snapshot taken of the StackOverflow user profile of 'Cody Gray', created on 1 September 2015.

Especially the ability to use StackOverflow anonymously makes it very attractive. The mechanism of link-click verification is not an actual barrier as trash mail accounts can be used, for example [10 Minute Mail](#). On one hand, this allows individuals to openly express their lack of knowledge without having to fear disadvantages, for example at work due to exposition to their superior. On the other hand, the possibility to create an identifiable account (associated with one's Google+ or Facebook account, or OpenID) allows helpful individuals to shine with their willingness to help as well as their expertise. It is not unheard of that companies have hired programmers after reviewing their StackOverflow profile. However, this needs to be carefully considered. Especially

³⁴ Here the term 'discussion' shall include questions with and without answers as sometimes there are no (correct) answers to problems. Preserving such still open questions and making them available to others allows for identification of open problems.

in the United States companies tend to force applicants to disclose their social media passwords in order to review the applicants' social media contributions. This raises privacy issues beyond what should be socially acceptable.

3.7 AWWAPP

From manifold interactive whiteboard systems, 'A Web Whiteboard Application' (AwwApp) is representative for V-IWBs spanning all four types, namely private as well as shared bulletins and notebooks. It is offered with a freemium pricing model: boards can be created without a user account as shared notebooks, but those boards cannot be saved and all interactions with others are limited to actions within the board. Premium features allow saving of up to one hundred boards, voice chat interaction with up to ten participants per board, and view-only guest access (that is bulletin mode) is possible. Utilisation is possible via personal computers as well as mobile devices, especially embedding of boards into other web applications is supported. –Overall, AwwApp supports all functions a physical IWB would also support with the exception of inclusion of documents such as presentation slides.

AwwApp's drawing functions are based on HTML canvas in combination with CSS widgets and JavaScript. Therefore, it is possible to use AwwApp in any modern web browser supporting those three core technologies. As HTML5 browsers are standard these days, there shouldn't be any problems, even on mobile devices. As the functions rely on canvas manipulation, any canvas oriented action is possible, namely display of any bitmap- or vector-based information such as texts, paint brush strokes, and images. The general idea is visualised in [Figure 3.7.1](#). Of course, downloading any state of the drawing area as an image as well as sharing via link or in-app invitation is possible. On the side of the voice chat, it entirely relies on the browser's HTML5 capabilities for audio peer-to-peer communication. Notably, voice chat is limited to open source codecs, hence iOS-based devices are *not* supporting this feature.



Figure 3.7.1: AwwApp: drawing canvas with examples for differently coloured and sized paint brushes, texts and uploaded images. (The 'The Children's Place' logo used with permission by The Children's Place Montessori (FAO Karen J. Lumsden), Famington Hills, MI, USA.)

As AwwApp's functionality is only limited by the accessing browser, a wide variety of devices is natively supported, making it an ideal tool to be integrated 'as is' into other platforms. Embedding

AwwApp is encouraged by the manufacturer, explicitly providing organisation licenses, which make it attractive for schools and universities. Additionally, no personal information needs to be provided by the users, allowing students to anonymously use the embedded boards. By design, the size of sharing groups need to be limited, especially when making use of the audio chat. However, when focussing on the main feature, namely the shared canvas, suitable student group sizes are natively supported, reducing technical expertise required of the teachers to a minimum. Embedded boards are *click and use*.

Shared notebook capabilities are provided in quasi real-time, only offset by network and communication delays. This allows for real simultaneous and parallel creation or manipulation of shared content. Combining this with conversations – either in person due to physical vicinity or via voice chat – fosters productive team work. The ability to share created contents with others in bulletin-mode ensures that the created content is not trolled/destroyed by the invited others.

Other important V-IWB solutions include but are not limited to: GroupBoard, Scribblar, and Twiddla. These partially rely on proprietary software (such as Adobe Flash) and are thus not as widely accessible as AwwApp, but support inclusion of documents such as presentation slides.

PART II PROCEEDINGS

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4 GLOBAL PICTURE AND PROTOTYPE

'That's the world out there, little green apples and infectious disease.'

Don DeLillo



GLOBAL PICTURE AND PROTOTYPE

Observably, the way students learn changes with each generation of new students. These changes originate in changes in society as well as advances in science and technology. Today's didactics are different from the dark ages of birching. Computers are everywhere, and students are required to know how to operate and make use of them. Often, the introduction of new technology is reason for dispute; traditional and established education principles collide with modern technology. These new principles become acceptable with the phasing-out of older teachers. Therefore, today's educational challenges lie not only in the way students learn, but also in how suitable teaching can be applied by all teachers. In short, the entirety of education is once again at a crossroads.

4.1 GLOBAL PICTURE

Time and again, questions regarding challenges in education repeat themselves. As it is utopic to assume to be able to provide concluding answers, this dissertation focuses on a selected subset of topical interests, mainly peer instruction (↔ [subsection 2.1.2](#)) and self-regulated learning (↔ [subsection 2.1.1](#)), thereby also affecting cognitive activation (↔ [subsection 2.1.4](#)). As there are manifold research results – theoretical as well as in practical application – for these three interests in the area of knowledge transfer, the application in knowledge consolidation shall be investigated. Addressing the basic problem of how the means of computer science can help the application of peer instruction and self-regulated learning (and partially cognitive activation) in knowledge consolidation scenarios like tutorials, the ambit shall briefly be described.

Having students be able to autonomously perform certain tasks requires effective transfer, consolidation and application of knowledge. All three factors can be addressed by efficient design of scenarios. Peer instruction primarily addresses transfer, but can also be applied to consolidation as will be proven later. Self-regulated learning assists students on the receiving end of transfer and is capable of fostering effective consolidation, depending on proper stimuli of the learning process. Cognitive activation addresses these stimuli and hence, directly influences effective consolidation and application. Strangely enough, with respect to the means of computer science this simple correlation has not yet been thoroughly investigated. For example, cognitive activation has been addressed by cognitive prompts provided within computer-assisted readings, but these are a means of knowledge transfer, ignoring the consolidation and application aspect. Vice versa, push messaging has been heavily investigated in computer science, for example spawning Web Socket communication, but targeted application in didactics has been degraded to a mere utilisation of design patterns at most, not giving any thought into controllable didactical effects. Therefore, it is fair to postulate that intensive research is desirable at this intersection of didactics and computer science. Simplifying this frontier of unknown extend, the focus shall be settled on the intersection of motivational psychology, learning psychology, interface design and web technologies. These intersections as well as selected involved concepts and technologies are depicted in [Figure 4.1.1](#).

Within the area of interest manifold concepts and technologies intersect. These include but are not limited to peer instruction, self-regulation, cognitive activation, discussion systems, virtual interactive whiteboard systems, audience response systems, as well as user management and profiling systems. To simplify matters, the so outlined area of interest shall be assumed w.l.o.g. exclusive. Consequently, this area includes three distinguishable application domains: exchange, control, and assessment. In the context of didactics, these application domains can be refined to tech-enhanced discussions, control facilities, and learning demand assessment. Finally, instigating actual interface design –and forestalling anonymity–, the three domains tech-enhanced peer discussion with PDS and V-IWBs, anonymous control facilities with ARS and evaluation systems, and learning demand assessment with corresponding systems emerge. All of these

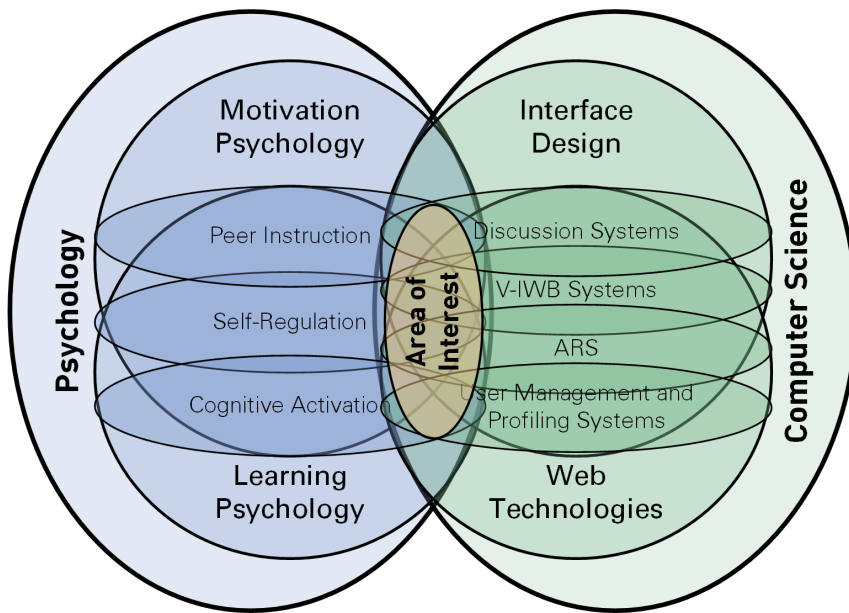


Figure 4.1.1: Schematic display of the intersecting concepts and technologies investigated.

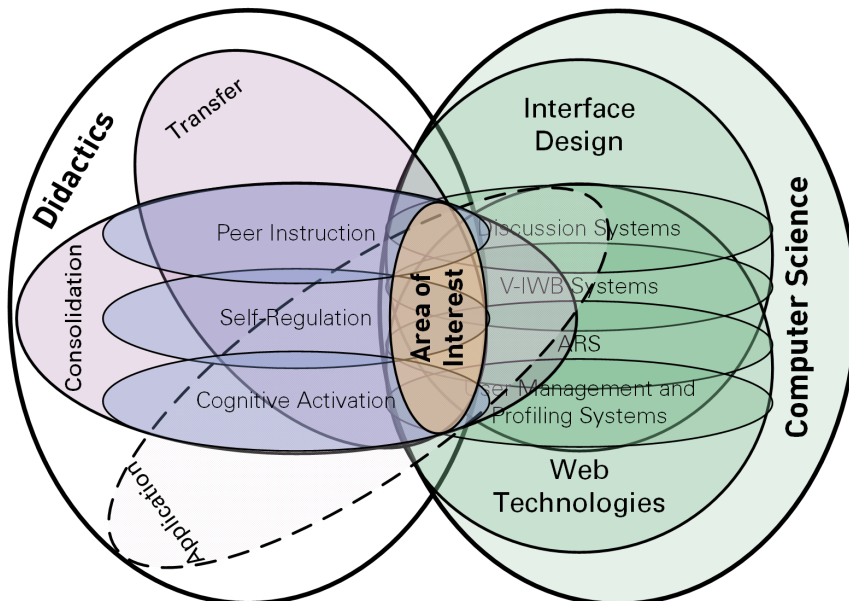


Figure 4.1.2: Didactics with the three main phases of the learning process (transfer, consolidation, application) laid over the intersection of [Figure 4.1.1](#).

can be connected by a user management system. If this system provides profiling functionality, targeted workflows and campaigns can be managed, or in didactical terms, personalisation can be achieved, namely providing the technological basis for all personalised processes such as cognitive activation.

Focussing more on didactics as a superset to learning psychology, learning processes with their three main phases in knowledge transfer, consolidation, and application can be considered as partially intersecting sets laid over the intersections of [Figure 4.1.1](#). It is obvious that consolidation and application reach beyond the scope of didactics, but still originate from it. The basic concept is depicted in [Figure 4.1.2](#).

As knowledge application is considered to be not exactly within scope, the clear focus is on transfer and consolidation. As mentioned earlier, transfer has been under heavy investigation, therefore transferring ideas to consolidation is worthwhile. Due to significant overlap in concepts and technology, this should be achievable with reasonable effort. Moreover, partial aspects of knowledge application drop off as a by-product. This is especially true for peer activities in which students attempt to exploit their knowledge to succeed, for example during peer discussion. Efficient application of knowledge yields good arguments for these discussions.

4.2 SYSTEM ARCHITECTURE

Based on the previous investigations into existing concepts as well as related work, and respecting the intended focus of the desired solution, a well-defined set of assertions was conceived (↪ [chapter 5](#)). These assertions allowed translation into a concept respecting their key aspects. Overall, the tools described in the assertions can be divided into two categories: tech-enhanced and anonymous discussion means, and anonymous control facilities. The combination of both shall be summarised in a *discussion and control design* (DCD), namely an education platform as a collection of reasonably feasible and suitable tools. The first category includes a conceptual conversion of the assertions on the (peer) discussion system as well as the virtual interactive whiteboard system, and the second of an emergency brake (a special type of ARS) as well as the evaluation system (refer to [Figure 4.2.1](#)).

The conceived DCD is extensible as can be seen in the results discussed later (refer to [figures 5.2.1](#) and [10.2.1](#)). It should be noted that the DCD described in [Figure 4.2.1](#) does not include learning demand assessment (LDA), even though it was investigated. This is due to the fact that the results on LDA were inconclusive. However, LDA should be investigated in the future as alluded in [Figure 10.2.1](#) in [section 10.2](#).

Comment

In the following, it is assumed the reader is aware of the widely used 'Model-View-Controller' design pattern.

Aside from reviewing the functional aspects of the system design (↪ [Figure 4.2.1](#)), the communication and system architecture can be easily conceived as a traditional client/server architecture. The idea is to provide amended learning experience by utilising the students' own devices as second screens. The simplest way to tie-in the students' devices is by providing a web-based solution either as an app, a web-app (website), or both. While at least one server provides data, at least one client provides instructions. Basically, the server(s) provide the model and parts of the controller, while the client(s) implement the rest of the controller as well as the view. The organisation of the different tools into client-side components is depicted in [Figure 4.2.2](#). An overview including utilised frameworks is provided in the next chapter with [Figure 4.3.3](#).

It should be obvious that the separation of the different functionalities by means of component encapsulation is only effective on the client side. On the server all data should be stored into one dataset – or be joinable into one merge set – in order to provide a maximum of additional benefit to individual students as well as teachers. The depicted audience response system (ARS) is still functionally available in the latest prototype. However, it no longer provides a view. Instead, the emergency brake utilises the ARS’ interfaces for model and controller. In fact, the emergency brake is a modified view utilising the same ARS controller: a ‘stop’ instruction is a simple ‘volume down’ data instruction within the ARS, merely differing in information visualisation. Additionally, the emergency brake makes use of the peer discussion system’s controller (will be described later). As mentioned, the LDA was investigated, but is no longer active; that is, no view and no active controller within the latest prototype.

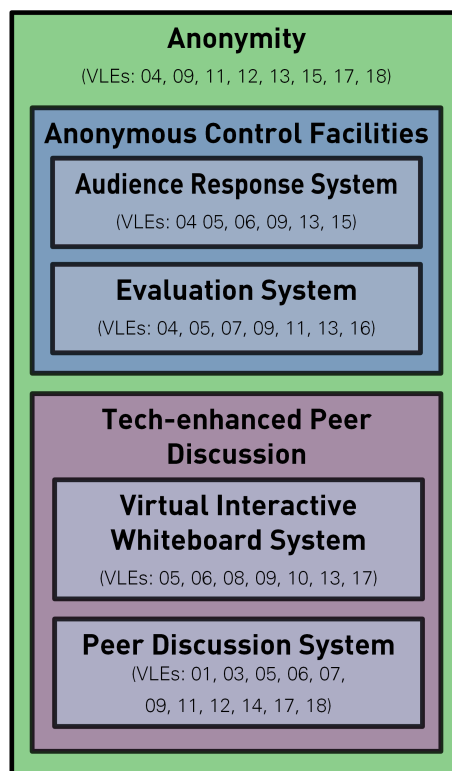


Figure 4.2.1: Discussion (bottom) and control (top) components within the system design.

Brief descriptions of the means available in the final system prototype are provided in the following (sub)sections. A more elaborate discussion is reserved for [chapter 5](#) in which the investigated tools are presented in detail.

4.2.1 Anonymous Discussion Means

Tech-enhanced and anonymous Peer Discussion

Providing students with a means to anonymously ask questions and discuss issues is in support of all three cyclical self-regulatory phases. Therefore, provision of a tech-enhanced peer discussion tool should be able to enhance the peer discussion phase of peer instruction by providing

traditionally not possible anonymous contributions as well as retroactively retraceable and comprehensible discussions on one hand, and a means to discuss issues in the moment they occur in low interactivity scenarios on the other hand. Therein, these tech-enhanced peer discussions should be an individually self-regulated and, within the group, self-moderated process, reducing hesitation to contribute to the class, as well as to ask questions or point out issues. Under aspects of CIU, tech-enhanced peer discussions should be capable of unobtrusively addressing students as well as tutors. Interruptions should only occur by the time the cognitive decision to incidentally utilise the tool is made. However, the concept must respect that any type of discussion is per definition not arrangeable under CIU aspects. – Further details are provided in [section 5.4](#).

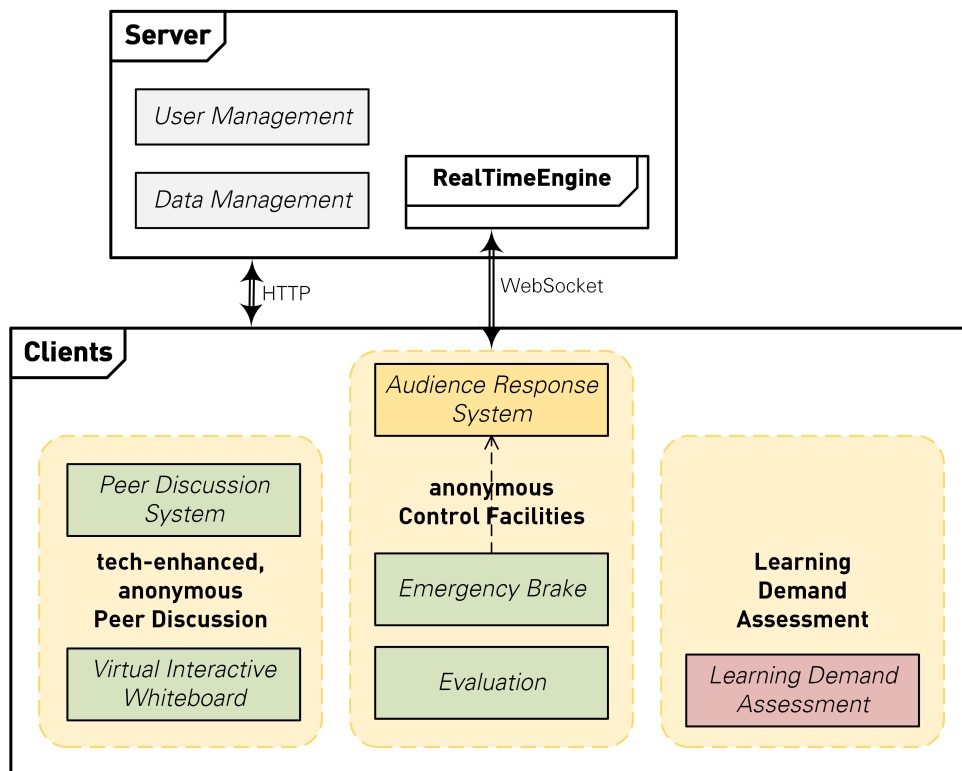


Figure 4.2.2: The general system architecture (client/server architecture).

Virtual Interactive Whiteboard

Increasing the amount of receivable graphical contribution should be easily achievable with a virtual interactive whiteboard. It allows more students to hand in in-course as well as off-campus work (like homework), and have the contributions available for easy presentation to and discussion with their peers. The tutor should act as a moderator in this setting, inviting for active discussions on the state of group knowledge. Having contributions being able to be observably modified in real-time also allows for timely identification of issues, as well as well-timed discussions, and step-by-step development of solutions rather than discussion of an already completed solution. – Refer to [section 5.5](#) for further details.

4.2.2 Anonymous Control Facilities

Anonymous Emergency Brake

In order to passively improve their learning surroundings, students require a means to announce deficits, yielding a correcting adjustment by the tutor. Providing an anonymous emergency brake tool should allow all students to announce deficits, even those who would not openly do so. Announcing deficits is a positive influence for the learning environment as it helps the teacher to realise and correct those deficits. However, feedback must be limited to a sole deficit annunciator in order to have tool utilisation arrangeable under CIU. Provision of the actual deficit should be separated from the annunciator in order to keep the entire emergency braking process simple. – [Section 5.6](#) provides further details.

Anonymous Tutorial Evaluation

Students' desire to influence their learning environment also manifests beyond the scope of immediate deficits (→ emergency brake). They require a feedback means covering a broader scope of potential deficit factors to be provided at a defined countable modicum of times. A tool observing these aspects should hence be decoupled from tutorial conduct and allow students evaluative feedback at any desired time, especially outside of class settings, for example in the refectory at lunch, or at home after having reprocessed the concluded tutorial. – In [section 5.7](#) further details are provided.

4.3 IMPLEMENTATION

Investigations into the selected tools took place in two consecutive iterations of the 'computer networks' course at TU Dresden, the first in the summer semester of 2014, the second in the summer semester of 2015. Refinement of the tools was conducted during and between both semesters.

Two prototypes, *RNUW*³⁵ and *ExerciseTool*³⁶ were implemented for the first iteration. Prototype *RNUW* was designed for continuous biweekly integration of additional features, whereas prototype *ExerciseTool* was designed to be utilised as a counterproposal to *RNUW*. Therefore, *ExerciseTool* was outsourced as a student task in a practical course (processed by Tommy Kubica and Huangzhou Wu). This provided a differing point of view and allowed for a separate approach based on the same didactics foundations. However, due to the implementation task being outsourced in that manner, *ExerciseTool* was not available earlier than tutorial unit U09. As the implementing students could only focus intensively on implementing Q&A and V-IWB functionality, tests of *ExerciseTool* were limited to attendance of the implementing students, hence U09 and U10 were selected for testing. A comparison of the functions included within both prototypes is provided in [Table 4.3.1](#). As mentioned in the description of the experimental scope (→ page IX), the tutorial units three (U03) and eleven (U11) are excluded from consideration even though the prototypes were utilised in them.

³⁵ German: [Rechnernetze Übungswerkzeug](#) – <https://rnuw.de> – accessed 2 February 2015; later cancelled.

³⁶ <http://exercisetool.inf.tu-dresden.de/> – accessed 15 March 2016 – Attention: the URL was recycled for use with the 2015 and 2016 versions of the prototype.

function	availability	
	<i>RNUW</i>	<i>ExerciseTool</i>
Anonymity	✓	✓
LDA	U03–U11	✓
ARS	U05–U11	×
Q&A	U07–U11	U09
V-IWB	×	U10
Evaluation	×	U11

Table 4.3.1: Functional comparison of the prototypes in the first iteration

Besides the obvious fact of both prototypes utilising different GUIs (→ screenshots in [chapter 5](#)), the functions provided differed slightly in both prototypes. Firstly, the LDAs differed in the possibility to take notes; secondly, V-IWB as well as evaluation functionality was only available in *ExerciseTool* and ARS functionality only in *RNUW*; thirdly, the Q&A system in *RNUW* was mis-programmed. Both prototypes allowed anonymous utilisation after registering a user account comprised of an individually determinable pseudonym and an arbitrary password.

Access to real-time functions (ARS, Q&A, V-IWB) was restricted in both prototypes by access key protection. Only students attending a tutorial were supposed to utilise the real-time functions as these were intended for in-class utilisation. Hence, the tutor would provide the required access keys on the blackboard at the beginning of each tutorial.

The prototype utilised in the second iteration was a functional combination of *RNUW* and *ExerciseTool* utilising the GUI of *ExerciseTool*. It was decided to retain the name *ExerciseTool*, however for better differentiation, the second version shall be denominated as '*ETv2*', explicitly reminding the reader that the students were presented with the name *ExerciseTool*. From a functional point,

- the Q&A systems of the first iteration were reprogrammed into a proper online text-based peer discussion derivative (PDS),
- the ARS results were condensed into the single 'emergency brake' suggested, but with added possibility to provide feedback via the newly introduced PDS, and
- an evaluation tool allowing students to provide feedback on tutorials and tutors was added.

As in the first iteration, an access key was required for the real-time functions of the prototype. It was distributed in the same way as in the previous iteration. A functional comparison of *ETv2* to the first iteration's prototypes is provided in [Table 4.3.2](#).

function	availability		
	<i>RNUW</i>	<i>ExerciseTool</i>	<i>ETv2</i>
Anonymity	✓	✓	✓
LDA	✓	✓	✓
ARS	✓*	✓*	✓**
Q&A	✓	✓	∈ PDS
PDS	×	×	✓
V-IWB	×	✓	U06&U08
Evaluation	×	✓	✓

*: gauging volume, speed and perspicuity

** : emergency brake

Table 4.3.2: Functional comparison of the second iteration's prototype to the previous prototypes

4.3.1 The Prototype

The prototype after both iterations matched the system architecture described in the previous section. However, it should be noted that only existing frameworks were utilised for the implementation. The apportion of frameworks is depicted in [Figure 4.3.3](#).

On the server side, user and data management was provided by a Ruby on Rails application. In combination with a PHP application embedded in the Zend framework, allowing utilisation of the Ratchet real-time framework, the server provided the model and parts of the controller. Notably, Ratchet relied on Zend for controller aspects, and on Ruby on Rails for the model.

On the client side, the view as well as the remaining parts of the controller were provided by the Bootstrap and jQuery frameworks. jQuery was required for the communication with Ratchet on the server. Non-real-time communication was solely handled by Bootstrap. Glyphicons were provided in the view by extending Bootstrap with FontAwesome, and the drawing capabilities of the interactive virtual whiteboard tool were provided by scetch.js.

The frameworks' (cross) utilisations by the individual functionalities are depicted by the 'uses' dependencies in [Figure 4.3.3](#). It should be noted that with the exception of the emergency brake (and the audience response system), all functionalities provided a fallback mechanism to provide their function asynchronously via Bootstrap. [Figure 4.3.3](#) also shows *.NET* as a utilised framework. It was used to provide a simple means of flashing some dots on to the wall in the lecture room via the LCD projector. The intention was to notify the tutor of important updates in the view. However, as this visual notification proved to be inept, it was no longer utilised.

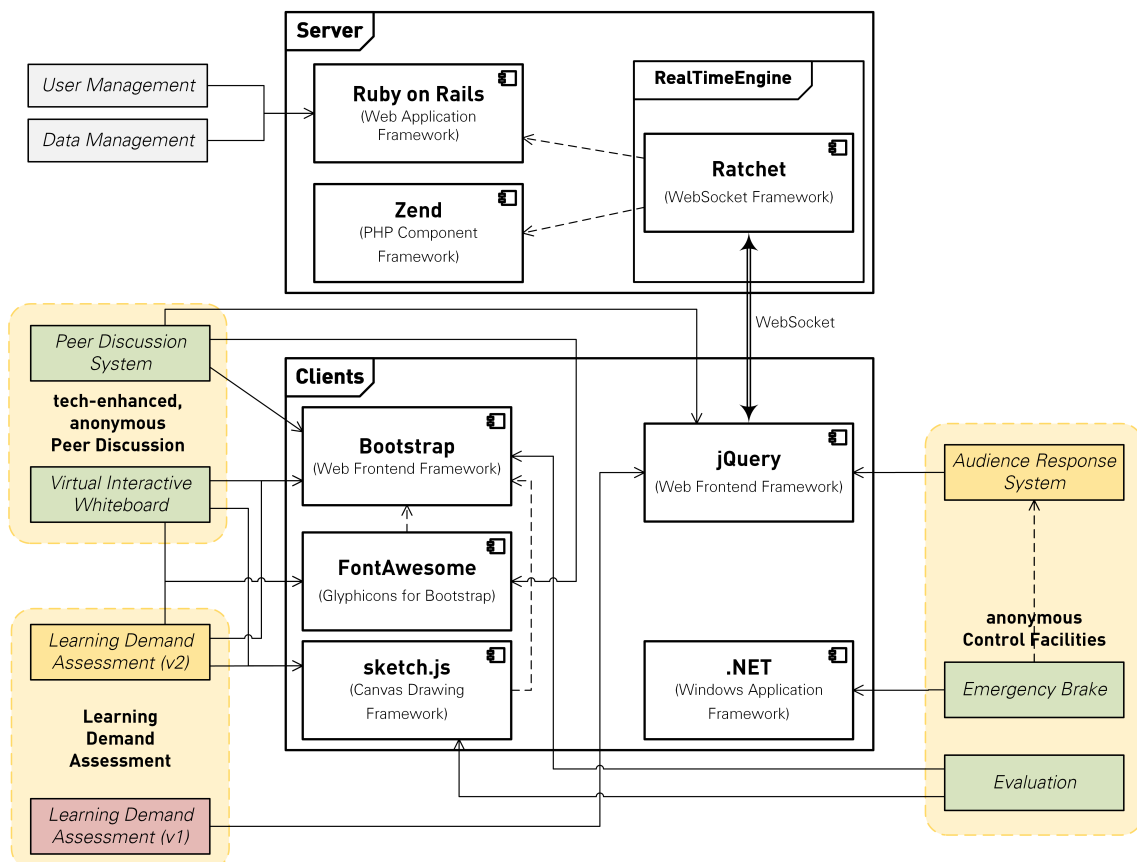


Figure 4.3.3: The general system architecture apportioned by the utilised frameworks.

5 INVESTIGATED TOOLS

'If your experiment needs a statistician, you need a better experiment.'

Ernest Rutherford



INVESTIGATED TOOLS

Taking the desire to make on-site tutorials more attractive to students and raise attendance as a starting point, the concepts presented in [chapter 2](#) and examples selected in [chapter 3](#) allow derivation of some assertions on amendments to tutorials by means of selected tools to be investigated. These assertions may be naïve at first, however they should not be dismissed without providing evidence for implicitness. A strong orientation along the working theses presented in [chapter 1](#) is intended as it is the goal to either prove or disprove single or all working theses. It shall be antedated that all initial assertions do not help with providing foundations for a proof of [Working Thesis 1](#). For each investigated tool the assertions revolve around some of Hattie's visible learning effects (\leadsto [section 3.1](#)). The list of applicable effects will be given for each assertion.

In the first iteration only eleven tutorial units were available due to unfavourable scheduling of public holidays and social events. Three tutorial instalments, all conducted by the same tutor, were selected for testing. The first instalment (14-G1) was selected to utilise prototype *RNUW* in the units three (U03) to eight (U08) as well as unit eleven (U11), the second instalment (14-G2) utilised the prototype *RNUW* in the units five (U05), seven (U07) and eight (U08), and prototype *ExerciseTool* in units nine (U09), ten (U10) and eleven (U11), and the third instalment (14-G3) acted as control group without the prototype. Another three instalments (14-CG) conducted by two other tutors collectively acted as comparison benchmark.

Students were asked to voluntarily provide feedback on different aspects of the prototype based on the platform feedback sheet (PFS \leadsto [section B.1](#)). If not stated otherwise, this data-base was utilised for numerical results provided in the following sections. Other results rely on interviews and other written, but not numerically evaluable types of feedback. The tutor's feedback was gathered in a similar way, however the PFS was filled out in their office at least fifteen minutes after tutorials had concluded, and not all questions were applicable.

In the second iteration all twelve tutorial units were available for testing. Again, three tutorial instalments of the same tutor were selected for testing. The first instalment (15-G1) was selected to utilise a prototype in the units three, six, seven, nine and eleven, the second instalment (15-G2) utilised the same prototype under different instructions in the same units, and the third instalment (15-G3) acted as control group. Another five instalments conducted by three other tutors collectively acted as comparison benchmark (15-CG), and one additional group conducted by a different tutor utilised the same prototype in unit eleven (15-GA), however only the V-IWB was actually employed.

As the results of the previous iteration seemed a bit equivocal, test group 15-G2 was left unaware that the prototype in test was part of a test run. Instead, they were left to believe it was a regular tool in their exercise, and instructions were given accordingly, for example *'As usual, in order to keep the volume down, please use the discussion system instead of talking with your neighbours during the tutorial. If you have something important in the discussion, please mark it so that we can continue the discussion this afternoon.'* instead of *'Today we want to examine the prototypes behaviour under heavy utilisation load, so please use the platform to discuss rather than talking to your neighbours. We will also test postponing of answers into after-class activities.'* This was actually done in order to double-check if the previous results were invalidated by the Hawthorne effect (\leadsto [Ada84](#)), but after realising that students – of course – had the possibility to talk among each other and thus be aware of the untrue nature of the instructions, the idea was overthrown. As long as the prototype is not utilised in *all* tutorials – thus, without a control group – no definitive elimination of the Hawthorne effect is possible. However, the procedure described allowed for testing of tool utilisation under differing tutorial design and instructions. Hence, starting unit U05 group 15-G2 utilised the prototype under peer instruction settings, having tasks prepared to be solved using the tools of the prototype, especially the discussion system as well as the V-IWB. 15-G1 continued to utilise the prototype as an addition to the regular tutorial setting.

5.1 NOTE ON METHODOLOGY

Before discussing the investigated tools themselves, a brief summary of the methodology explaining the intended/expected scope and validation idea shall be presented. Beyond the scope of the general experimental setup (↪ [Appendix A](#)), each of the investigated tools was subject of a more or less specific test setting as well as notional results.

For all tools, students were invited to use their own devices as second screen, namely smartphones, tablets, and laptop computers. The availability of the platform containing the tools under test was presented to the students at the beginning of each tutorial during which tests were to be conducted. At the same time, the required access key (passphrase) as well as the URL was written onto the blackboard. Further methodic information is provided for each individual tool in the following sections.

5.2 ANONYMITY

5.2.1 Methodology

Knowing the technical background of the implementation, it is impossible to test anonymity itself on a technical level beyond the scope of hardening to known attack vectors. Therefore, the tests were focussed on the perception of anonymity as well as perceived benefits thereof.

In order to acquire corresponding information, students were regularly presented questionnaires, and orally interviewed. The notion was, anonymity should provide an incentive for platform utilisation. In the worst case, it would have no impact on platform utilisation.

5.2.2 Visible Learning Effects

Anonymous utilisation of the tools prevents attribution to individual, identifiable persons. Anonymity is achieved on the user level, not on the (meta) data level, as of course technical identification markers are still available, for example accessing IP address. However, such an address can not be easily attributed to an individual. In context of visible learning effects, anonymity

- VLE04: provides a means to influence class behaviour without fear of negative repercussions,
- VLE09: does not permit attributable labelling of students (only of non-identifiable meta-individuals),
- VLE11: allows for peer bonding without influences of social standing, peer pressure, et cetera,
- VLE12: reduces attributable negative feedback from peers and allows peer influences to arise that would normally be suppressed due to identification,
- VLE13: allows for class organisation and group building that would normally not be possible due to peer pressure and cliques,
- VLE15: provides a positive incentive as negative repercussions do not need to be considered as much during planning phases,
- VLE17: removes identifying properties and allows for contributions of students who would normally refrain from contributing due to social anxiety or other angsts, and
- VLE18: allows strivers and nerds to contribute without having to fear to expose themselves.

5.2.3 Assertion

Assertion (Anonymity):

Utilisation of pseudonyms instead of identifiable traits is inviting for users.

This assertion on anonymity pays respect to volition and fiat-tendency. The ability to anonymously utilise a tool should present a strong incentive to overcome the initial hesitation of putting in the effort of actually utilising the tool. The planning phase is significantly shortened as external factors such as impact of utilisation of the perception by others are eliminated. Since the utilisation is anonymous, no negative repercussions are to be feared; neither fellow students nor the teacher will bear any enmity toward the actuator of tool utilisation results. The entity having to fear repercussions is reduced to an intangible abstract construct, namely the anonymous pseudonym. Referencing the achievement and goal oriented motivational basis (\leadsto [subsection 2.1.1](#)), students are assumed to strive toward two distinct goals: *performance*, displaying students' accomplishments and hiding insufficiencies, and *mastery*, improving students' capabilities and eliminating deficiencies. Roschelle et. al. derive a positive influence on goal driven motivation by obfuscating performance aspects and emphasising mastery aspects of courses [RPA04]. By highlighting differences in contributions while at the same time detaching the contribution source, performance avoidance goals can be significantly removed from planning, that is strategies oriented at preventing embarrassment or exposition. In this sense, anonymity – or at least anonymous display of tool utilisation results – can enable students to collectively concentrate on maximising learning success by disregarding performance goals. All students should thereby be encouraged to participate in course activities and provide their (anonymised) opinion on topics [DB02]. This should provide satisfactory proof for [Working Thesis 4](#) and lay out foundations for [Working Thesis 3](#).

5.2.4 Experiments

All prototypes allowed anonymous utilisation after registering a user account comprised of an individually determinable pseudonym and an arbitrary password. At no time was anonymity disabled as users clearly stated the importance of anonymity with respect to their willingness to actually utilise the prototypes. However, automatic user tracking as well as feedback on the discussion and virtual interactive whiteboard tools were influenced by the strict anonymity, and in return allowed extraction of results for anonymity.

5.2.5 Results

Due to the conclusions drawn from the utilisation results of and provided feedback on the peer discussion system and V-IWB functionality, a modification of the anonymity assertion was required. As initially asserted, performance goals should be deferred, however highlighting positive achievements should provide an incentive for future planning phases. Hence, enabling students to associate their positive achievements with their identity would benefit their motivation. Obfuscating their insufficiencies at the same time should boost this effect even more. As achievements cannot be accredited to individuals while anonymity is present, allowing optional retroactive revocation of anonymity should provide for the required incentive.

Assertion (Anonymity, revised):

Utilisation of pseudonyms instead of identifiable traits is inviting for users.

- a) Initial anonymity encourages utilisation.
- b) Retroactive revocation of anonymity provides positive incentives by allowing students to accredit achievements.
- c) Retroactive revocation must be optional.

The revised assertion is sensible considering the motivational boost (addresses [VLE15](#)) students may perceive when being enabled to publicly attribute their achievements to their person, namely one correlated with their self-regulation performance goals, and to some extent also their mastery goals. Additionally, revocation of anonymity may benefit class management ([VLE13](#)) and feedback ([VLE06](#)) in positive ways, for example students could be enabled to collect attributable bonus points for the final exam. A corresponding extension of the DCD is depicted in [Figure 5.2.1](#).

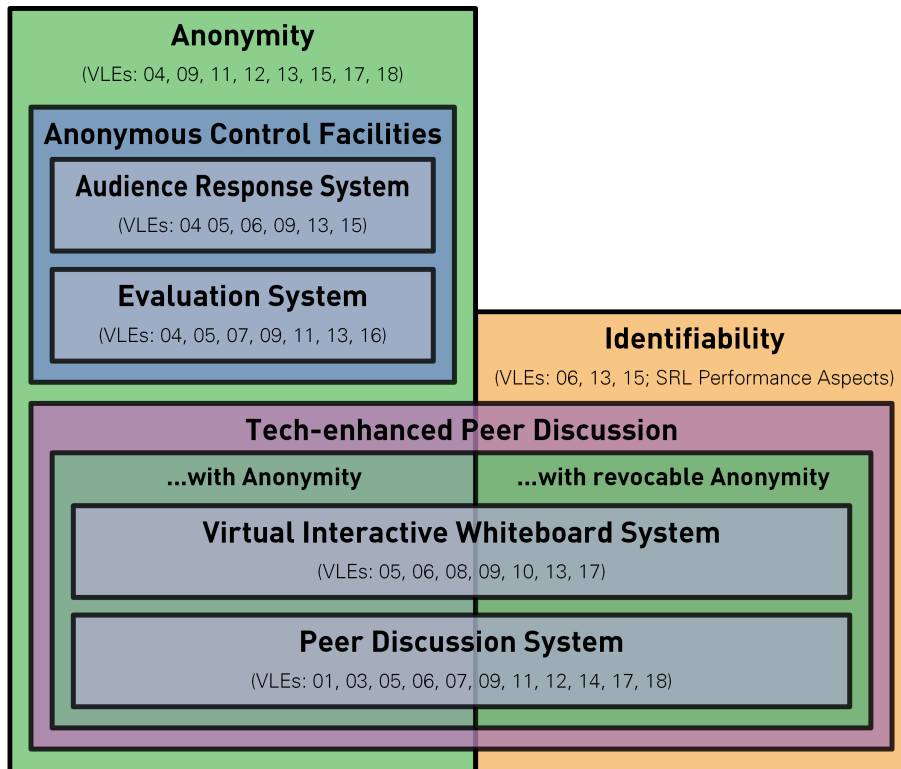


Figure 5.2.1: The discussion and control design extended by retroactive revocation of anonymity.

5.2.6 Conclusions

The DCD must hold anonymity for all users in order to invite students to utilise the learning platform or tool collection. A well-proven means is utilisation of pseudonyms rather than any information attributable to identities. Therefore, the identity of the student should not be required for tool utilisation, ensuring that even the tutor or system administrator is unable to identify students. However, some functions may require attributable information, for example provision of an e-mail address in order to notify a student of a reply a tutor has deposited for them within a tool. This information should be obfuscated from tutors. Unfortunately, under self-regulatory performance goals it should be possible for students to identify with their contributions. Hence, retroactive revocation of anonymity should be supported, allowing students to voluntarily add personal information and accredit their contributions. This should provide positive incentives. In result, an extension to the system design including retroactive revocation of anonymity as depicted in [Figure 5.2.1](#) is self-evident.

The proposed retroactive revocation of anonymity could be designed as a two-step process. In the first step, the total anonymity would be replaced by anonymous attribution by adding pseudonyms to contributions of the same student. That way, the student remains anonymous,

but their contributions can be attributed. In the second step, personal information (for example name or e-mail address) could be added; hence completely revoking anonymity and replacing it with identifiability.

Comment

Anonymity – or more generally: privacy – is a research area of its own and definitely is not within the scope of this dissertation. However, one clarifying comment shall be allowed here: the wording is important as ‘retroactive revocation of anonymity’ is a process initiated willingly by the affected individual, whereas ‘retroactive deanonymisation’ would be a process in which someone else attributes identifying markers and hence break anonymity, possibly without the affected individual’s consent.

5.3 LEARNING DEMAND ASSESSMENT

5.3.1 Methodology

Designed to assist students in their exam preparations, the learning demand assessment was designed to determine a student’s individual learning demand based on simple confidence questions. The notion was to raise students’ confidence in their knowledge as a key factor for less exam stress. In order to realise this, all tutorial tasks’ topics would be presented to the students within the platform before and after each tutorial, allowing estimation of the learning progress. Students were invited to revisit the confidence questions later during exam preparation in order to check-off specific topics.

In order to test the suitability and acceptance of the tool, a combined approach was used. On one hand, the actual utilisation of the tool was automatically tracked with means of log files and client-side scripts. On the other hand, students were asked to provide feedback in questionnaires as well as oral interviews. Availability of the tool was proclaimed to the students regularly. The idea was to observe either an increase, decrease or unchanged utilisation in frequency as well as length. At the same time, feedback on the quality of the provided assessments as well as the acceptance of the tool should become available.

5.3.2 Visible Learning Effects

Habitually, the bulk of students (at least the ones at TU Dresden) postpone learning and preparing for exams as long as possible. Therefore, the learning curve is very flat over the course of tutorials, but then turns precipitous closer to the exam. Regular admonitions remain ignored. As it seems impossible to change students’ attitude toward learning, an alternative may be providing them with support means to identify important topics with high learning demand. The goal should be to help students organise topics into ones with urgent learning priority and ones that can actually be postponed. Of course, this does not mean teachers should resign and accept deferment of learning tasks, but if it is inevitable, students should be given a fair chance of selectively postponing. The following visible learning effects are addressed, as learning demand assessment systems

VLE01: provide a means for externally verified self-assessment,

VLE02: allow for class assessment and ranking among peers,

VLE06: support self-control, self-observation and self-judgement by providing externally verified assessments,

- VLE13: allow the teacher to reorganise classes and adapt to overall class knowledge,
- VLE15: address core aspects of self-regulation phases, and
- VLE17: remove examination anxiety by providing proficiency level assessment in due time *before* an exam.

5.3.3 Tool Description

LDA systems base on a reliable knowledge model for each student. Learning suggestions are based on deviations of the current state of the learning model from a specification model. W.l.o.g., these models are quantifications of knowledge, with deviations being numerical values or vectors with numerical compounds. The specification model as well as the current state model are designed to be adaptive; changes require continuous enquiry of model-defining parameters. Thus, LDA rely on input provided by both, the students and the teachers.

For the herein investigated prototype, the LDA consisted of a server-based model stored in a database and a client-based input/output webform. The specification models were designed to represent the contents of each tutorial unit at first, and later connect tasks into knowledge areas correspondingly. Students were required to regularly submit numerical confidence values to train their corresponding student learning model, which could then be utilised for computations of learning demand. This type of model matching was designed to allow for learning demand assessment along tutorial contents. Individualised LDA in which the students themselves would be able to define learning goals and hence also update the specification models was planned for later prototype iterations, but never implemented.

Workflow

The associated workflow can be split in three phases. In the first phase, the teacher is required to define the specification model by providing the topics of each tutorial unit and linking associated topics with each other by providing pointers from one specification model to another (could also be self-referencing). In the second phase, each student is presented with the topics of the current tutorial unit and asked to provide confidence assertions (which are linked to numerical values). These assertions are stored in the learning model. After the tutorial the student has to provide another confidence statement, which is also stored in the learning model. Based on both assertions the deviation to the specification model is calculated. In the third and final phase (w.l.o.g. before the final exam), the student can request an LDA from the system. Based on the difference between the models the student is then presented with a list of topics to be revised sorted in decreasing order of urgency. Iff the student decides to follow the proposal, they can mark topics as settled, which updates the LDA based on the association links within the specification model (urgency of topics may decrease as their associated topics become settled, making other differently associated topics more urgent based on the new state of the model).

5.3.4 Assertion

Assertion (LDA):

Including LDA functionality stimulates students to regularly utilise tool providing platforms.

LDA functionality should be a good means for students, if the recommendations generated by the LDA system are presented at the right time for the students' just-in-time learning. This should help students in constructing their own learning environment and thus addresses Working Theses 1 and 2. Iff utilisation is unobtrusive and requires little time during the semester, Working Thesis 3 should also be addressable.

Übung 11 - Verteilte Systeme

Der Fragebogen **nach der Übung** dient dazu deinen durch die Übung **veränderten Wissensstand** festzuhalten. Dadurch können wir deinen **Lernplan optimieren**, der dir später beim Vorbereiten für die Prüfung helfen wird.

Thema	Ich bin zuversichtlich ich kann das	Ich glaube ich kann das	Ich weiß nicht ob ich das kann	Ich bin mir nicht sicher ob ich das kann	Ich glaube ich kann das nicht
RPC	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Verteilte Transaktionen	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
Web Services	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mobile IP	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

[Fragebogen absenden](#)

(a) Post-tutorial confidence questions.

Themenübersicht

Offene Themen

Status	Übung	Thema	Lerndringlichkeit
<input type="checkbox"/>	Übung 11 - Verteilte Systeme	Web Services	<div style="width: 20%; background-color: #00aaff; height: 10px;"></div>
<input type="checkbox"/>	Übung 11 - Verteilte Systeme	Mobile IP	<div style="width: 40%; background-color: #ff9900; height: 10px;"></div>
<input type="checkbox"/>	Übung 11 - Verteilte Systeme	Verteilte Transaktionen	<div style="width: 100%; background-color: #cc0000; height: 10px;"></div>

[runter](#)

Erledigte Themen

Status	Übung	Thema	Lerndringlichkeit
<input checked="" type="checkbox"/>	Übung 11 - Verteilte Systeme	RPC	<div style="width: 10%; background-color: #808080; height: 10px;"></div>

[hoch](#)

(b) LDA urgency indicators. Open topics requiring urgent attention on top, settled topics on bottom. (Screenshot provided by Tommy Kubica, B.Sc.)

Figure 5.3.1: Student view of *ExerciseTool*'s LDA tool.

5.3.5 Experiments

LDA functionality was investigated in all three prototypes, having two different LDA systems implemented. Both LDA systems were based on confidence statements asked from the students before and after each tutorial unit. They were designed for exam preparation phase support and learning progress monitoring. Students were given a brief introduction into the system with an explanation of the goals of the system. For each unit the students were presented the rubrics of the tasks (→ [Table A.0.5](#)) and asked to provide statements on their confidence to successfully solve each task without help just from reading the rubric. In *RNUW* a simple binary feedback ('yes', 'no') was implemented, while *ExerciseTool* and *ETv2* utilised a 5-step Likert scale from 1 ('not at all confident') to 5 ('absolutely confident'). In *RNUW* students were additionally enabled to save individual notes on the tasks via the same HTML form. These notes were only visible to the students themselves and the tutor, but not other students. In return tutors were able to provide text-based feedback to students' notes. Both LDA systems provided students with a means of self-assessment, especially with respect to their initial assessment (before the tutorial) and after having been presented the correct solution (after the tutorial). This allowed for a more realistic feedback on whether their self-assessment benchmarked correctly to their actual knowledge. At the same time the LDA systems provided students with the ability to track their individual learning progress, especially when having confidence statements turn positive, when having answered negatively earlier. For tasks that remain uncertain, students can easily identify increased demand for exam preparations. – From the tutors' point of view, the LDA system provided a good means of assessing the student group's collective knowledge and swiftly and timely identify critical topics that required some repetition, or even urgent repetition. A few screenshots are provided in figures [5.3.1](#), [5.3.2](#), [5.3.3](#), and [5.3.4](#).

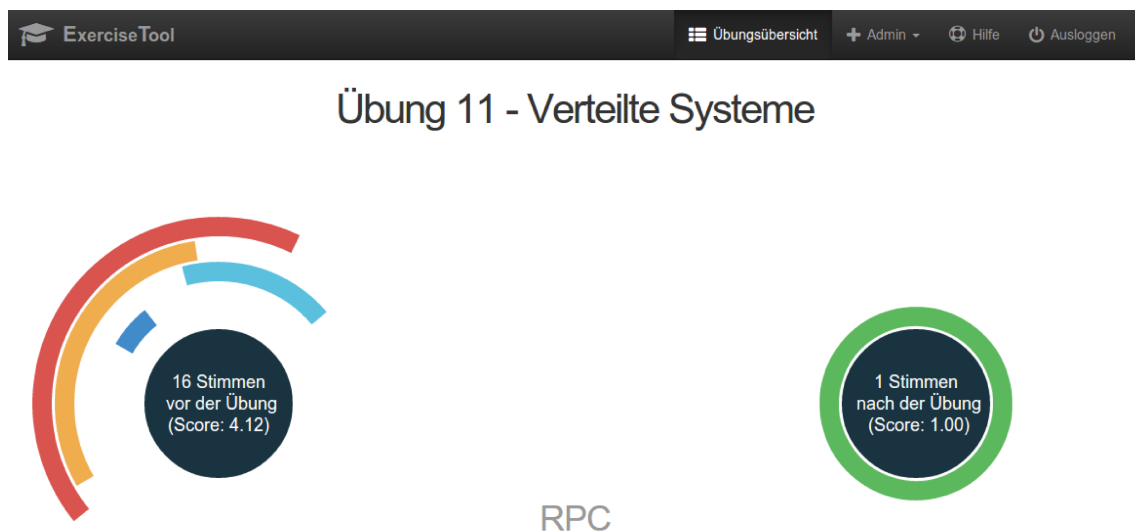


Figure 5.3.2: Tutor view of *ExerciseTool*'s LDA tool. Students' aggregated pre-tutorial confidence indicator on the left, post-tutorial on the right. (Screenshot provided by Tommy Kubica, B.Sc.)

5.3.6 Results

Even though the described possibilities of the LDA system were announced to the students, utilisation remained low. Nine students began using the *RNUW* LDA system in unit U03. By unit

U04 the number had decreased to five, and by U05 to three. As of unit U06 only one student continued to utilise the LDA system until tutorial unit U10. The *ExerciseTool* LDA version was only utilised by one student, and only for the pre-tutorial questions. The follow-up post-tutorial questions remained unanswered. One feedback sheet contained a 2 score with respect to the LDA tool being able to provide effective help in exam preparations (↪ PFS-Q01). – Due to heavy investigation into the other tools within the prototypes, investigations into the reasons for the insufficient LDA system utilisation were desisted. No intermediate conclusions to be considered reliable could be drawn.

Die Überschriften des Aufgabenblattes vor der Übung betrachtend:
Bist Du zuversichtlich, diese Aufgaben ohne Hilfe lösen zu können?

Aufgabe	Thema	Zuversicht	Notiz
1	Shortest Path Routing (Dijkstra-Algorithmus)	ja nein	
2	IP-Pakete	ja nein	Liegen irgendwie in Ethernet-Paketen drin.
3	Einsatz von IP: Adressen und Subnetze	ja nein	
4	Routing	ja nein	
5	Überlaststeuerung	ja nein	

einreichen zurücksetzen löschen

(a) Pre-tutorial confidence questions.

Die Überschriften des Aufgabenblattes nach der Übung nochmals betrachtend:
Bist Du zuversichtlich, diese Aufgaben jetzt ohne Hilfe lösen zu können?

Aufgabe	Thema	Zuversicht	Notiz
1	Shortest Path Routing (Dijkstra-Algorithmus)	ja nein	
2	IP-Pakete	ja nein	Ethernet-Payload ist das IP-Paket.
3	Einsatz von IP: Adressen und Subnetze	ja nein	
4	Routing	ja nein	Routing-Entscheidungen?
5	Überlaststeuerung	ja nein	

einreichen zurücksetzen löschen

(b) Post-tutorial confidence questions.

Figure 5.3.3: Student view of *RNUW*'s LDA tool. Pre- and post-tutorial GUI are meant to match each other. Note the ability to input different comments pre- and post-tutorial.

5.3.7 Conclusions

In light of scanty results for LDA utilisation and the extent of investigation on the other tools provided by the prototype, LDA must be considered of negligible importance to the students in context of the investigated exercises and the utilised prototype implementations. No affirmative conclusions can be drawn for different settings or implementations. However, LDA remains an important facet of self-regulated learning and will most definitely have an influence on overall

platform acceptance and utilisation. For now, this must remain an unproven assumption that has to be investigated in the future.

Aufgabe	Thema	Zuversicht	Unsicherheit	Notizen				
1	Shortest Path Routing (Dijkstra-Algorithmus)	1 / 1	0 / 0	0 / 0				
2	IP-Pakete	0 / 1	1 / 0	1 / 1				
3	Einsatz von IP: Adressen und Subnetze	1 / 1	0 / 0	0 / 0				
4	Routing	0 / 0	1 / 1	0 / 1				
5	Überlaststeuerung	1 / 1	0 / 0	0 / 0				

vorab
 anschließend
 nullen
 löschen

Zum Umsortieren der Fragen einfach die Fragen mittel Drag&Drop verschieben.

(a) Overview of all submissions (left to right): task number, topic, confidence pre/post, uncertainty pre/post, notes pre/post, controls

zurück zur Übersicht

Antworten und Notizen zur Aufgabe „IP-Pakete“.

Studierende/r	Vorab		Anschluss	
	Antwort	Notiz	Antwort	Notiz
TTT1111	nein	Liegen irgendwie in Ethernet-Paketen drin.	ja	Ethernet-Payload ist das IP-Paket.

„TTT1111“ eine Nachricht senden.

(b) List of students' note pre/post-tutorial with ability to write individual message to students.

Figure 5.3.4: Tutor view of RNUW's LDA tool.

5.4 PEER DISCUSSION SYSTEM

5.4.1 Methodology

Designed to allow students to discuss among their peers in parallel to the regular tutorial conduct, the discussion system was implemented as a text-based real-time communication means. The notion was to allow students to discuss issues without having to interrupt the regular tutorial and to allow for off-site continuation after tutorials had concluded. If the tool was well accepted in that fashion, it could also provide as a technical means for scheduled discussions, especially during the peer discussion phase of peer instruction. The general idea is visualised by an exemplary organigram of a fictive peer discussion in Figure 5.4.1.

In order to test the suitability and acceptance of the tool, a combined approach was used. On one hand, the actual utilisation of the tool was automatically tracked with means of log files and client-side scripts. On the other hand, students were asked to provide feedback in questionnaires, oral interviews as well as directly within the discussion tool. Availability of the tool was proclaimed to the students at the beginning of tutorials within which it was to be used as well as by the time the test was being conducted (meaning by the time the tutorial task to be supported by a discussion

was current). The idea was to observe either an increase, decrease or unchanged utilisation in frequency as well as length. At the same time, feedback on CIU compliance and acceptance of the tool should become available. Based on this information the tool could be further refined for different discussion types.

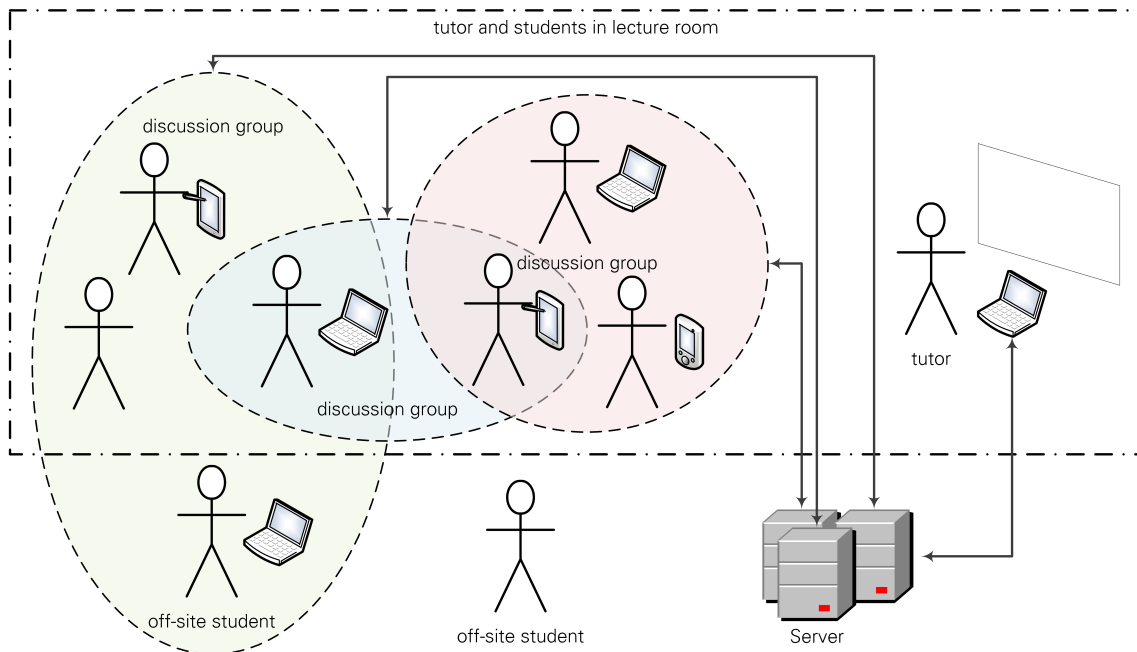
5.4.2 Visible Learning Effects

Having a question on a topic is often not immediately obvious to students. Sometimes they tend to be insecure whether a question is appropriate, or not. Even though there are no 'stupid questions' as all questions help purge uncertainty, students often believe that some questions cannot be asked. If not generally unaskable, questions may also be deemed unpresentable toward the teacher. This type of question is the often observable peer question where students ask their neighbours instead of the teacher. However, this type of question may interrupt the neighbour in their learning process. Additionally, if the neighbour themselves have not yet sufficiently trained or consolidated their knowledge, the answer may prove unsatisfactory, leading to a peer discussion with erroneously consolidated knowledge. Questions may also be deemed temporarily unaskable, and are then postponed to a later point in time. The student's reasons for postponing often arise from a desire of autonomously being able to clarify the underlying issue by continued exercise, or from not wanting to interrupt the teacher. Unnecessary interruptions may be perceived negatively by fellow students, which further influences the planning phase of the asking action. Also, negative experiences with prior questions influence the decision process, for example when the teacher has reacted negatively: 'I was going to answer this in a moment', or even worse 'don't interrupt me'. A tool observing these conceptual forethoughts should address visible learning effect by

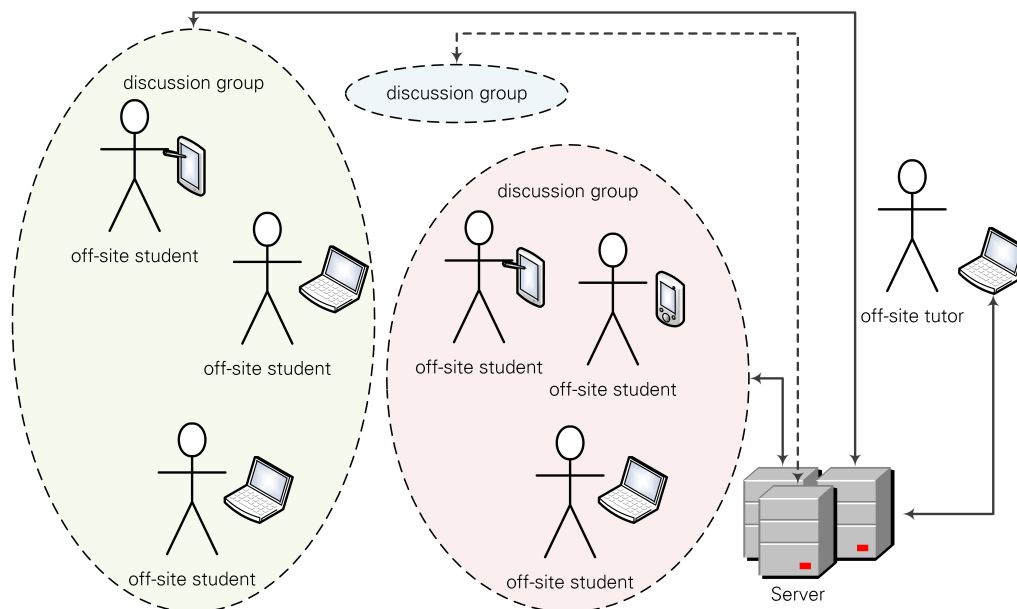
- VLE01: allowing to test own knowledge against a group benchmark,
- VLE03: allowing teachers to address issues within a confined environment and audience,
- VLE05: allowing teachers to clarify aspects of material specific to students' issues,
- VLE06: allowing teachers and other students to provide feedback on questions and answers,
- VLE07: requiring an adequate vocabulary in order to express issues or to provide comprehensible answers,
- VLE09: allowing students to ask questions they wouldn't ask in fear of being labelled 'stupid',
- VLE11: allowing for peer bonding based on contributions rather than influences of social standing, peer pressure, et cetera,
- VLE12: allowing students to receive reactions from their peers and influence each other,
- VLE14: helping students organise in issue-specific discussion and learning groups,
- VLE17: reducing students' social anxiety by allowing them to ask, comment and answer anything they want without fear of negative repercussions, and
- VLE18: allowing good students to contribute to the class and support weaker students.

5.4.3 Tool Description

In general, PDSs are –like all forum systems– based on a server-side database (central or distributed) and many clients providing webforms. The data entered in any webform is transmitted to the database and stored with unique identifiers, mainly a submission ID and the thread the submission is associated with. Additionally, timestamps for creation and modifications, the creating users' IDs, view counters, et cetera are often stored alongside the actual submission. This data is then utilised in order to provide an informative view to the users. Often, submissions can be 'deleted' in a first step by marking them as 'not to be displayed' in the database, and the purged in a second step by actually deleting them from the database. In general, the first



(a) Students in the lecture room as well as off-site students can form discussion groups. All contributions are synchronised, stored, and distributed by a server. The tutor can 'listen-in' on all discussions.



(b) After the tutorial has concluded, discussions can be continued or reviewed off-site. Note the empty discussion group; its discussion history is still available, and the discussion can be reactivated if required.

Figure 5.4.1: Exemplary organigram for a tech-enhanced peer discussion during (5.4.1a) and after (5.4.1b) a tutorial.

step is available to the creator of a submission and certain privileged users (administrators, moderators), while the second is reserved for the privileged. By replacing the associated thread ID submissions can be *moved* from one thread to another; the position where they are then displayed depends on the underlying ordering, for example by timestamp. Thus, threads are often re-orderable, but also individual 'out of context' submissions are threadable. In some systems submissions and/or threads can be voted on by users, providing a karma or reputation system for threads, submissions and/or users.

The prototype utilised for the research presented initially utilised an open Q&A system, but it was soon replaced by a discussion system without re-ordering. Deletions, votes and threading were added later. The entire system was designed to perform best on second screen devices, hence focus was emphasised for finger-based control. However, the implementation is open for future addition of gestures such as swipe, pinch, or drag-and-drop (for both, fingers as well as mouse).

Workflow

The associated workflow is very simple. Users of the system request a list of threads or the list of submissions within a given thread from the server. The server's reply contains the requested information, which is then displayed on the client. If a user wants to submit a new post to an existing thread or create a new thread for a new post, a webform is filled on the client and submitted to the server. The submission is stored in the database and connected clients are notified of availability of new data. As soon as a client requests the contents of a thread, all submissions within that thread (not marked as not to be displayed) are then transmitted to the client. The client then renders either a new view or updates the existing view if only a difference was messaged. Deletions, manual re-ordering, moving, voting, et cetera of content are handled similarly, namely by transmitting the instruction together with the corresponding ID to the server. The update of the clients' views is handled analogously to new submissions.

5.4.4 Assertion

Assertion (Question and Answer System (Q&A)):

Provision of Q&A functionality invites students to discuss issues in the moment they occur.

- a) Hesitation to interrupt no longer influences the decision to ask questions.
- b) Unobtrusive discussions can address all fellow students as well as the teacher on demand, thus allow for parallel discussion and answering of questions when the situation permits.
- c) Documented, reproducible and anonymous discussions provide a means for tech-enhanced peer discussion.

If addressed correctly, an anonymous Q&A system may provide a good starting point for a proof of [Working Thesis 2](#), especially when applied to peer instruction, and particularly peer discussion therein. However, [Working Thesis 3](#) is definitively jeopardised as discussion functionality presents an attention hazard in the context of mental resource models.

5.4.5 Experiments

In the first iteration both prototypes included a Q&A system aimed at providing students the opportunity to ask questions (under the protection of anonymity) in the moment they arose. By this, students were supposed to ask questions they would normally keep to themselves. In order to prevent multiple instances of the same (or similar) questions to be asked by different students, the implementation of the Q&A tools envisaged a voting system allowing the students to up-vote

and down-vote questions. The intention was for students to provide a 'I have the same question' statement. Further, the urgency of questions was supposed to be auto-regulated by the student group, making a 'top n ' ($n \in \mathbb{N}$) questions overview available to the tutor at any time. This way, the tutor would be able to answer selected questions as time permits during tutorials, and others in a follow-up off-site (thus, online) session. Students were also given the possibility to mark their question as answered (*ExerciseTool*), or revoke their question as long as no up-votes were registered (*RNUW*). In both prototypes students were also enabled to add comments to their questions in order to clarify aspects thereof or amend a question itself. Screenshot of the *RNUW* prototype are provided in figures 5.4.2 (student view), 5.4.3 and 5.6.3 (tutor views).

The concept did not work as expected within the *ExerciseTool* prototype. No conclusive results on suitability can be derived from only one question being asked and no PFS containing information of this. The voting mechanism provided no conclusive data, either. The asked question itself was valid, and the answer was provided about two minutes later after the tutor turned their attention back from the blackboard to the audience.

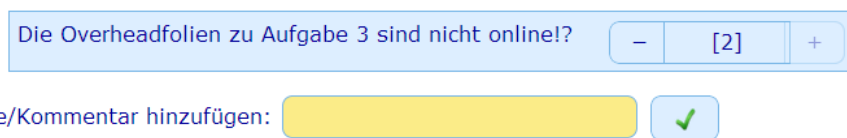
Within *RNUW* the concept did not work as expected, either. Two issues impacted the results. The minor of the two was related to the revocation and voting mechanism of questions. Being able to revoke questions only as long as there were no up-votes proved impractical. In oral interviews students stated that instead the asking student should have been enabled to revoke their question even though up-votes were present, as some questions had been answered (either directly or indirectly) by the tutor, and by the time they went through the list of open questions they read the question aloud to the audience, stated that the question had already been answered and moved on to the next question. This effect was amplified by an implementation fault of the commenting function: instead of only having the original questioner being able to comment on questions (intended for them to be able to amend their questions), all students were able to comment on questions of all students. Comments stating that question(s) that had been answered were present. Of course, this makes the second, more major issue obvious: a programming error in the prototype. However, this error was a very fortunate one: students stated in oral interviews as well as minute paper feedback that they would not want to miss this 'feature' they thought of as imperative. In light of the programming error and the students' reaction to it, the Q&A tool was modified, implementing the error into an actual feature. The resulting peer discussion system allowed students to post questions and comments at any time. Both types of contributions could be answered or commented on by other students. Furthermore, the up-vote and down-vote system was extended to cover all three types of contributions. Depending on the type of initial contribution, the received comments, and the received votes thereon, associated contributions were handled as discussion threads by the *RNUW* system. All system users – that is students and tutors – were then displayed an ordered list of topical discussions in real-time. The so redesigned tool provided valuable contribution means to the students ($\bar{X}_{PFS-Q07} = 4.0$, $n = 8$). While the tutor was occupied by blackboard, OHP or LCD projector activities, or was engaged in interactions with students in the lecture room, students were able to state questions or comments in the prototype ($\bar{X}_{PFS-Q08} = 3.8$, $n = 10$). These were then actively discussed by other students, often leading to (mostly) correct answers. By the time the tutor could attend back to the prototype some issues had already been cleared within the students' peer group by active online discussions conducted in parallel to the exercise via the second screen. After including a derived question in the PFS, students stated to slightly value the contributions provided by their peers ($\bar{X}_{PFS-Q08a} = 3.5$, $n = 11$).

Having students be able to mark questions as answered was the result of a major point of criticism. The fact that the tutor was able to mark questions as answered (\leadsto Figure 5.4.3) was not received well. The decision whether a question was (sufficiently) answered or not was to be made by the asking student themselves. Therefore, an adjustment to the system made 'helpful' markers available to students and 'handled' markers to tutors. With this compromise, questions would remain in the activity flow and could remain unanswered from the students' point of view, while the tutor was able to remove the question from their view of topical questions (that is, move on to the next question without having a sticky question on top of the flow).



(a) Q&A tool in the vertical centre shows a student's own comment with revoke button (red X) and voting indicator. Below: text field to add a new question or comment.

FRAGEN UND KOMMENTARE



(b) How other students see the centre area in 5.4.2a. Note the missing revoke button. This student has provided an up-vote via the now disabled + button. –Screenshot provided for reuse by unknown student.

Figure 5.4.2: Student view of *RNUW*'s Q&A tool.

FRAGEN UND KOMMENTARE

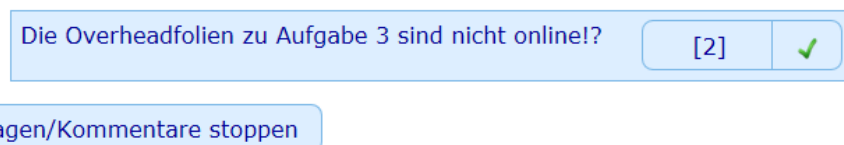


Figure 5.4.3: Detail of a student's contribution within the tutor view (→ bottom area in Figure 5.6.3) of *RNUW*'s Q&A tool. The '[2]' indicates the sum of all down- and up-votes. The check mark allows the tutor to mark the contribution as concluded.

Based on the lucky misprogramming of the *RNUW* prototype, *ETv2* included a revamped version of the PDS, now fully grown with some additional perks. The new PDS allowed students to post questions and comments at any time, answer or comment on contributions, up-vote and down-vote on contributions, mark any own contributions as settled (not only questions as in the previous version), mark any answer or comment as helpful, and revoke any contribution that had not led to an answer or comment that had been marked as helpful (up-voted contributions were revocable as per students' requests). As before, all associated contributions were handled as threads by the discussion system, displayed as an ordered list of topical discussions to all users in real-time.

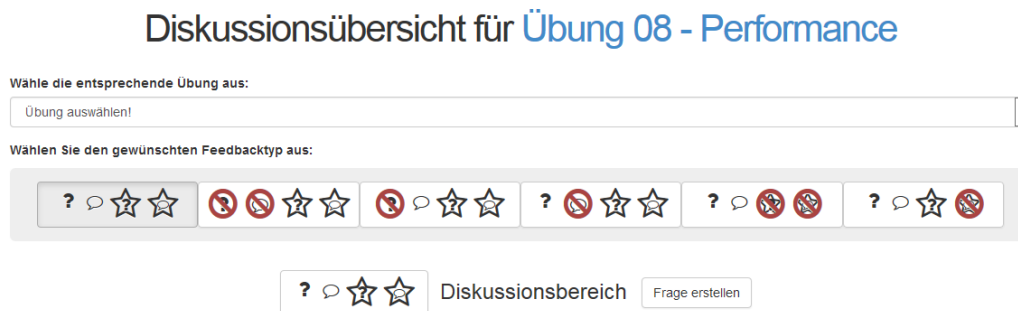


Figure 5.4.4: Settings view of the PDS tool. Different combinations of functionality can be selected. The lower area presents a preview of how students will see the PDS tool (a mouse-over would display an explanatory text on the icon set: creation of new topics (question mark), reply to existing topic (speech balloon), vote on topics' initial post (star with question mark), and vote on individual replies (star with speech balloon)).

Concerning tool functionality itself, different combinations of features were tested. The tutor was able to change corresponding settings for each tutorial unit and also during a tutorial. A screenshot of the settings in the tutor backend is provided in [Figure 5.4.4](#). Possible combinations included settings for topic creators (questions and comments creating new discussion topics), replies (answers and comments on existing contributions), votes on topic creators, and votes on replies. Votes include the possibility of 'helpful' markers. Pre-selectable combinations (icon sets in the screenshot) were:

- **PDS1** – *Allow new topic creators, new replies, and new votes on existing contributions:*
The standard combination of functionalities. Students are able to create new discussion topics, provide answers or comments on existing discussions, and up-vote or down-vote any questions, answer or comment.
– Intended as default unrestricted scenario.
- **PDS2** – *Disallow new topic creators and new replies, but allow new votes on contributions:*
Students can only vote on any existing contribution in order to influence the ordering of the topic stream, mark any reply as helpful, and revoke their own contributions.
– This combination allows tutors to pause the discussion system.
- **PDS3** – *Disallow new topic creators, but allow new replies and new votes on contributions:*
Limits students to discussions within existing topics with all voting and marking functions.
– Intended for the tutor to limit discussions, for example have discussions come to a conclusion. If the tutor prepares topics, they can pre-define discussable topics, for example for controlled discussions.
- **PDS4** – *Allow new topic creators and new votes on contributions, but disallow new replies:*
Takes away the ability of discussions from students as all new contributions must be topic creators. Voting is still allowed in order to influence the ordering of the topic stream.
– Intended to limit students to asking questions or providing direct comments without engaging in peer discussion.

- **PDS5** – *Allow new topic creators and new replies, but disallow new votes on contributions:* Allows for vote-free discussions. Due to missing computing base for the ordering of the topic stream, all discussions are displayed within the topic stream in descending order of latest contribution.
 - Intended for unjudged discussions, inviting all students to contribute anything, including trolls. Typically, this is a single-phase brainstorming³⁷ scenario.
- **PDS6** – *Allow new topic creators, new replies and votes on topic creators, but disallow votes on replies:* Limits only the students' ability to vote on replies or mark any of them as helpful.
 - Intended for the students only voting and marking entire topics.

5.4.6 Results

Interestingly, the discussion functionality was able to operate in parallel to the regular tutorial to some extent ($\bar{X}_{PFS-Q07} = 3.1, n = 9$). Some students were regularly active within the system, while others used the system intermittently. The parameters influencing the feasibility of parallel tool utilisation are not only based in CIU, but also in the set of rules defined for the tutorials by the tutor. In more or less relaxed tutorials –due to less material to discuss–, the tutor would allow oral questions at any time, but would also additionally interact with all attending students by parsing through the attendees one at a time asking them activating questions. In this setting tool utilisation was negligible. However, if the tutor only permitted important interruptions due to heavy workload by reason of plenty of materials to discuss during the tutorial or high attendee counts, a rule defining questions only permissible at certain times during the tutorial, and only iff asked via the prototype, tool utilisation increased significantly and was also accepted ($\bar{X}_{PFS-Q09} = 1.8, n = 9$). This allowed students to decide which questions were important amongst their peers, potentially answering some of the questions within the group, and enabled the tutor to present the bulk of material and focus exclusively on the 'top n ' ($n \in \mathbb{N}$) important issues during question breaks.

An unexpected result of the utilisation of the tool was observable self-moderation among the students. Contributions that can w.l.o.g. be considered as trolling were mercilessly down-voted by the other students. This way, the tutor would only see 'valuable' contributions far up in the topic stream. The reason for this self-moderation group dynamic is inscrutable and requires further investigation.

Students wished for visually pleasing dependency correlation to be added, allowing different topics with related content to orthogonally converge in a contribution. Due to implementation time constraint this valuable feedback had to be postponed.

Tool utilisation was strongly dependent on tutorial conduct. Two main scenarios were identified: peer discussion and low interactivity (like ex-cathedra teaching or overly full class). In the setting of conduct as peer discussion, the discussion system provided a feasible means for the peer discussion phase, especially as all discussions were stored within the system and thus allowed for retroactive recapitulation and comprehension of discussion contents. Additionally, the ordering of discussion threads based on votes and helpful markers helps students to quickly and efficiently go through discussions off-site, for example at home when recapping the tutorial units, or when preparing the next tutorial unit. The second scenario, low interactivity conduct, provided the students with a means to discuss questions and comments while the tutor was busy with tutorial conduct or discussions with other students. In tutorials with too much material to cover or too many attendees to allow for prolonged discussions with individuals, et cetera, clarifying discussions on issues could be transferred into the platform and be handled in parallel to the regular tutorial conduct. Especially stronger students were willing to answer questions or comment on contributions in order to reduce their idle time, while weaker students were given a chance to clarify uncertainties without having had to rely on a chance to have the tutor revisit a topic or

engage in discussions. This in return reduced the amount of interaction required by the tutor, allowing them to focus on managing the curriculum workload within the fixed ninety minutes time-frame of a tutorial. If time allowed at the end of a unit, the tutor could still answer or discuss the 'top n ' ($n \in \mathbb{N}$) of the remaining issues.

As a result of the misprogrammed Q&A system in the *RNUW* prototype, a full-blown PDS appears to be what students want. However, with respect to attention span, focus and CIU, such a system seems to be over the top. In light of these reservations, the Q&A system based on the initial assertion was quickly replaced by a fully-fledged PDS, and it proved beneficiary to tutorial conduct. Especially in a peer instruction setting the PDS is a feasible tech-enhanced means for peer discussion. In low interactivity settings the tool provides the students with a means to interact among peers other than the direct seating neighbours or the tutor. The question being of course how 'low interactive' a tutorial needs to be. However, in the moment they occur and are actively engaged, discussions present an attention focus and are thus irreconcilable with CIU. Correspondingly, the observed self-moderation occurs. Per definition a decision to regulate has to precede a moderation and it cannot be cognisant incidental, hence self-moderation violates CIU compatibility. Of course, this forced a new assertion:

Assertion (Tech-enhanced Peer Discussion):

Provision of a tech-enhanced peer discussion derivative invites students to discuss issues in the moment they occur.

- a) Tech-enhanced peer discussions are an individually self-regulated and, within the group, self-moderated process.
- b) Hesitation to interrupt no longer influences the decision to ask.
- c) Tech-enhanced peer discussions can unobtrusively address all fellow students immediately as well as the teacher loosely time-coupled. *
- d) Tech-enhanced peer discussions are not arrangeable as CIU. *
- e) Tech-enhanced peer discussions in low interactivity scenarios decoupled from peer instruction occur iff the level of offline interactivity is below a critical threshold.

At first glance, the aspects marked with an * seem to exclude each other. For now, the assumption is that both aspects of the assertion hold. It remains to be investigated whether they are mutually exclusive.

As to be expected, the different combinations of allowed/disallowed functionalities proved differently suitable, yet even feasible. The default combination (PDS1) as well as the pausing combination (PDS2) proved to be the easiest manageable for tutors during tutorials as these two options were most intuitive and did not require any forethought. Combination PDS3 was not well received by the students during tutorials. However, PDS3 was deemed worthy as standard setting for after-class continuation of discussions. Designed for quick gathering of open issues without having students get engaged in discussions, PDS4 did not keep what it promised. Instead, students stated that this combination was only sensible if the tutor reacted to issues in due time, or if the setting was available ahead of tutorials in order to have issues declared *before* the start of a tutorial unit. This would support the pre-class reading phase of peer instruction. However, this was not possible as access to the discussion system was only possible after having entered an access key the tutor would provide to the attendees at the beginning of each tutorial. Some students suggested to provide a pre-class key only utilisable for PDS4. The intended scenario for PDS5 was designed for an anonymous single-phase brainstorming³⁷ activity, but not played through in this iteration of tutorials as the tutor forgot about the brainstorming activity in the unit they wanted to test it. Finally, PDS6 was intended to ease the tutor's understanding of the topic flow ordering by having students vote on entire topics rather than single contributions. This way, the ordering would be dominated by the overall rating of a topic rather than a single contribution

³⁷ Brainstorming can be roughly divided into two types: single-phased, in which all contributions are collected immediately, and dual-phased, in which all participants collect their ideas discretely before compiling a shared collection.

that may have been an answer not yet marked as helpful. However, the PDS6 combination was not received well at all. Students disliked being forced to vote on the first contribution of a topic, especially if this involved scrolling over the screen. Additionally, they criticised that such voting would provide a false perception of the first contribution itself. Instead, topic voting should be either decoupled from single contribution voting, or discarded entirely as two voting mechanisms would most likely be too distracting and not provide any benefit, but disadvantages instead.

The identification of the two main scenarios mentioned earlier arose from the analysis of tool utilisation via the five settings combinations. PDS1 allowed for active tool-based discussions on topics, with the tutor being able to ask the students to come to a conclusion by switching to PDS3. Having PDS2, the tutor was able to pause any discussion for an interjection. This worked well with peer instruction and multiple ConcepTest outcomes ranging within discussion range ($L \leq B \leq U$). By unpausing the discussions students were able to pick up discussions where they left, or enter other topics and discuss with other peers. However, it also worked well in low interactivity scenarios where the tutor would allow parallel discussions, but pause the discussion tool's availability when coming to an important explanatory matter. This way the tutor was able to redirect the students' attention solely to the blackboard. PDS4 worked in the same way, allowing the tutor to gather issues without having students discuss. When time permitted, the top issues could be addressed in descending order of importance in-class, and the rest online after-class. Students perceived their issues as being taken seriously, while the tutor could focus on more pressing issues (the conduct of the tutorial) before attending to the issues. Based on the students' feedback as well as utilisation observations, it can be assumed that the combinations given are ordered in an inclusive taxonomy, that is some combinations are able to cover the same intended scenario as others. Therefore, combinations included in others can be designated 'more restrictive', while the encasing super-set can be designated 'less restrictive'. The assumed taxonomy is depicted in [Figure 5.4.5](#) and remains to be verified.

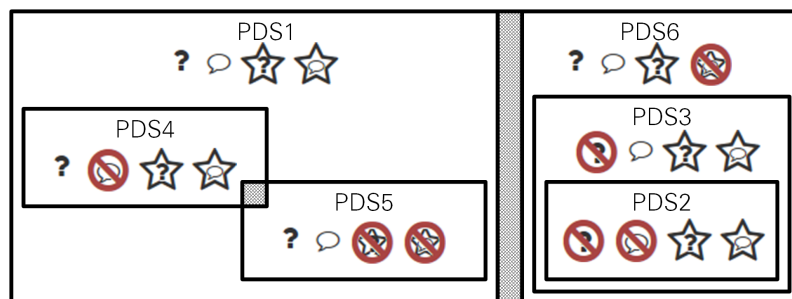


Figure 5.4.5: Venn diagram representation of the assumed PDS taxonomy.

Observation of the PDS tool utilisation in light of varying attendance (ranging from five to thirty-six attendees) produced some noteworthy results, as well. On one hand, if there were insufficient attendees (approximately seven), students perceived the anonymity provided by prototype to be insufficient. On the other hand, if there were too many attendees (approximately twenty-five), students were unable to focus on selected discussions. However, these minimum and maximum numbers are yet to be determined. For the minimum it would be helpful to have the platform announce a warning toward the tutor if the group size was insufficient. In order to do so, the required minimum attendance needs to be investigated for each combination of settings. The different combinations suggest themselves to require different minima. On the side of the maximum, it needs to be assumed that there are also indeed different maxima for each combination. Minima and maxima are also subject to external influences, such as existing group dynamic among the peers, et cetera. However, complicating the issue even further seems to be an organisational aspect lacking in the peer discussion system: an automated or forced group split. For example, a tutorial with twenty-five attendees entering a peer discussion phase would serve well with an automated split (and random assignment of group members) into five subsets

of five members each. A group split would help students to easier navigate within their reduced set of topics and discuss within their reduced set of peers. The random assignment would allow for students to discuss with changing peers, independent of their spatial distribution or system behaviour (fast-clickers versus slow-scrollers). On how to assign students to certain sets needs to be investigated. The same is true for which topics to include in which subset. Another question to be answered is whether the student sets and topic sets need to be congruent, or if intersecting sets fulfil the requirements equally or even better. These considerations open a wide variety of research aspects for the future.

Further observing utilisation by comparing the experiment iterations, a significant decrease in the second iteration in comparison to the first becomes obvious: students submitted roughly 40% less contributions, even though the PDS tool was utilised for peer discussions in test group 15-G2. This can be well observed with having 85% of all contributions originate within 15-G2 tutorials. As students overall perceived the functionality of the PDS more positive than of the simple discussion system provided in the previous iteration, it is questionable whether the decrease in contributions must be attributed to the extended functionality, or rather other aspects. Lacking data on actual time spent utilising the tool, it is impossible to relate the fewer contributions into a context of same or corresponding less time spent with the tool. It might be that students simply did not contribute as much but spent same as much time with the tool as before, or they overall spent less time with the tool and hence contributed less. – This needs to be further investigated and reasons determined. For the investigations to be conducted with the latest prototype it should be assumed that reduced contributions are related to reduced utilisation overall, probably due to a CIU side effect based in perception of system capabilities. The –in comparison– primitive GUI of *RNUW* may have been more inviting than *ETv2*'s eye-candy GUI. The tentative assumption shall be that students presume to be less distracted from CIU by tools with primitive GUIs, expecting them to be less functional and thus less distracting, and to be more distracted from CIU by tools with appealing GUI, expecting them to provide more distracting functionality.

With respect to the self-moderation group dynamic observed, the effect could be partially reproduced over the multiple utilisations of the PDS. Self-moderation occurred when the students were not too busy attending to other aspects of the tutorial. Especially tutorials with an abundance of material were keen to eliminate all self-moderation tendencies sooner or later. In the opposite, more relaxed tutorials –and peer instruction settings especially– invited for self-moderation iff the tutor themselves were not attending to the PDS at that time. However, in default of investigations into the reasons in favour of other investigations³⁸, the reasons had to remain unfathomed.

Having PDS functionality planned into the curriculum and the tutorials adjusted accordingly, the students' consolidation of the material was significantly increased. The impact is visible for 15-G2 (full integration and adjusted tutorial) and 15-G1 (normal tutorial with tool-support) in the outcome of the final exam (↪ [chapter 6](#)).

5.4.7 Conclusions

PDSs present a valuable amendment to exercise settings conducted as peer instruction as well as in low interactivity settings. Different combinations of available functionality like voting or commenting have different impact on the exercise conduct. Levels of distraction (that is violations of CIU) may vary and should be investigated in the future. The same is true for the source of self-moderation, especially why students are moderating rather than simply ignoring trolls.

An aspect not conclusively investigated lies in the impact of anonymity on the discussions. As outlined in [subsection 5.2.6](#), a two-step retroactive revocation of anonymity seems to be in demand in order to further motivate students. However, the obvious unanswered question is on

³⁸ Students were observably annoyed by exuberant questionnaires and interviews.

how to attach identifying traits³⁹ to contributions. Different possibilities are conceivable: add an identifying trait to selected contributions only, add an identifying trait to all contributions within a thread, or add an identifying trait to all contributions throughout the PDS or even platform. Having identifying traits be attached on a per-thread level may provide benefits as well as deficits; being beneficiary when different levels of performance or mastery urge for separation (that is, one will not be able to attribute contributions from different threads to the same student), or being detrimental when a student wants to be attributed over multiple threads.

The impact of the group sizes within discussions should also be further investigated. With strict anonymity (that is without any identifying traits), discussions tend to become confusing very quickly. Even when adding simple identifiers such as timestamps, attribution of contributions of the same user become difficult. It is comparable with a classroom being asked to discuss on a certain topic, as soon as the set of actively discussion students surpasses a certain size, the discussion becomes unproductive due to the need of moderation, having the group cross-talk otherwise. In general, it is observable that subgroups form, having subsets of the students discuss in smaller groups, ideally bringing their results together into the larger group later. – Such behaviour would be favourable for the PDS, too. Beyond the obvious question when and how to split discussion groups, further important questions arise. Should this be an automated process or should the split be initiated by the students themselves? Who is supposed to be in which subgroup? How are the subthreads supposed to be reintegrated into the larger group?

It should be noted that PDS go very well with emergency brake systems (↪ [section 5.6](#)), which is why experiments with a prototype utilising a combination of both systems were also conducted, as can be seen in [Figure 5.6.4](#).

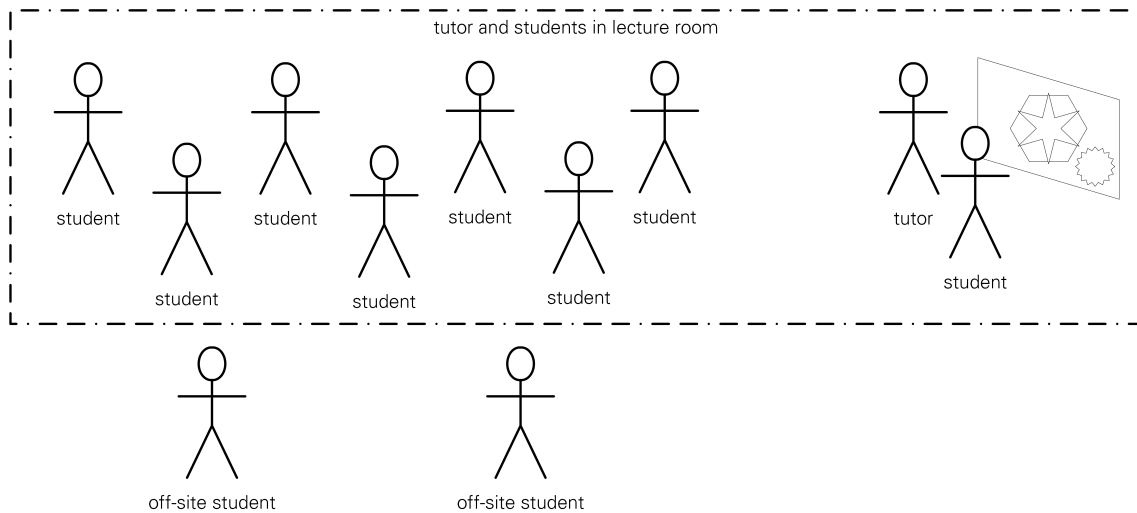
5.5 VIRTUAL INTERACTIVE WHITEBOARD

5.5.1 Methodology

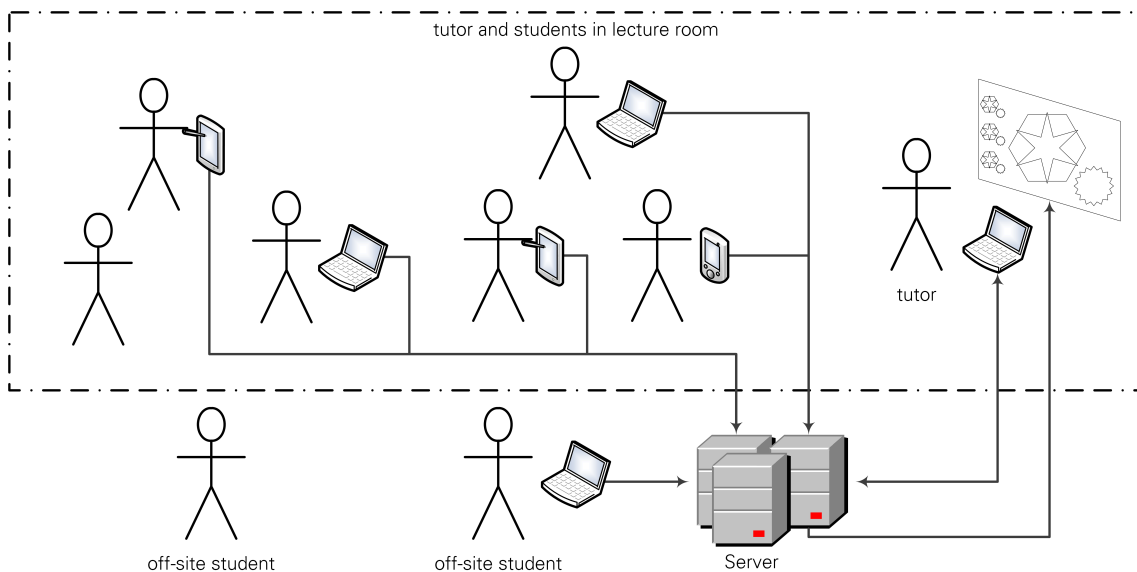
Designed as a virtual means, it should allow all students to contribute whiteboard canvases rather than only one selected student called to the physical whiteboard. The notion was to allow all students, or a majority thereof, to receive feedback on their canvases. This should support classification of their own performance in comparison to their peers' performances. Hence, self-regulated learning should be fostered. If the tool was well accepted in that fashion, it could also provide as a technical means for off-site students to participate in whiteboard activities. The general idea is visualised by an exemplary organigram of whiteboard utilisation. [Figure 5.5.1](#).

In order to test the suitability and acceptance of the tool, a combined approach was used. On one hand, the actual utilisation of the tool was pushed with corresponding tutorial tasks; all attending students were asked to contribute. On the other hand, students were asked to provide feedback in questionnaires and oral interviews. Availability of the tool was proclaimed to the students at the beginning of tutorials within which it was to be used as well as by the time the test was being conducted (meaning by the time the tutorial task to be supported by a discussion was current). The idea was to design tutorials in a test-supporting fashion and observe any changes in contribution quantity and quality, as well as the students' willingness to contribute. Based on this information the tool could be further refined.

³⁹ Identifying traits may include, but are not limited to: distinct username, selected avatar image, per thread username, per thread avatar image, or per thread timestamp identifier (for example, 'by: 2015-09-21 14:57:13' for all contributions of the same user who submitted their first contribution within the active thread at that time).



(a) Only one student at a time can present at the whiteboard. The canvas is elusive.



(b) All students can contribute either by submitting their canvas to the server, or by presenting at the physical whiteboard. All submitted canvases are stored on the server, and can be recalled and reviewed on-site as well as off-site. The tutor can discuss any stored canvases with the on-site students by displaying the canvases via LCD projector.

Figure 5.5.1: Exemplary organigram for a traditional whiteboard setting (5.5.1a) and a V-IWB enhanced setting (5.5.1b).

5.5.2 Visible Learning Effects

Traditionally, students are asked to actively participate in tutorials. Such participation can be provision of interesting questions, engaging in discussion, or presenting solutions or drafts in front of the group (for example at the blackboard/whiteboard). Due to limitations of space and time, not all students – independent of their readiness to participate in activities – are able to contribute. This limits the possibility of individual feedback significantly. Neither is the teacher able to provide feedback to each individual student, nor is the group able to discuss the entirety of the group’s contributions. Hence, often students raise hands and are called forward, or the teacher goes through the attendants serially over the course of the semester in order to call forward each student at least once. This way, some prepared students are able to receive feedback, but the gross receives none in that particular moment. This is regrettable in light of the heavily graphical nature of the possible student submissions on tutorial topics (→ [Table A.0.5](#)). A solution to this dilemma can be the utilisation of V-IWB functionality. The idea to use a V-IWB instead of any regular submission system (like text forms) pays respect to the numerous possibilities to submit diagrams. All students are able to contribute via shared notebook, and group work can be contributed via shared bulletin. The teacher is then able to browse through all contributions and identify and point out common mistakes, point out selected good contributions, et cetera. When decoupling the feedback from the in-course activity, all students are able to receive feedback, for example when the teacher goes through the contributions in the afternoon and provides individual feedback. This allows for more contributions to be assessed as well as a prompt overview on the state of group knowledge. With V-IWB the following visible learning effects are addressed, as they

- VLE05: allow teachers to clarify aspects of their conduct visually,
- VLE06: allow teachers to provide feedback on visual contributions from all students rather than only selected ones,
- VLE08: demand students to creatively visualise,
- VLE09: allow students to contribute to the class without fear of negative repercussions,
- VLE10: demand students to comprehend visual contexts,
- VLE13: allow teachers to request contributions from all students rather than only selected ones, and
- VLE17: iff combined with anonymity, allow students to contribute to class without fear of negative repercussions.

5.5.3 Tool Description

Virtual interactive whiteboard systems heavily rely on centralised processing of information. Thus, client/server infrastructures are commonly utilised, but peer-to-peer networks are also possible (making use of distributed computation). Either way, shared input and output devices are utilised for the whiteboard’s virtual canvas, making input with immediate observability of effects possible. For this, the input/output devices must be capable of simultaneously doing so. Therefore, touch screen devices are the means of choice, but other GUI metaphors such as screen/mouse, screen/touchpad, et cetera are also possible. However, touch screens provide the highest correlation between input and output.

For the prototype utilised within the presented research, a web-based client/server system was implemented. The entire drawing logic was handled on the client devices, which had to be capable of HTML canvas manipulation. Only the resulting *images* were transferred to the web server for storing within a database. The drawing tools included a pen for free drawing as well as tools for rectangles, solid and dashed lines, different arrows, and an eraser. The drawing tools were based on the different types of objects required for a UML sequence diagram. On the tutor’s side, a list of submitted images allowed for discussions of all or individual drawings with all students.

Workflow

The associated workflow is very simple. V-IWB utilisation is not possible for the students as long as the tutor has not explicitly cleared the tool. As soon as clearance has been provided, students can manipulate the rendered HTML canvas according to the capabilities associated with the selected drawing tool. Once they select to submit their drawing, the canvas was processed and converted into a PNG image, which is then transmitted to the server for storing. As soon as the teacher decides to discuss the submitted drawings, the server generates an overview of all drawings associated with the current tutorial unit from the database. Utilising an LCD projector, the tutor can then either discuss the overview (for example discussing common mistakes), or select individual drawings for a detailed (enlarged) view and in-depth discussion.

5.5.4 Assertion

Assertion (V-IWB):

Provision of V-IWB (\leadsto [Definition 2.2.1](#)) functionality allows more students to hand in in-course work and invites for active discussions on the state of group knowledge.

Of course, the so phrased assertion addresses aspects of environmental self-regulation. Utilising V-IWB functionality in controlled situations, [Working Thesis 1](#) should be addressable, and if the V-IWB allows for anonymous usage – thus, providing anonymous contribution means – [Working Thesis 4](#) should be provable, especially if anonymous utilisation leads to a significantly higher contribution rate compared to identifiable utilisation.

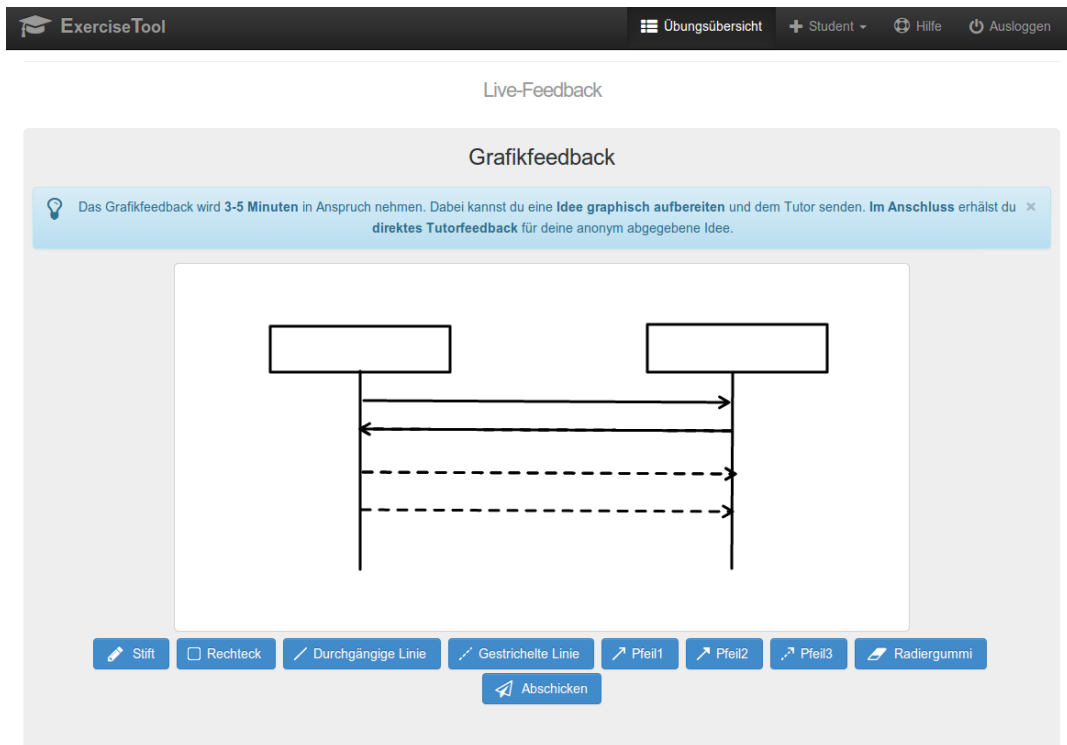
5.5.5 Experiments

Following the arguments of the assertion, V-IWB functionality was added to *ExerciseTool*. Focussed on personal bulletin functionality (\leadsto [Definition 2.2.1](#)), it provided a good means for a majority of the attending students to provide solutions to tasks demanding graphical contributions. Traditionally, solutions to these tasks were deduced by the tutor at the blackboard while querying through the attending students for thoughts on the matter. Iff time allowed, a student could be asked to present a proposal for a solution at the blackboard. Now, with utilising V-IWB functionality (\leadsto [Figure 5.5.2a](#)), all provided solutions could be presented to the group via a dashboard, and three solutions could be discussed, namely one exemplary false one with common mistakes (\leadsto [Figure 5.5.2b](#)), an acceptable one, and finally an exemplary well-constructed one.

5.5.6 Results

Students perceived the anonymity of their contributions in combination with the comparability of all submissions very positively ($\bar{X}_{PFS-Q10} = 3.6, n = 7$; $\bar{X}_{PFS-Q11} = 3.8, n = 7$). From fourteen submitted drawings thirteen were related to the task, one can be considered trolling and led to some laughing when presented to the group. This is not a negative effect, but actually a positive one as laughing about a numerable amount of silly contributions helps loosen the tenseness of learning, thus enabling reduction of sternness and with that, less negative emotional and environmental influence on learning motivation, also disarming destructive intentions of trolls.

The results gained in the first iteration could be reproduced in the second iteration; as to be expected: students perceiving the anonymity of their contributions in combination with the comparability of all submissions very positively. All provided solutions were presented to the group



(a) Student view of *ExerciseTool*'s V-IWB tool. Top to bottom: navigation menu, explanatory text, V-IWB area, drawing tool selection.



(b) Tutor view of *ExerciseTool*'s V-IWB tool. A mediocre contribution was selected for display to the class. Top to bottom: navigation menu, contribution count (14 contributions from 22 attendees, 19 of which were logged in), graphic display area.

Figure 5.5.2: *ExerciseTool*'s V-IWB tool. (Screenshots provided by Tommy Kubica, B.Sc.)

via a dashboard, and once again three solutions were discussed, namely one exemplary false one with common mistakes, an acceptable one, and finally an exemplary well-constructed one. However, the focus of the experiments was not aimed at general tool feasibility and utilisation, but actually at the influence of different explanatory instructions.

Having V-IWB functionality planned into the curriculum and the tutorials adjusted accordingly, tool utilisation was expectedly higher. However, the impact did also significantly increase students' consolidation of the material. The impact is visible for 15-G2 (full integration and adjusted tutorial) and 15-G1 (normal tutorial with tool-support) in the outcome of the final exam (↪ [chapter 6](#)). The outcome of the final exam clearly shows a tendency of V-IWB users to achieve better marks. Therefore, a simple amendment to the V-IWB assertion should include correlated exam tasks. Whether such an effect is also observable for tasks within the same context as well as overall consolidation of entire topics associated with the tasks the V-IWB was utilised in needs to remain to be investigated. Thus, the amendment shall be limited to *correlated* exam tasks.

Assertion (V-IWB, revised):

Provision of V-IWB (↪ [Definition 2.2.1](#)) functionality allows more students to hand in in-course work, invites for active discussions on the state of group knowledge, and has a positive effect on the outcome of correlated exam tasks.

5.5.7 Conclusions

Virtual interactive whiteboards present a well suited means to allow all willing students to participate in whiteboard activities. Contributions and results can be discussed not only for few students called to present in front of the class at a physical board –be it an interactive whiteboard, or a non-interactive white- or blackboard–, but for all students using the tool as a group. Individual contributions can be put in context of the group's performance. Semi-individual feedback can be provided to all students, as well. Thus, V-IWBs support key aspects of self-regulation.

In the future it should be investigated how collaborative utilisation can further benefit the students, especially when making use of shared bulletin functionality (↪ [Definition 2.2.1](#)). This can prove valuable especially when considering the questions on group size that the PDS yielded. More so, when conceiving a combination of PDS and V-IWB into one visual discussion tool.

Another aspect that should be investigated is how personal and/or shared notebook functionality could benefit students. However, this aspect shifts the focus into the direction of paperless classrooms (as intended by Google Classroom for example). Careful consideration is required in order to find a balance between students attending exercises in a paperless-classroom-like conduct and traditional conduct amended by the tool.

5.6 AUDIENCE RESPONSE SYSTEM AND EMERGENCY BRAKE

5.6.1 Methodology

Designed to allow students to provide feedback on the tutorial conduct, the audience response system was stipulated as a means for the students to manipulate their learning environment to a certain degree. The notion was to allow students a better learning experience as well as limited support in self-regulated learning. If the tool was well accepted in that fashion, it could allow students to answer prepared learning tasks. However, the conducted experiments showed that

a fully-fledged audience response system was excessive for tutorials. Instead an *emergency brake* was sufficient. The general idea is visualised by an exemplary organigram in [Figure 5.6.1](#).

In order to test the suitability and acceptance of the tool, a combined approach was used. First, the actual utilisation of the tool was automatically tracked with means of log files and client-side scripts. Second, the actual contributions were analysed regarding content, especially providing information on quality. Finally, students were asked to provide feedback in questionnaires as well as oral interviews. Availability of the tool was proclaimed to the students at the beginning of every second tutorial. The idea was to observe either an increase, decrease or unchanged utilisation as well as willingness to utilise. At the same time, feedback on CIU compliance and acceptance of the tool should become available. Based on this information the tool could be adapted into the above mentioned emergency brake as well as further refined with respect to CIU compliance.

5.6.2 Visible Learning Effects

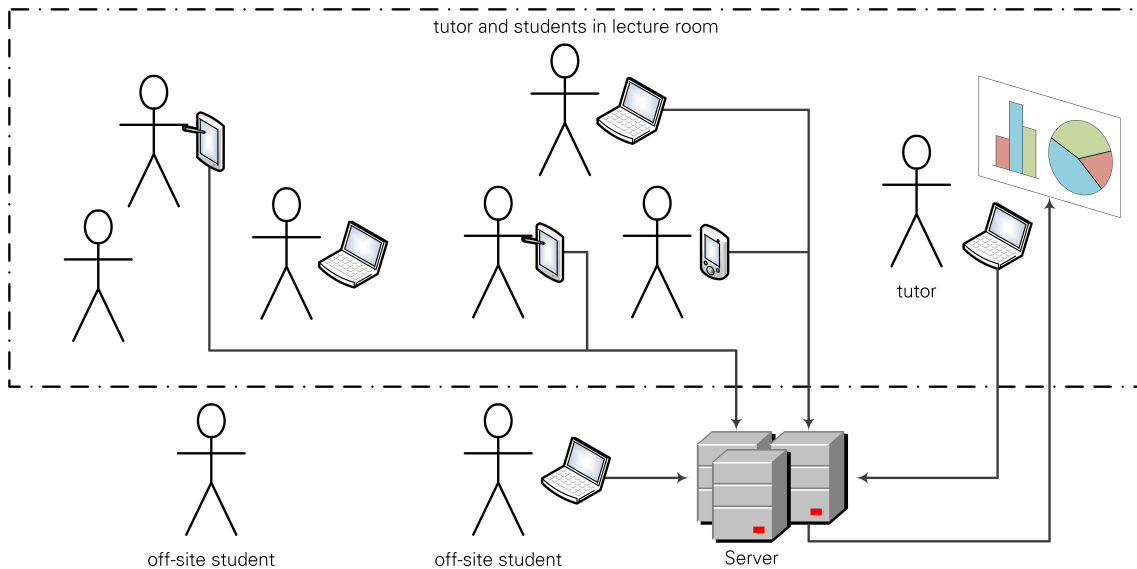
ARS functionality should be a means of allowing all students to provide immediate feedback on tutorial quality. Normally, only students with extrovert correction impulse tend to point out deficits in quality ('Could you speak louder?'), potentially interrupting the teacher. Other students with more introvert correction impulse often delay their criticism to the semestral anonymous pen&paper evaluation, which often takes place late in the semester. Such feedback does not lead to perceptible improvements for the students as temporal correlation is lost. Most of the time the improvement –if any– will be woven into the next iteration of the course, hence the feedback might help future generations of students, but has no merit for the provider of the feedback. Other situations may involve the group of students being asked to provide feedback ('Is there room for improvements?', 'Was everything understandable?'), or having an individual being put into the situation of acting as a group avatar ('Were you⁴⁰ able to follow?'). When utilised correctly, ARS functionality addresses the following visible learning effects, as it

- VLE04: provides a means to persuade the teacher to adapt their performance,
- VLE05: provides a means to reduce obscurity,
- VLE06: provides inverse feedback from students to teachers, but also regular feedback as the teacher's reaction provides feedback on the correctness of the students' assessment,
- VLE09: removes any identifying features from student responses,
- VLE13: allows the teacher to adapt class conduct to eliminate deficits in a timely manner, and
- VLE15: allows students to influence their learning setting.

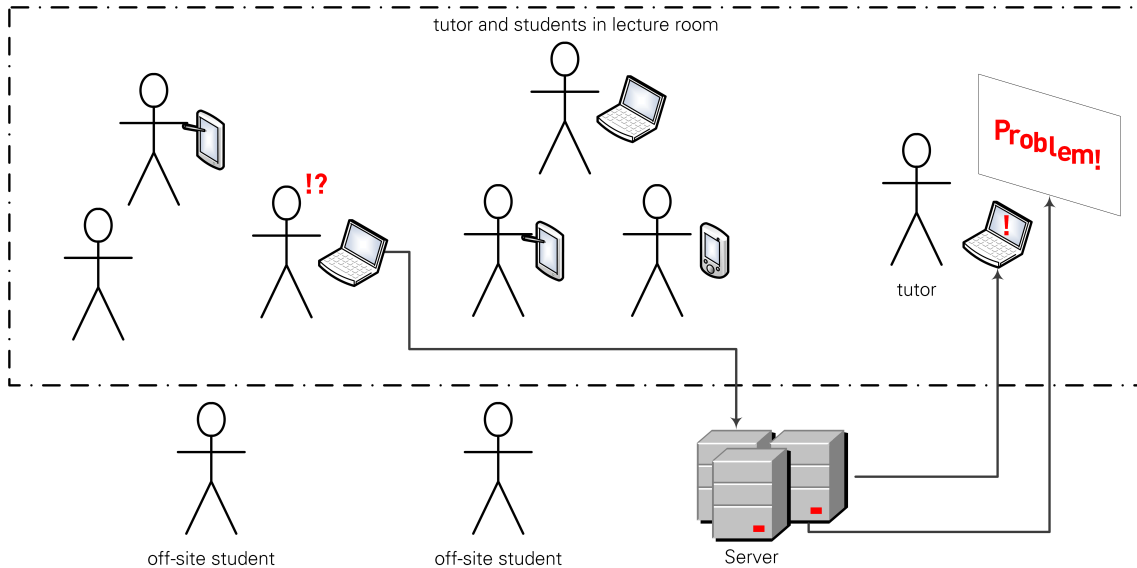
5.6.3 Tool Description

In principle, an ARS fulfilling the basic expectations can be provided by a few clickable buttons on the client device. Each button is linked to an action to be performed when clicked, where part of the action is the transmission of a predefined data-set to the server. In this sense, buttons providing their own context can be imagined, labelled 'louder', 'slower', et cetera. Additionally, buttons within a superordinate context can be imagined, labelled 'yes', 'no', '+1', et cetera. However, that context needs to be provided, for example by a text in the proximity of the button, or an unambiguous instruction by the lecturer. Carrying the idea further, any webform-based data can be utilised for ARS feedback, especially scales and text-areas. Needless to mention that the degree of attention required by the ARS increases with the complexity of the webform-input possible. Foreclosing the experimental results, the simplest ARS with a single button and predefined data-set requires the least attention and is best compatible with CIU.

⁴⁰ As a personal salutatory address toward an individual.



(a) Students in the lecture room as well as off-site students can provide anonymous feedback on prepared tasks as well as on parameters of the tutorial conduct (such as speed or volume). All contributions are synchronised, stored, and distributed by a server. The tutor is delivered an evaluation.



(b) The conducted experiments showed that a fully-fledged audience response system was excessive for a tutorial. Instead, a version reduced to a deficit annunciator is practical, allowing students to anonymously point out deficits.

Figure 5.6.1: Exemplary organigram showing usage of an audience response system to collect student feedback (5.6.1a) and as a deficit annunciator (emergency brake; 5.6.1b).

The prototype utilised for the presented research started out with an ARS providing three contexts with three pre-defined buttons each. Later iterations were reduced to a single button, namely an emergency brake, providing no further information. Thus, a slightly more complex ARS with webform-inputs for the provision of reasons, be it via pre-defined or self-entered reason texts, was considered. The conveyed reasons could be connected to an automated creation of corresponding threads in the PDS (→ [Figure 5.6.4](#)).

Workflow

The on-site workflow is pretty simple for students as well as teachers. While the student clicks on a button and, if applicable, enters some text, the teacher is displayed the aggregated feedback from all students. The workflow becomes slightly more complex when considering that the teacher may need to define possible actions, for example preparing a set of questions or a questionnaire with corresponding answer possibilities (either pre-defined buttons or input-field).

From a technical perspective, ARSs can be divided into two types: ones with display of changes to students and ones without. The latter only requires a submission accepting logic on the server, which then passes the received ARS data to a controller that adjusts the teachers model; afterwards, the teacher's view is updated. The type with display of changes additionally requires an update of the students' individual models and views, making it more complex as individualisations may apply and further complicate the views and controllers.

5.6.4 Assertion

Assertion (ARS):

Provision of ARS functionality invites provision of feedback by students who normally would not.

- Useful feedback includes information on speed, volume and depth of explanation.
- ARS utilisation can be arranged as CIU.

Both situations mentioned in the introduction paragraph may have negative influence on motivation. The first situation involves individuals to be brave enough to answer, potentially forestalling other students' chance to provide feedback, or being in pushed into a focus position, as in the situation everybody's attention will shift to the answering individual. Both outcomes may provide discomfort and thus may be demotivating. It should also be noted that pressure of silence may make an individual provide an answer even though no intention to do so was initially present. Awkward situations occur when an answer is expected, but nobody has any contribution. In the result, an awkward silence is present in the room until somebody starts talking. Such a situation is difficult for the teacher, too. If the teacher breaks the silence too early, they may have prevented a student from acting, which in return may be demotivating for the student as their willingness to contribute is suppressed, hence demoting their potential contribution, which – measured as a value – has a negative influence on future planning phases.

The other situation with having an individual act as group avatar can put a student into an exposed position. If the answer to the question is not obvious, the student may provide their own opinion, or an assumed group opinion, both yielding risks. If the student provides their own opinion, it may represent the actual majority opinion, but it could also represent a minority. Having the majority opinion, students with important feedback, however in the minority, are suppressed and kept from providing feedback. Sometimes the majority of students do not realise a problem as they accept everything the teacher does as correct; only when a student (the minority) points out a deficit it may become obvious to the majority. Having the minority opinion, the group avatar may become demotivated in the moment they realise they were of the 'wrong' opinion. Group pressure and negative responses may occur in after-hour situations ('What the hell were you thinking

in school today?'). If the student provides an assumed group opinion, the same arguments hold, however a negative influence on future planning phases may occur if the assumed opinion is incompatible with the student's own opinion. For example, the student may be happy with the teacher's performance, but feels pressured to criticise the teacher's utilisation of the blackboard. The negative impact may intensify if the students learns afterwards that the assumed opinion was incorrect.

From the teacher's point of view valuable feedback includes such on the contents as well as on the conduct of the tutorial. The conduct can be split into parameters of volume, speed, visibility, organisation and acceptability, while the content can be split into comprehensibility, correctness, value and appropriateness. The feedback is most valuable to the teacher if it is available immediately, thus allowing strongly time-correlated adaptation of conduct and content. However, it is impossible to satisfy all students, so the goal should be to satisfy an educated majority. For this reason, acceptability, appropriateness and value cannot be evaluated in immediacy, but only in retrospective. Often correctness can only be adapted time-decoupled as non-trivial corrections require research and cogitation, both not possible during the conduct of a tutorial. Due to these reasons acceptability, appropriateness, correctness and value must be excluded from on-site real-time feedback. The remaining parameters, namely volume, speed, visibility, organisation and comprehensibility can be retrieved in real-time. As visibility and organisation have great impact on comprehensibility – or can be considered a part thereof –, they shall be merged into a perspicuity parameter. This condenses the surveyable parameters to volume, speed and perspicuity. In combination with the previous assertion on anonymity, ARS integration should address Working Theses 2, 3 and 4, and experimental results origination from the ARS integration should provide a good source for a proof of them.

5.6.5 Experiments

RNUW provided an ARS inspired by the real-time feedback functionality of AMCS (↪ section 3.3). However, the GUI was modified (↪ Figure 5.6.2). The ARS implementation of *RNUW* provided students the possibility to submit feedback on volume, speed and perspicuity. While feedback values were reset in AMCS after each change of slides, this was not feasible in tutorials. Therefore, a different mechanism had to be implemented in *RNUW*. Hence, ARS feedback was investigated on different time bases: 5, 15 and 30 minutes, as well as decoupled from time.

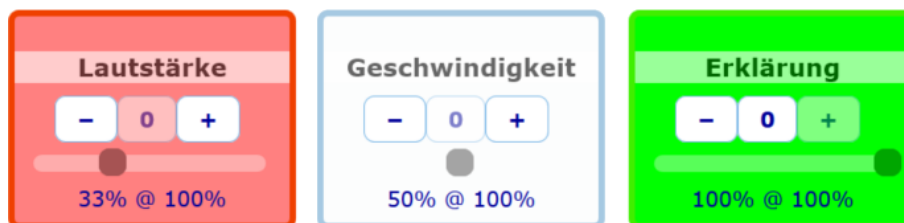


Figure 5.6.2: Student view of *RNUW*'s ARS tool. Left to right: volume, speed and perspicuity. Colours: red ≡ negative, white ≡ neutral, green ≡ positive (could be changed for vision impaired to blue in settings). Buttons: – ≡ dislike, 0 ≡ revoke vote, + ≡ like (per dimension the three buttons are linked; only one can be active at a time). Bar: vote quantifier. Number left of @: percental vote quantifier. Number right of @: percentage of logged-in users who have voted.

For the time-based ARS feedback tutor and student acceptance varied over the course of the semester ($\bar{X}_{PFS-Q03}^{students} = 3.4, n = 83$; $\bar{X}_{PFS-Q03}^{tutor} = 4.0, n = 7$). Strict obedience to the fixed time intervals proved impractical. Varying time consumption of different exercise tasks made a reasonable feedback correlation extremely challenging ($\bar{X}_{PFS-Q04} = 3.9, n = 10$; $\bar{X}_{PFS-Q05} = 1.7,$

$n = 10$), especially when having the tutor face the blackboard and forcing them to attend to the feedback by turning around, potentially interrupting line of thought. Furthermore, it was hardly possible for the students to appreciate any feedback-based change in the presentation when the correlation with the original reason for the feedback was surpassed or lost ($\bar{X}_{PFS-Q04} = 3.0$, $n = 9$; $\bar{X}_{PFS-Q05} = 1.4$, $n = 13$). Therefore, a 'reset button' was introduced (\sim Figure 5.6.3). Astonishingly, this minor –and in retrospect very obvious– solution proved to be very practical. It eliminated the time-constraints of the system while still allowing attributable reactions to the provided feedback ($\bar{X}_{PFS-Q04} = 3.1$, $n = 12$; $\bar{X}_{PFS-Q05} = 3.8$, $n = 8$). Nevertheless, the point in time of the reaction proved to be crucial. Investigations conducted via oral interview –extending the PFS questions– showed that having the tutor react to feedback as soon as they realised there was feedback irritated the students ($\bar{X}_{PFS-Q03} = 2.5$, $n = 17$; $\bar{X}_{PFS-Q05} = 1.3$, $n = 17$). Reactions in the midst of a line of thought distracted both students and tutors ($\bar{X}_{PFS-Q03}^{students} = 1.6$, $n = 12$; $\bar{X}_{PFS-Q05} = 1.4$, $n = 13$; $\bar{X}_{PFS-Q03}^{tutor} = 1.5$, $n = 2$). Next, having the tutor react to feedback between different tasks was practical, but some students judged this referred response as being too slow ($\bar{X}_{PFS-Q04} = 2.2$, $n = 14$), however it generally improved perceived acceptance ($\bar{X}_{PFS-Q03} = 3.9$, $n = 14$). In a final modification the tutor reacted to feedback as soon as a line of thought was finished and positioning (as a person relative to the audience) allowed perception of the feedback. This compromise proved to be worthwhile to the students as irritations were limited ($\bar{X}_{PFS-Q03} = 4.0$, $n = 8$; $\bar{X}_{PFS-Q04} = 4.2$, $n = 9$; $\bar{X}_{PFS-Q05} = 4.0$, $n = 9$). In any case, tutors tend to emphasise changes of lines of thought by changes in intonation, speed, et cetera.



Figure 5.6.3: Tutor view of RNUW's ARS tool. Design of boxes as in Figure 5.6.2. Icons on top (left to right): pause ARS (retaining all votes), reset ARS, reset Q&A, disable ARS and Q&A. Bar below boxes: number of attendees logged-in into platform. Area below: tutor view of Q&A tool (button far bottom: pause Q&A tool retaining all contributions).

The time decoupled ARS proved to be impractical for the students' requirements ($\bar{X}_{PFS-Q04} = 1.5$, $n = 4$). Even though students were able to provide feedback at any time, they opted for a per-unit feedback behaviour, only providing the tutor with opportunity of improvements in the next unit ($\bar{X}_{PFS-Q03} = 3.5$, $n = 4$). Motivation to participate was as low as with the paper based semestral evaluations, if not even lower. Based on oral interviews, investigations into the reasons showed a strong correlation between the time of the tutor's reaction to feedback and the students' satisfaction with the ARS tool. Often the tutor was facing the blackboard while feedback was submitted. By the time the tutor turned around to check feedback on their computer display, the critical

moment of prompt feedback reaction had already passed, even if only by a few seconds. Another aspect was the availability of feedback dimensions. Students stated insufficient feedback possibility when based on volume, speed and perspicuity; they wished for a more evaluation-oriented feedback mechanism to provide evaluative feedback on the tutor's performance. This valuable feedback – in combination with the success of the evaluation system of *ExerciseTool* (↪ section 4.3) – led to a new assertion on evaluation features (↪ section 5.7).

Overall, students disliked the design of the ARS and deemed it to infringe upon CIU ($\bar{X}_{PFS-Q06} = 1.7, n = 18$). Therefore, an investigation into a redesign of the ARS under CIU aspects was conducted. Respecting common practices of GUI design as well as bio-psychological aspects of perception, the ARS needs to be modified not only in GUI aspects, but also slightly in possible feedback actions, namely reducing ARS feedback to 'speed' and 'perspicuity'. Follow-up interviews with students insinuated the suggested three feedback options to be too bulky ($\bar{X}'_{PFS-Q06} = 2.9, n = 9$). The students would actually prefer a more simplistic means to point out something was troubling them ($\bar{X}''_{PFS-Q06} = 3.5, n = 9$). Only in a second, optional step a means of then anonymously stating what was troubling them would be handy ($\bar{X}'''_{PFS-Q06} = 3.5, n = 9$). Details on the research method as well as the detailed results are available in Alexander Martin's excellent master thesis [Mar15], which – due to the sheer amount and quality of results – cannot be reproduced in a compressed but meaning preserving manner here, without veering away from the scope of this dissertation significantly.

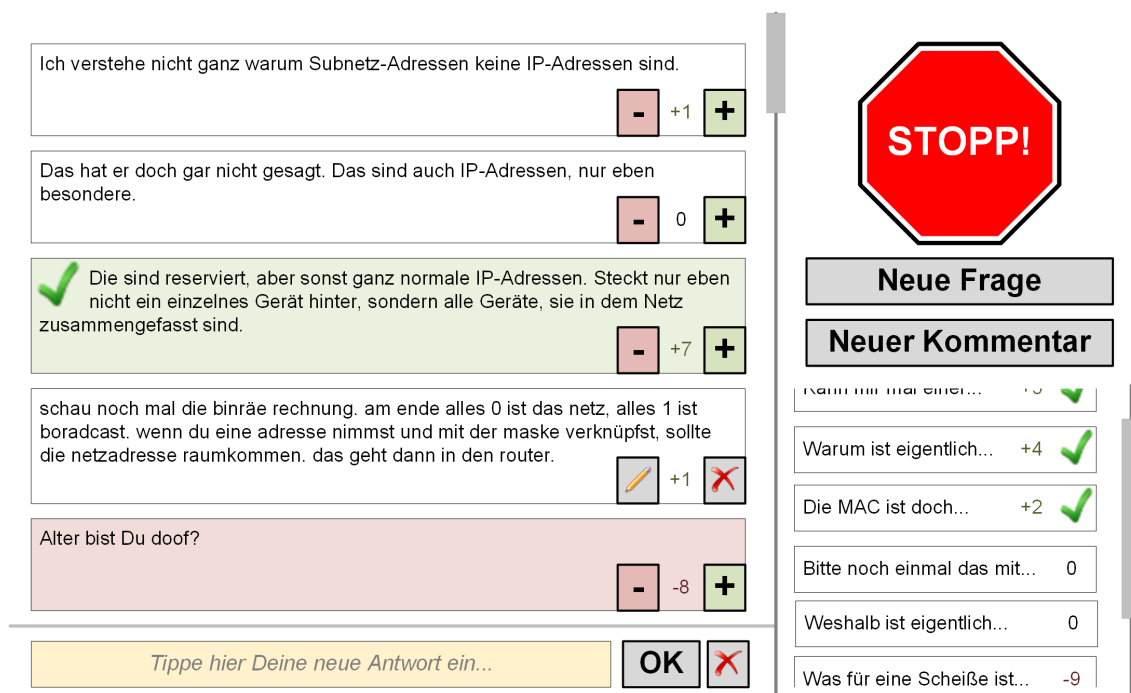


Figure 5.6.4: Combination of emergency brake with peer discussion system in ETv2 (circa U07). As soon as the 'Stop!' button is clicked, an input field to provide the reason is displayed.

Based on the results gained from *RNUW*, full ARS functionality is infeasible for CIU in tutorials, even when limited to few dimensions. As a result, *ETv2* instead presented a single feedback button labelled 'Stop!'⁴¹ to the students. Once the button was hit, the prototype would display a corresponding indicator visible for everybody. At first, the button was provided as itself, but this

⁴¹ Actually it was labelled 'Stopp!' as correct in German.

proved to be infeasible as nobody would use it without being able to provide a reason why they stopped the tutorial (→ Figure 5.6.4). Therefore, starting tutorial unit U06 the button was then provided in combination with a single free text form field intended for the students to provide a reason on why they stopped the tutorial. Feedback was optional, but when provided, the reason was displayed alongside the stop indicator. This led to the button being utilised, but in some occasions the other students wanted to be able to discuss the stop. As of unit U09, the text field was linked to the newly created peer discussion system (PDS, replacing the Q&A system). Provision of a reason was mandatory if a student wanted to stop the tutorial. The provided reasons would be automatically moved into a new discussion topic within the PDS. In all iterations students were able to revoke their stop request at any time.

Indication of a stop request was tested in several forms. The first concept (U03) provided a red border around the platform for all students, and an entirely red colour scheme for the tutor. The second concept (U06) added the optionally provided reason as a red text at the top margin of the display for students, and as an overlay in the centre of the display for the tutor. As the tutor sometimes would not realise the stop request until they turned around, in unit U07 their laptop computer was linked to the lecture room's LCD projector, whose image coincidentally covered large parts of the blackboard area. While the laptop screen would display the prototype's tutor website as before, a tool accessing the backend API would display a completely black screen via the LCD projector. If a stop request was detected, two red squares⁴² were projected onto the vertical centres of the left and right border of the blackboard. This way the tutor was able to realise a stop request as soon as it was processed by the prototype system. However, students considered this type of indicator as too obvious. Additionally, it is too reliant on projection devices available in the lecture room. A smarter solution may be utilisation of wearables, for example utilising a smartwatch's vibration alarm. However, due to deficient access to wearable technology, this idea had to be discarded. For the last two units (U09 and U11) the red bordered full screen indication on the tutor's laptop computer was re-enabled. Instead of the entire reason only a stub of the first few words was displayed alongside a contribution count for the PDS topic. When clicking anywhere on the screen, the tutor was directly forwarded to the PDS tool, and therein to the corresponding topic. In U11 this workflow was amended by an 'ignore' button in order for the tutor to discard a stop request. Due to a negative comment on perception of such 'ignoring behaviour', tutors are advised to at least provide reasons on why doing so, like 'I cannot react to this stop request at this time; first I want to finish this thought that may clear up some uncertainties currently present'.

5.6.6 Results

The combination of emergency brake, stop request indication visible to everybody, and PDS thread was well received, however not utilised often. Over the course of the ten test tutorials, the tutorials were halted/interrupted by students orally eleven times, and via the emergency brake four times. Nevertheless, questionnaire and interview feedback clearly show that the system is well received and would have been utilised if the students would have had a wish to stop the tutorial. They stated, they would utilise the emergency brake in future situations. However, they would wish for the emergency brake to a) allow a stop with providing the reason separately later, b) provide a random delay so that fellow students cannot attribute a stop to individuals in the room, and c) only display a stop request to the requester themselves as well as students who have opted to have these displayed, namely having the default behaviour to not indicate other students' stop requests. This definitively needs to be investigated further.

The information on the way students perceive ARS in tutorials led to a concept modification by reducing ARS feedback in tutorials to an 'emergency brake'. The continued experiments with the ARS reduced to that single emergency brake button provided some valuable feedback with respect to feasibility of such a tool. Even though the test only focussed on a deficit annunciator,

⁴² In the test setting these had an approximate size of $(4 \times 4) \text{ cm}^2$ to $(6 \times 6) \text{ cm}^2$, depending on the size of the projection.

it seems very improbable that an anonymous annunciator would be feasible. A 'keep going' feedback would be difficult to use for students as they wouldn't know when to press it on one hand, but more gravely, a student actually having an issue would be unable to make themselves noted. Having one student from a group not provide a 'keep going' may simply be the result of them not having pressed the button, yet. Therefore, the deficit annunciator is the only feasible option. However, it must be possible to provide a reason on why a deficit has been announced, otherwise the tutor would have to guess, probably ending in a wild-goose chase. These results culminate in the new assertion:

Assertion (Emergency Brake (a.k.a. ARS, revised)):

Provision of ARS functionality invites provision of feedback by students who would normally not do so.

- a) Useful feedback must be limited to a deficit annunciator.
- b) ARS utilisation can be arranged as CIU iff a single parameter is surveyed.
- c) ARS utilisation can be arranged as CIU even when combined with PDS functionality.

5.6.7 Conclusions

Students should be enabled to make an issue announced with fewest tool interaction as possible, also in order to maintain their anonymity, that is without having other students realise who requested/announced an issue. Bulky ARS are unsuitable for the task, hence an ARS reduced to a simple emergency brake should suffice. Then, a feasible solution may be to provide a set of pre-defined reason texts after the emergency brake has been triggered. This would allow students to halt the tutorial and provide a reason with two clicks or taps, probably allowing utilisation under CIU aspects. Extending the idea, other students may contradict the reasoning for a halt. Automatic inclusion of the stop request into the peer discussion system may be a good solution. It would allow students anonymous request of tutorial halt with two clicks/taps, and afterwards allow their peers to discuss, contradict or support the halt. This should be further investigated.

5.7 EVALUATION SYSTEM

5.7.1 Methodology

Designed to allow students to provide timely evaluative feedback on tutorials, as well as allow tutors to receive such feedback regularly instead of once at the end of the semester, the evaluation system presented the students a reduced set of evaluatory questions, which could be answered based on Likert scales. The notion was to raise students' influence on tutorial conduct, as well as their willingness to do so. This should eliminate students' low participation in traditional paper-based evaluations with feedback only benefiting the next generation of students, not the ones actually providing the feedback. In order to realise this, all tutorial units were made available for evaluation within the platform after each tutorial. Students were invited to provide evaluatory feedback at any time. The tutor was to take the automatically generated evaluation results into consideration and (re)act accordingly.

In order to test the suitability and acceptance of the tool, for students as well as tutors, a combined approach was used. On one hand, the actual utilisation of the tool was carefully observed with the evaluation feedback being submitted. On the other hand, students were asked to provide feedback in questionnaires, oral interviews, and using the evaluation system itself. Availability of the tool was proclaimed to the students regularly. The idea was to observe either an increase, decrease or unchanged utilisation in frequency as well as length. At the same time, information on the quality of the provided feedback as well as the acceptance of the tool should become readily available.

5.7.2 Visible Learning Effects

As mentioned, the often conducted pen & paper evaluation at the end of a semester does not benefit the students handing in feedback. ARS can address immediate (or even real-time) feedback on tutorial quality. However, ARS feedback must be limited to very few dimensions, or – as discussed in [section 5.6](#) – only a deficit annunciator. Such feedback does not lead to perceptible improvements over the course of a semester. Therefore, a solution placed in the temporal gap between immediate feedback and semestral evaluation would be handy. Visible learning effects addressed by such a solution are: it

- VLE04: allows students to influence their learning environment,
- VLE05: allows teachers to adapt their conduct in order to enhance explanatory clarity,
- VLE07: demands students to verbalise issues in order for teachers to understand exact issues,
- VLE09: allows students to contribute to the class without fear of negative repercussions,
- VLE11: allows students to *collectively* influence their learning environment,
- VLE13: allows teachers to adapt their conduct in order to maximise class success, and
- VLE16: allows teachers to adapt their conduct in order to maximise their performance as perceived by the students.

5.7.3 Tool Description

An evaluation system is supposed to make identification of positive and negative aspects of whatever/whoever is evaluated easy for both, the evaluating as well as the evaluated. In this sense, an evaluation system provides a simple interface for input of evaluatory feedback as well as one for understandable output of (processed) results. Commonly, a client/server infrastructure is sufficient for this task with the model and controller on the server, and the view (interface) on the clients. Similar to ARS (↪ [section 5.6](#)), evaluative feedback is provided in a computable, commonly numerical, format, hence simple webforms can be utilised. The providable feedback depends on desired evaluatory depth, but in general either simple statements representable with simple webform buttons ('yes', 'white', 'banana', ...), scales ranging from a minimum to a maximum, or free input are possible.

The research presented within this dissertation in part is based on an evaluation system prototype providing feedback on the tutor conducting tutorials. It utilises webforms and presents styled scales with ten steps for feedback on speed, motivation, utilisation of appliances, communication, and knowledge gain, as well as a text area for free input of feedback. Evaluative feedback can be made available to all students on a per-tutorial basis. This allows for monitoring of progress and changes in performance via a visually pleasing GUI to the tutors.

Workflow

The workflow is a very simple webform workflow. When they are willing to and not have yet done so, students access their current tutorials evaluation area in their web browser. Here they move the sliders for each of the evaluation dimensions to a value representing their assessment. If they want, the free text area allows for additional comments. After submitting the form, the server stores the feedback in a database. As soon as a tutor wants to see their rating for a certain course, they select the corresponding area via their web browser. The server then computes all available feedback stored in the database corresponding to the tutorial associated with the requesting tutor and linked to the selected course. The results of the computation are then visually prepared and delivered to the tutor's web browser.

5.7.4 Assertion

Assertion (Evaluation):

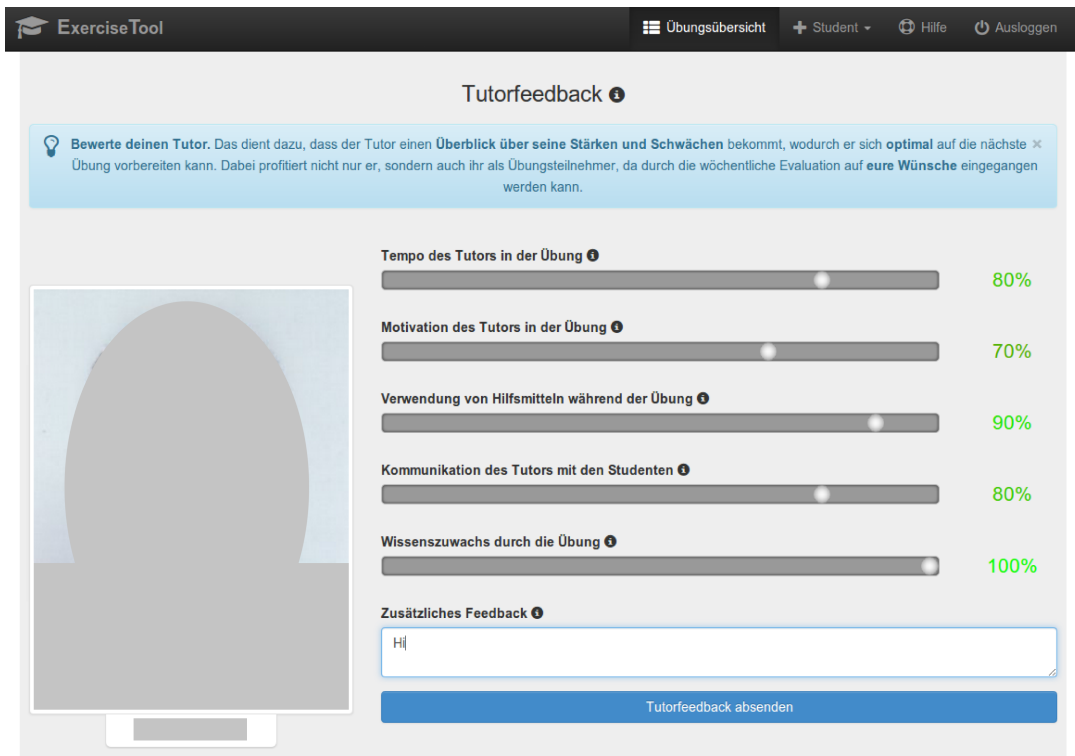
When provided at a defined countable modicum of times, provision of distinct evaluation functionality, decoupled from ARS functionality, but with broader scope, invites students to point out deficits and benefits of their learning environment.

If addressed correctly, an anonymous evaluation system may provide a superior alternative to end-of-semester evaluations. By that, it fosters Working Theses 1 and 2, especially if adaptations based on early evaluative feedback are part of the didactics concept followed. Moreover, Working Thesis 3 is strongly supported if students are allowed to provide evaluative feedback whenever and wherever they want.

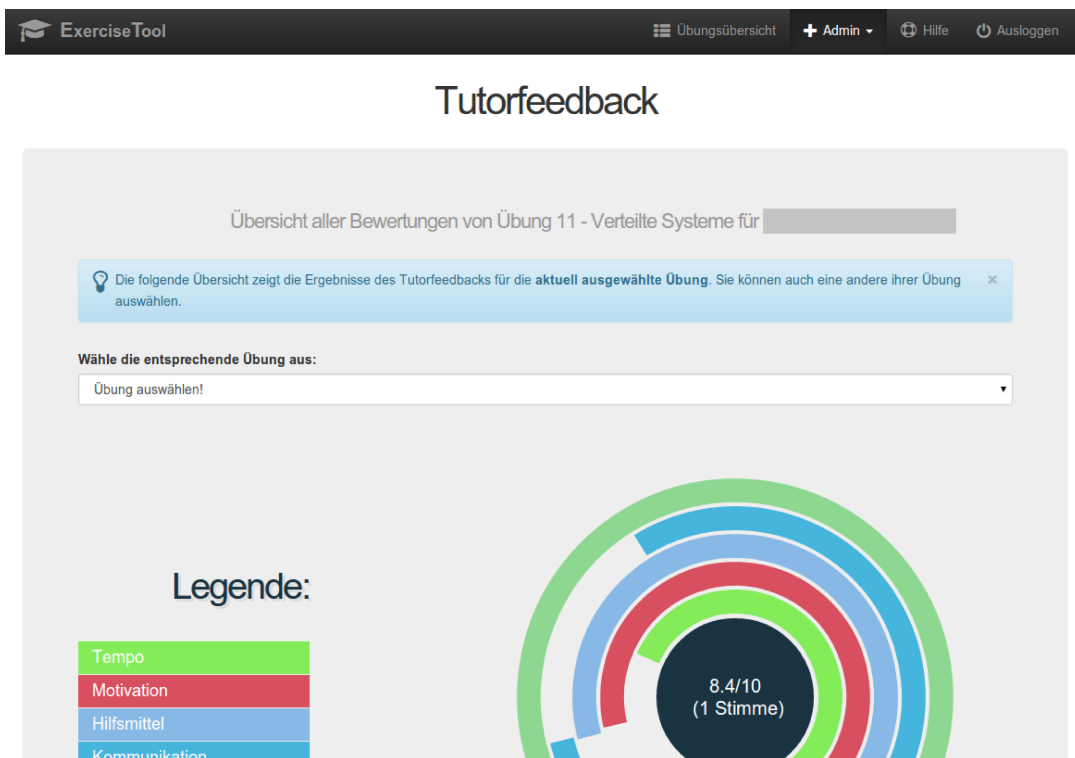
5.7.5 Experiments

Even though there was an evaluation tool implemented into the *ExerciseTool* prototype, no formal investigation was conducted. As mentioned earlier, the evaluation tool was implemented as part of a practical course by students based on loosely discussed options for features to be implemented. The formal initial assertion on evaluation systems was recorded after the successful test of the tool. Even though tested only in one tutorial unit, and that one being U11, which is not within the defined scope (these results can be excluded from comparisons between both iterations), they provided a solid foundation for the prototype in the second iteration as well as the derived concept. By the time the students presented their prototype evaluation system to the 14-G2 test group, they had not designed a formal evaluation of the tool, but conducted open conversations with the attendees, recording the contents afterwards in their practical course report. The 'results' therefrom largely verify what has been derived from *RNUW*'s ARS with respect to evaluation aspects (→ section 5.6). Despite this mishap, the evaluation system could be considered a success. The evaluation system allowed students to provide feedback on the tutor's performance during the tutorial. Evaluation dimensions were speed, motivation, aid utilisation, interaction and knowledge gain, and based on a ten-step scale ranging from 0% to 100%. Additionally, free text feedback was possible (→ Figure 5.7.1a). Evaluative feedback provided was processed by *ExerciseTool* immediately and provided instant evaluation for the tutor (→ Figure 5.7.1b).

The experimental results of the first iteration could be verified in the second iteration with *ETv2* in which a separate tool for time-decoupled feedback similar to the semestral evaluation was implemented. However, feedback could be provided any time rather than only once at a time to the end of the lecturing period. Feedback provision was designed to base on tutors' per-unit performance factors, namely task progression speed, own motivation, motivational attitude toward students, aid utilisation (for example OHP), communication with the students, students' knowledge increase, as well as open text feedback. This allowed students to provide feedback any time they wanted – for example, after a tutorial in the bus on their way home – while the system would automatically attribute the feedback to the current tutorial unit of the instalment the student was enrolled in. Linking to the last unit the students actually attended, detected by their log-in with the access key, was considered in order to attribute evaluative feedback to the main contributing unit, but the idea was dismissed. Feedback provided by students could base on a set of tutorials, their current mood, or even the tutor's clothes. Therefore, it was decided to attribute any feedback to the closest previous unit in order to make the feedback available to the tutor as soon as possible. This way, the main criticism of the traditional semestral pen & paper evaluation could be addressed, namely it providing feedback too late, only benefitting the next generation of students with adaptations, if at all.



(a) Student view of *ExerciseTool*'s evaluation tool. Top to bottom: navigation menu, explanatory text, picture of tutor (redacted area in the left vertical centre), evaluation sliders and free text (right vertical centre).



(b) Tutor view of *ExerciseTool*'s evaluation tool. Top to bottom: navigation menu, explanatory text, tutorial selector, graphical representation of evaluation results.

Figure 5.7.1: *ExerciseTool*'s evaluation tool. (Screenshots provided by Tommy Kubica, B.Sc.)

5.7.6 Results and Conclusion

Students acknowledged that being able to provide timely feedback affects tutorial conduct positively ($\bar{X}_{PFS-Q12} = 4.1, n = 7$). Students perceived prompt reaction of the tutor as very positive ($\bar{X}_{PFS-Q13} = 3.8, n = 8$) if feedback was provided and an adaptation of the tutor's conduct was cognisable in the next tutorial ($\bar{X}_{PFS-Q14} = 3.7, n = 6$). However, if for any reason feedback would not or could not be addressed by an adaptation, the negative drawback was significant. Students who felt their feedback was ignored assumed it was unvalued. They stated not to provide further feedback in future as any attempts of influencing the tutor's conduct were futile. Basically, students should be encouraged to provide feedback as often as possible, but the rapid set-up of ARS may constrain the overall evaluable feedback as ARS need to focus on few selected aspects. A fully-fledged evaluation can provide more detailed feedback on a wider range of aspects and thus allow for a broader context of possible adjustments to tutorial contents, conduct, et cetera. Therefore, it seems worthwhile to provide a distinct means for broader feedback at set times, unobtrusive to tutorial conduct, hence after tutorial units.

As the experiments verified the initial assertion so far, no modifications to the assertion are required. Quite the contrary, being verified, the results demand inclusion of an evaluation system in any education platform.

6 EXAM OUTCOME

“En los exámenes los estúpidos preguntan cosas que los sabios no pueden responder.”

Santiago Posteguillo



EXAM OUTCOME

In the investigated 'computer networks' undergraduate course the final exam consists of seven tasks (T1 to T7) spanning material from all tasks discussed in the tutorial units as well as some definitions and concepts from the readings. For the investigations students were asked to provide information on which tutorial instalment they attended on a volunteer basis⁴³.

The exam at the end of the first iteration yielded two hundred one exam sheets handed in, but only ninety could be associated with the respective tutorial instalments. One of the control group instalments had to be precluded from analysis as only five students declared having attended that instalment. From the remaining eighty-five attributable exam sheets only seventy-five allowed biunique attribution as some students provided having attended multiple instalments. The attributable results of these remaining exams are depicted in [Figure 6.0.2](#).

Comment

Attention is invited to all figures of this chapter following after the contents. The figures can be found on pages [122](#) to [125](#).

Overall, the test groups 14-G1, 14-G2 and 14-G3 neither in average nor median performed significantly better than the control group 14-CG. However, this can be explained by the fact of the three test groups being instructed by the same tutor, while the control group comprised of tutorials instructed by other tutors. Another influencing factor is the degree programme the students were enrolled in. Information system technology (IST) programme students on average and median performed better than students enrolled in other programmes (↪ [Figure 6.0.3](#)). Significantly, the majority of attributable IST students were member of the 14-CG group. This in part explains the overall good average of 14-CG.

Only taking the results of 14-G3 as a benchmark, the tutor instructing the test groups was able to increase students' performance – measured by students' average and median exam success – to equalise with the control group. By only comparing over the test groups this shows a significant exam performance increase due to tool utilisation; the tech-enhanced tutorials 14-G1 and 14-G2 clearly outperform the tech-free group 14-G3. On average, members of 14-G1 and 14-G2 scored 25% more points compared to 14-G3 members. Interestingly, in task T6, which was correlated with V-IWB utilisation, 14-G2 students achieved more points (average|median of 5 achievable points: 3.8|3.8) than students specifying to have attended 14-G1 (3.0|3.0) or 14-G3 (3.1|3.5) tutorials, and even performed on a level comparable to 14-CG students (3.5|4.0). This allows for the assumption of V-IWB to contribute significantly to learning success.

U11 was excluded from comparisons as comparability with later instalments – that would have the full twelve tutorial units – would be deceptive and make the results not comparable (refer to [Appendix A](#)). However, when not intending to compare results with later instalments, the exam results provide remarkable evidence for the effectiveness of the discussion system in *RNUW*. The material of task T7, namely Mobile IP, was a content of tutorial unit U11. Ample discussion among the students' peers developed around this topic. Both, 14-G1 and 14-G2 show a significantly higher success in T7 than 14-G3. The tech-enhanced tutorials also performed above the control group; especially 14-G2 outperformed all other groups (average|median of 5 achievable points: 14-G1: 3.5|4.5; 14-G2: 4.5|5; 14-G3: 2.3|2.3; 14-CG: 3.6|4.0). This calls for the conclusion that the utilised type of discussion system can provide significantly positive impact on students' learning success, so it requires further investigation with respect to the validity of the conclusion.

⁴³ German laws and common practice on data protection and privacy prohibit mandatory designation beside name, degree programme and matriculation number.

In the subsequent iteration the return rate improved to 54.4%: from two hundred fifty exam sheets handed in, one hundred thirty-six could be associated with the respective tutorial instalments. From those three did not allow biunique attribution; the attributable results of the remaining one hundred thirty-three exams are depicted in [Figure 6.0.4](#). Unfortunately, it must be mentioned that it seems as if only students who seemed quite certain to pass provided this information. The gross of students not passing (and dragging down overall the average) did not provide information on which tutorial instalment they attended. However, the bases for groups 15-G1 and 15-G2 seem credible. From the average of attending students (15-G1: twenty-six, 15-G2: twenty-three), the counts of ones stating to have used the prototype (15-G1: fourteen; 15-G2: eighteen) can be correlated with the return on attributable tutorial statements: the numbers do not allow a confident statement on any of the student groups to be either included or not included in the statistics.

Overall, the test groups 15-G1 and 15-G2 performed slightly above the control groups 15-G3 and 15-CG. The one-time prototype utilisation group 15-GA performed within the average, but with notably worse median. As in the previous year, IST students performed significantly better than students of all other degree programmes (\leadsto [Figure 6.0.5](#)). However, the feedback allowed for statistically relevant consideration of the instalment compositions. With that in mind, impact of IST students on the outcome of the exam can be factored in. The composition and result outcome for the tutorial groups are given in [Table 6.0.1](#).

	15-G1	15-G2	15-G3	15-GA	15-CG
BA-Inf	5	3	0	3	23
BA-Medien-Inf	1	5	0	6	21
Dipl-Inf	7	3	0	4	9
IST	0	0	4	1*	3
teacher degree	1	1	5	2	3
Wirt-Inf	7	3	5	0	3
miscellaneous	0	3	0	0	2
ρ_{min}	6.5	9	9	7	7
ρ_{max}	31	31.5	30.5	33	32
$\bar{\rho}$	20.4	21.4	19.7	19.4	19.8
$\tilde{\rho}$	20.5	22.8	19.3	16.5	19.5
σ_{ρ}	6.69	6.51	6.76	7.98	5.28

*: best student in exam (33 out of 35 points)

Table 6.0.1: Group compositions and exam outcomes.

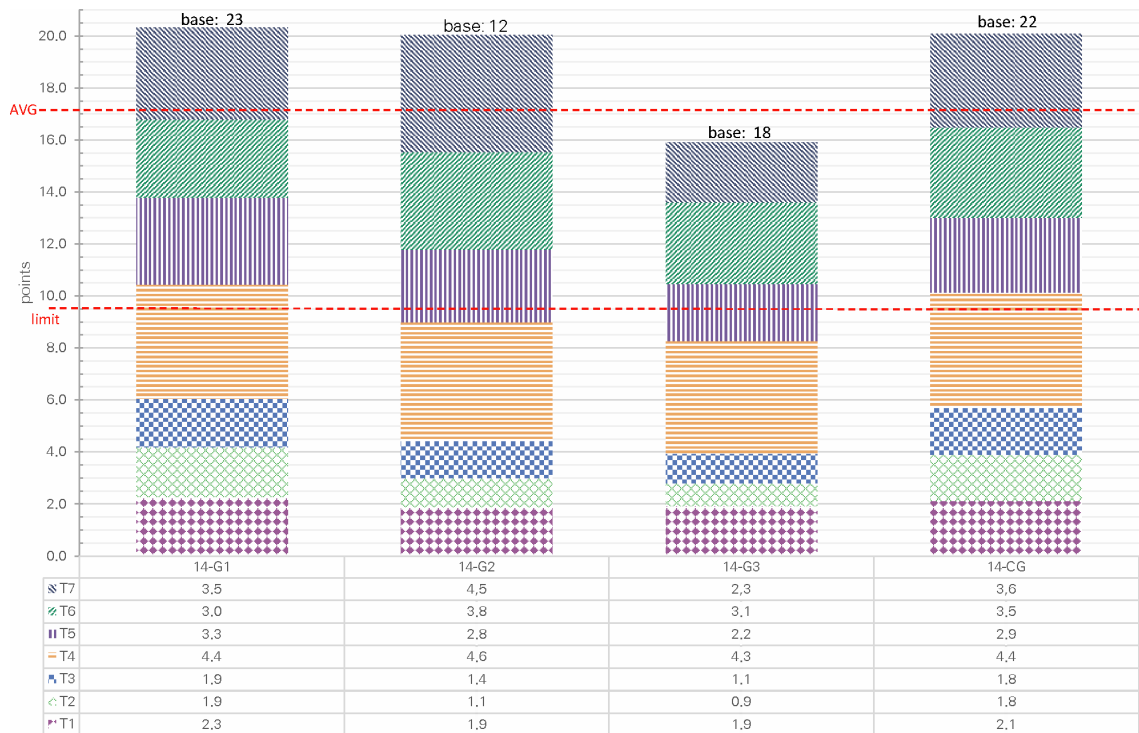
Significantly, group 15-G2 outperformed all other groups in average and median, even though none of 15-G2's students were enrolled in the IST degree programme, and 16.7% of the students from miscellaneous degree programmes (60% of those who were attributable to a tutorial group) attended the tutorial. Especially with respect to the miscellaneous degree programme students, it should be noted that all three attending 15-G2 tutorials passed, they themselves already making up one third of the passing students from that set of students. This allows for the conclusion that the results on increased exam performance due to (classic) peer instruction [[Maz97](#), [CM01](#), [FCM02](#), [CWFM07](#), [LMW08](#)] are reproducible for peer instruction settings utilising an online discussion tool instead of 'analogue' peer discussion. As in the previous year, exam tasks clearly related to the tools of the prototype show better results for 15-G1 and 15-G2. Group 15-GA had utilised the prototype in tutorial unit U11, which relates to T7, a task on distributed systems. In 15-GA the V-IWB tool was utilised to collaboratively draw out RPC binding as well as a distributed transaction (combined flight and hotel reservation). Obversely, the exam task did not require any graphical solution, but was aimed at the underlying principles and mechanisms. Therefore, it can be assumed that the inconspicuous T7 results of 15-GA can be attributed to this fact; possibly the explanation of the principles and mechanisms suffered from

the introduction to and utilisation of the V-IWB tool. All other tasks (T1 to T6) align to the 15-CG average and median.

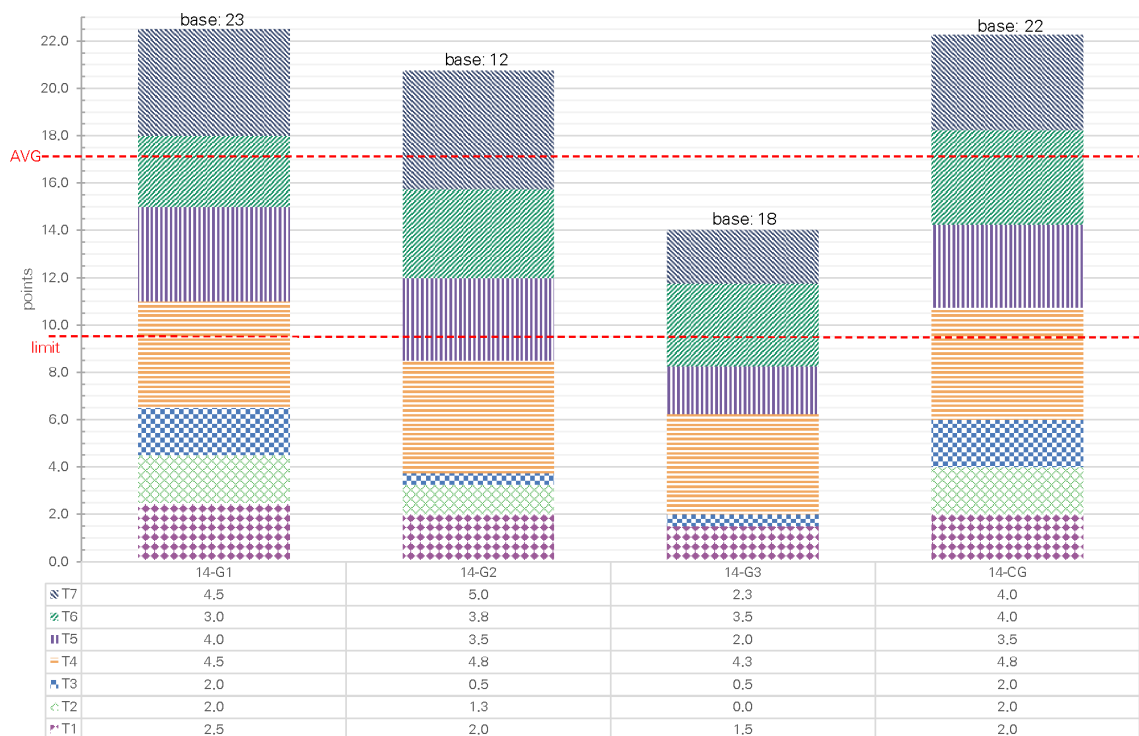
Looking at the tasks mainly contributing to 15-G1 and 15-G2's exam performance, three tasks can be identified: T3, T5 and T6. Task T3 was a task on IP subnets and routing tables, T5 on fairness in networks, and T6 on the Domain Name System. The latter two rely heavily on graphical and tabular explanations and discussions within the tutorial, while T3 requires multiple repetitions of explanation of the principles and mechanisms involved. Due to these facts, T3 performance can be correlated with utilisation of the discussion system, and T5 and T6 performance with utilisation of the V-IWB tool.

Significantly, in T3 group 15-G2 performed well above average ($\bar{p}_{T3}^{15-G2} = 3.1$, $\tilde{p}_{T3}^{15-G2} = 4.5$; $\bar{p}_{T3}^{AVG} = 1.8$, $\tilde{p}_{T3}^{AVG} = 1.5$), but also clearly outperformed all other groups. This can be attributed to the peer instruction setting and the utilisation of the discussion system as a peer discussion means. In order to understand the principles of subnets, the construction of routing tables, as well as their applications, past students have required multiple iterations of discussions and explanations. This was true in the second iteration, too, but having the ability to utilise the discussion tool within the prototype provided the students *a)* with the possibility to continue discussions after tutorials had concluded, at times involving the tutor, and *b)* with the ability to retroactively read, retrace and comprehend discussions. Marking of helpful contributions and the voting system surely contributed to discussion content tangibility. The median performance of 15-G2 in T3 can lead to the assumption that the discussion tool had students' knowledge close ranks.

Being correlated with heavily graphical and tabular tutorials, tasks T5 and T6 allowed the test groups 15-G1 and 15-G2 to once again outperform the average ($\bar{p}_{T5+T6}^{15-G1} = 6.7$, $\tilde{p}_{T5+T6}^{15-G1} = 8.0$; $\bar{p}_{T5+T6}^{15-G2} = 7.7$, $\tilde{p}_{T5+T6}^{15-G2} = 8.3$; $\bar{p}_{T5+T6}^{AVG} = 5.3$, $\tilde{p}_{T5+T6}^{AVG} = 6.0$), including outperforming all other groups individually. The result is slightly more obvious for 15-G2. Interestingly, task T6 (Domain Name System) did not show a significant increase in point average, but the median increased significantly, even though the corresponding tutorial tasks rely on graphical and tabular explanations even more than the tutorial tasks corresponding to task T5. This should be further investigated.



(a) Exam outcome by average.

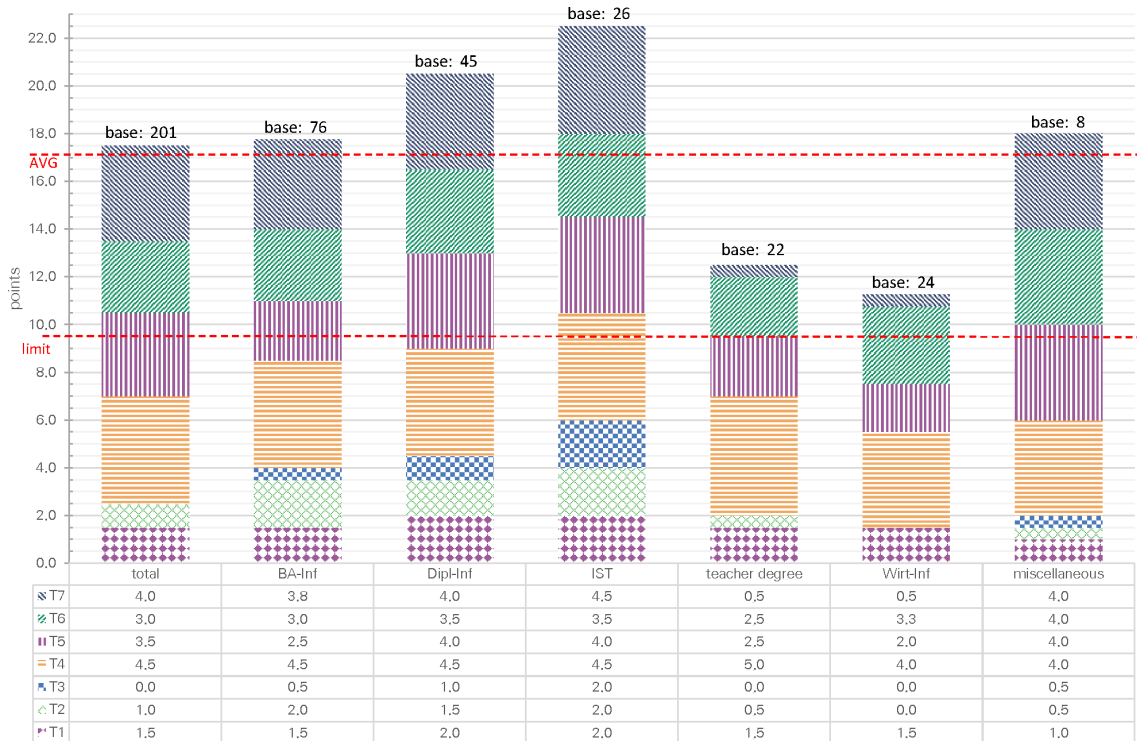


(b) Exam outcome by median.

Figure 6.0.2: Outcome of the final exam following the first iteration by test and control groups. Base $n = 75$; maximum achievable 35 points; average 17.1 points; passing limit 9.5 points. The included table shows the point distributions per task (T1 to T7); max. 5 points per task.

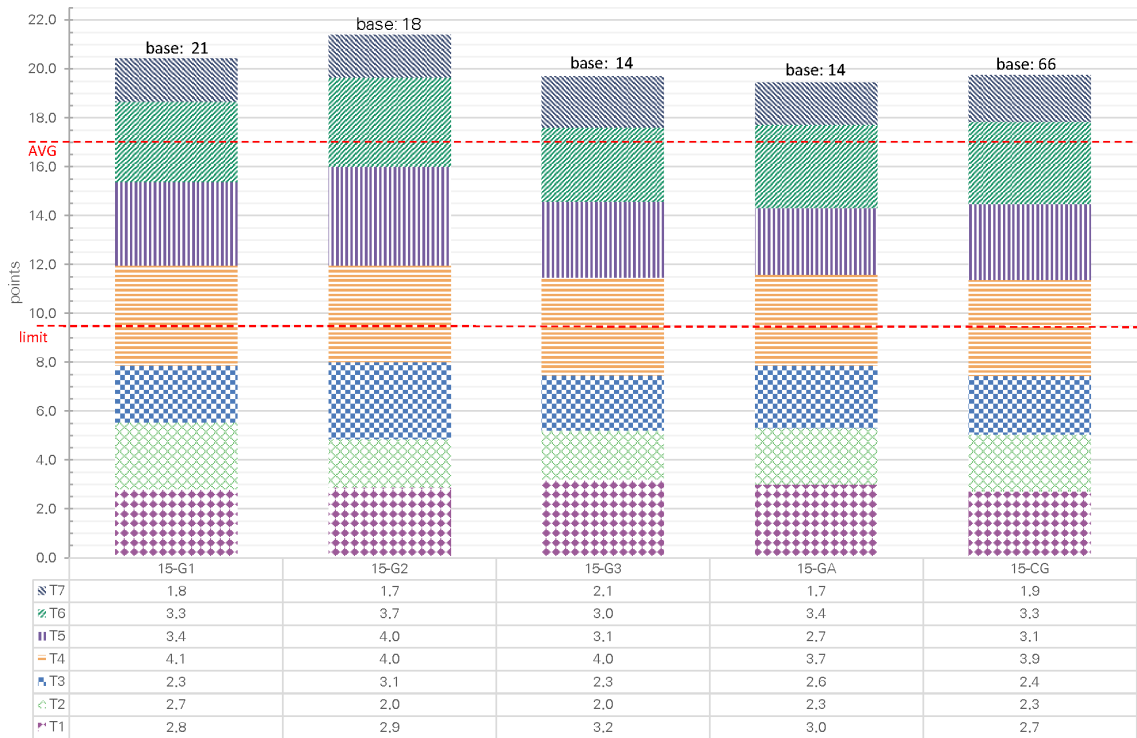


(a) Exam outcome by average.

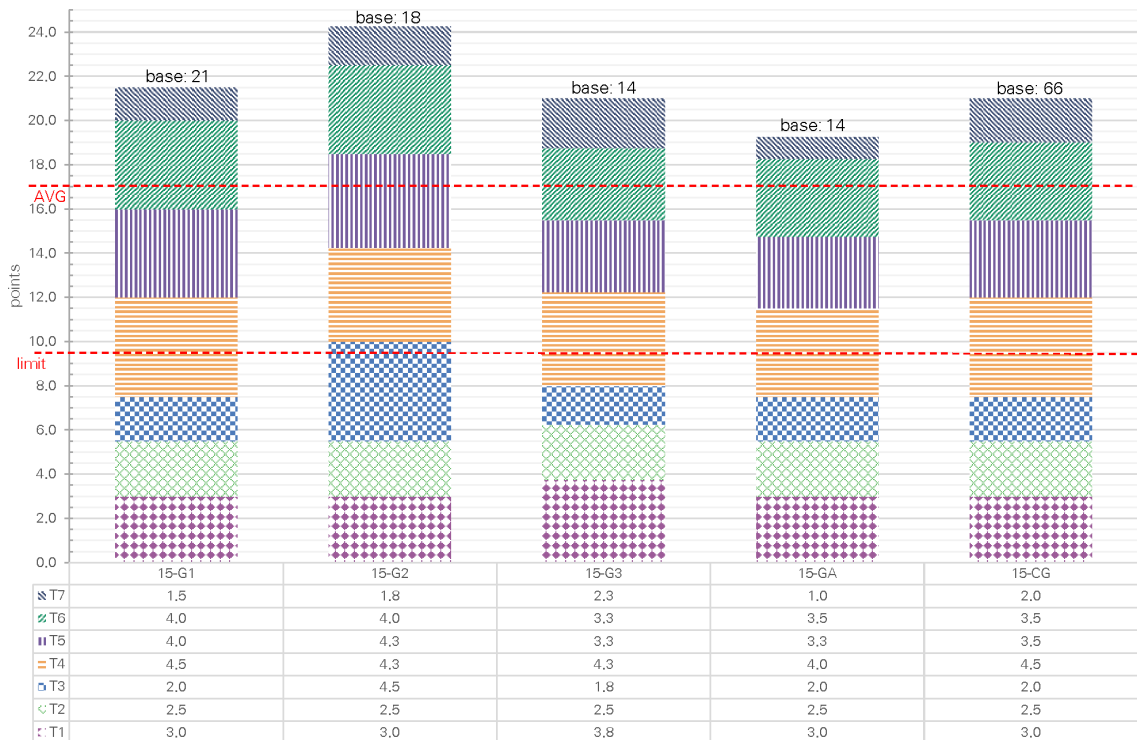


(b) Exam outcome by median.

Figure 6.0.3: Outcome of the final exam in the first iteration by degree programmes. Base $n = 201$; maximum achievable 35 points; average 17.1 points; passing limit 9.5 points. The included table shows the point distributions per task (T1 to T7); max. 5 points per task.

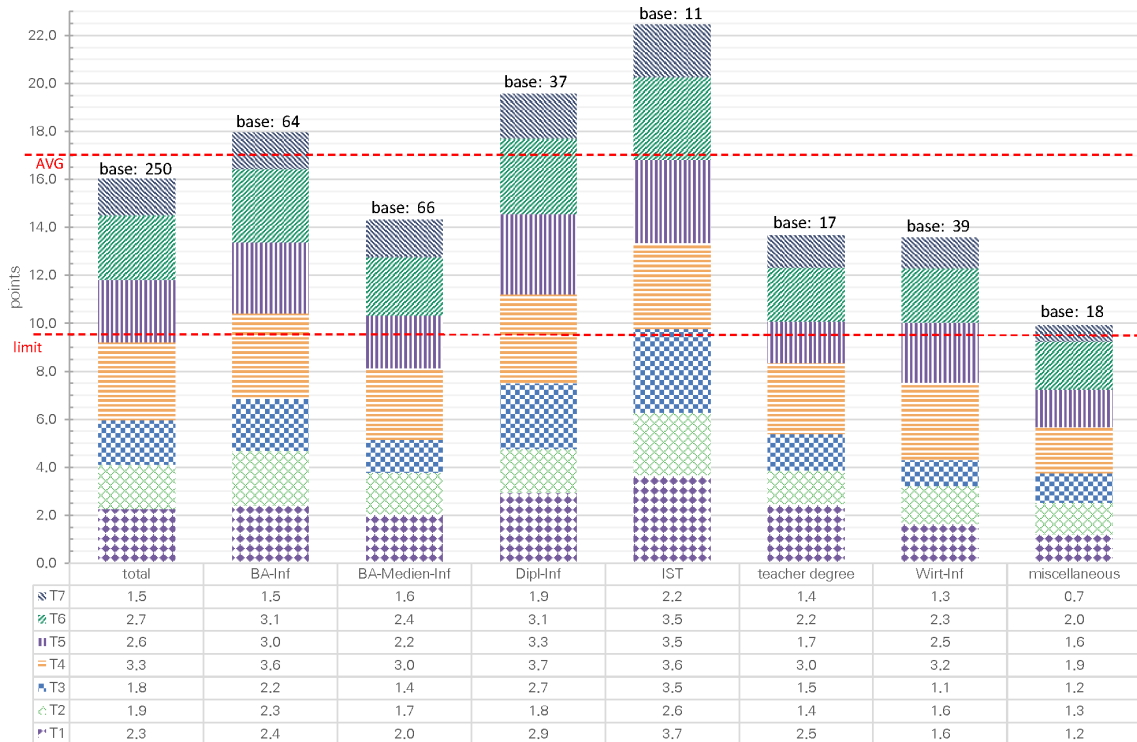


(a) Exam outcome by average.

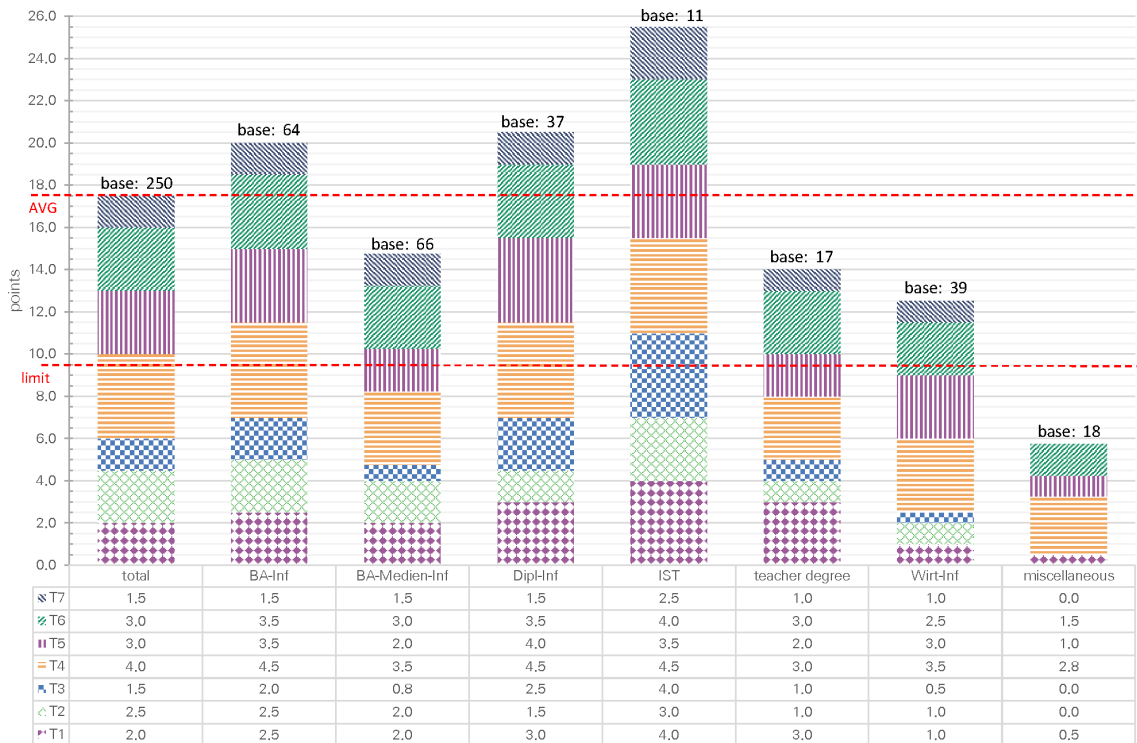


(b) Exam outcome by median.

Figure 6.0.4: Outcome of the final exam in the second iteration by test and control groups. Base $n = 133$; maximum achievable 35 points; average 17 points; passing limit 9.5 points. The included table shows the point distributions per task (T1 to T7); max. 5 points per task.



(a) Exam outcome by average.



(b) Exam outcome by median.

Figure 6.0.5: Outcome of the final exam in the second iteration by degree programmes. Base $n = 250$; maximum achievable 35 points; average 17.1 points; passing limit 9.5 points. The included table shows the point distributions per task (T1 to T7); max. 5 points per task.

7 UTILISATION AND MOTIVATION

'You don't know what you have until you use it.
You don't have to wait until you lose it.'

Constance Chuks Friday



UTILISATION AND MOTIVATION

Beyond the observable impact of tool utilisation on learning success (\leadsto [previous chapter](#)), a more or less concealed impact on motivation can be asserted. This motivation can be divided into two types, namely overall motivation correlated with tutorials in general (to learn, attend, et cetera), and motivation correlated with tool utilisation. Therefore, a brief examination of students' prototype utilisation and their motivations shall be provided, especially in order to be able to correctly classify the findings of the previous chapters.

7.1 PROTOTYPE UTILISATION

Students' prototype utilisation in test group 14-G1 was manually enquired (\leadsto [Table 7.1.1](#)) by carefully observing the number of attending students, counting second screen devices, interviewing students orally and in writing, and by automated user tracking within the *RNUW* prototype (\leadsto [Table 7.1.2](#)). Manual enquiry was imperative for some of the prototypes' functions. For example, in lack of ambience sensors⁴⁴, there was no way for the prototypes to automatically determine the attendee count for calculations on ARS significance (percentage of logged-in users voting in a certain way versus number of logged-in users on second screen devices versus number of students in the lecture room).

unit	n_S	n_D	\bar{X}^{Q1}	σ_X^{Q1}	\bar{X}^{Q2}	σ_X^{Q2}
pre	18	n/a	inapplicable		4.20	.43
U04	28	16	3.91	.29	4.08	.91
U05	27	16	3.21	1.08	4.18	.55
U08	31	14	2.98	1.15	4.02	1.22
U09	29	11	2.96	1.21	3.93	1.07
AVG	29.3	13.4	inapplicable			

Table 7.1.1: Utilisation of the *RNUW* prototype (manual enquiry). Columns left to right: students attending; students with devices capable of providing as second screen; average answer score and standard deviation for questions Q1 and Q2.

This table also contains data from a paper based questionnaire conducted prior to tutorial unit U01; it is in the first line, marked 'pre'. The two questions asked could be answered on the reverse side of minute papers handed out to the students *after* tutorials. Both questions allowed answer scores ranging from 1 ('not at all') to 5 ('absolutely'). The first question (Q1: 'Will you use the provided online learning tools in the next tutorial?') aimed at the students' willingness to utilise the provided tools, while the second (Q2: 'Are online learning tools useful for tutorials?') aimed at the students' general perception of usefulness. It should be noted that Q2 does not query 'the provided online learning tools', but uses a more general phrasing. This was intentional in order to query the students' general thoughts on usefulness, rather than the usefulness of the provided tools. Of course, the general perception may have been compromised by the tools provided. Additionally, it must be noted that the questions were not printed on the reverse of the minute papers. Instead, the students were queried orally and asked to kindly note their scores (as a reminder, two integers ranging from 1 to 5). This compromise was the result of not making

⁴⁴ With current technology it is questionable whether automated attendee count is possible without having the attendees actively contribute to the count (for example by scanning a ticket). This is an open research area that is out of scope for this dissertation. Hence, manual counting was the best option.

the minute paper double-sided (minute papers are supposed to be single-sided), but still being able to receive feedback on the questions.

Regarding general willingness to utilise learning tools in tutorials, an overall positive attitude could be observed. Even though the absolute average decreases in the latter half of the data-base, the willingness remains around a positive value of 4. The deviation of values allows for the conclusion that 4 is the final value. In regard of willingness to utilise the provided tools, a more or less indifferent attitude can be observed. The first average can be considered strongly correlated with overall willingness to utilise tools. Under observation of the deviation, both values are positive around 4. After having actually utilised the provided tools, tool utilisation willingness decreased by about one point to an average of approximately 3 with significant deviation from that value. Some students appeared to be more willing to utilise the tools than others, who seem to have hated it. In lack of questions prepared to address these opposing attitudes, it could not be determined whether the willingness values are correlated with actual tool utilisation, or not. It cannot be ruled out that a strongly negative rating was provided based on an initial misconception of tool functionality, having given up on the tools before even getting to the point of habitual utilisation. As the general willingness did not decrease, but the tool-specific willingness did, this needed to be investigated further.

The *RNUW* prototype included automated user tracking functionality for automatic enquiry starting unit U06. Therefore, no data is available for unit U04 and U05. The available data is provided in [Table 7.1.2](#).

unit	n_s	n_D	t_{min}^{TA}	t_{max}^{TA}	t_{avg}^{TA}	t_{min}^{SA}	t_{max}^{SA}	t_{avg}^{SA}
U06	34	14	10s	661s	39s	6s	42s	10s
U07	29	12	8s	534s	174s	6s	41s	14s
U08	31	14	9s	578s	224s	6s	34s	13s
U09	29	11	6s	415s	161s	6s	18s	9s
U10	27	11	6s	392s	181s	6s	131s	83s
AVG	30.0	12.4	7.8s	516s	155.8s	6s	53.2s	25.8s

Table 7.1.2: Utilisation of the *RNUW* prototype (automatic user tracking). Columns left to right: students attending; students with devices capable of providing as second screen; the minimum, maximum and average total interaction time for all activities recorded during the tutorials; the corresponding times for single activities.

Due to technical limitations only active utilisation (interactions with the platform) could be tracked. This means a user being logged-in and only reading discussion contributions could not be recognised as doing so, while a user scrolling in a discussion's thread view could be detected due to their interaction with the prototype. Additionally, the minimum aggregation interval was limited to six seconds. All mouse movements, finger gestures and text inputs were logged on a listener⁴⁵ basis, but at shortest once per second, on the clients. Shorter intervals would have led to unacceptable computation load values on the client devices. While assuming that the users would require additional time before and after such actions in order to perceive the display contents, a four seconds ahead activity buffer and a two seconds follow-up activity buffer were utilised for segment merging, resulting in the minimum six seconds frame. On the server side, connection handling was the limiting factor, since user tracking was meant to not influence the other functions of the prototype. Standard-respecting browsers only support a maximum of four standing TCP connections between servers and clients. As the prototype utilised distinct Web-Socket communication for the general website performance, the ARS, and the Q&A system, only

⁴⁵ A non-blocking programme hook that only gets active when triggered. Otherwise it merely waits for an interaction; it 'listens' whether it is being addressed.

one universally available TCP connection remained. This had to be kept usable under all circumstances, thus the granularity of the user tracking was limited to having client devices report their aggregated tracking data only once per minute. This in return led to deficits in data availability in the last few minutes of the tutorial units. Often students shut down and stored away their devices before the last set(s) of tracking data were transmitted to the server. Apart from the time interval constraints, user tracking was limited in cautious respect of German laws on privacy to sporadic interactions, namely having the user tracking only record that an interaction took place, however not what kind of interaction and with which tool within the prototype. Retrospectively, this decision is regrettable, especially as the anonymity of users, breakable only via their accessing devices' [MAC address](#) and [IP address](#), and targeted user observation, would have allowed –pending users' declaration of consent– such user tracking. Results could have benefited from more detailed user tracking, however the administrative effort should not be underestimated. Nevertheless, even though coarse, user tracking data is available for the *RNUW* experiments. Within the available scope –as a reminder: U06 to U10–, one hundred nineteen identifiable user samples containing nine hundred fifty-one activities were collected, averaging 23.8 user samples per tutorial and 39.96 actions per sample. These numbers exceed the average amount of students logged-in to the prototype (13.4) as some users utilised multiple pseudonyms. Such user samples could not be aggregated into one anonymous account as it was impossible to correlate two pseudonyms with the same originator without checking for MAC or IP addresses in the server's log files. As that would have provided a clear breach of privacy principles, log files were never touched. However, based on the tracked actions valid conclusions can be derived (~ [Figure 7.1.3](#)).

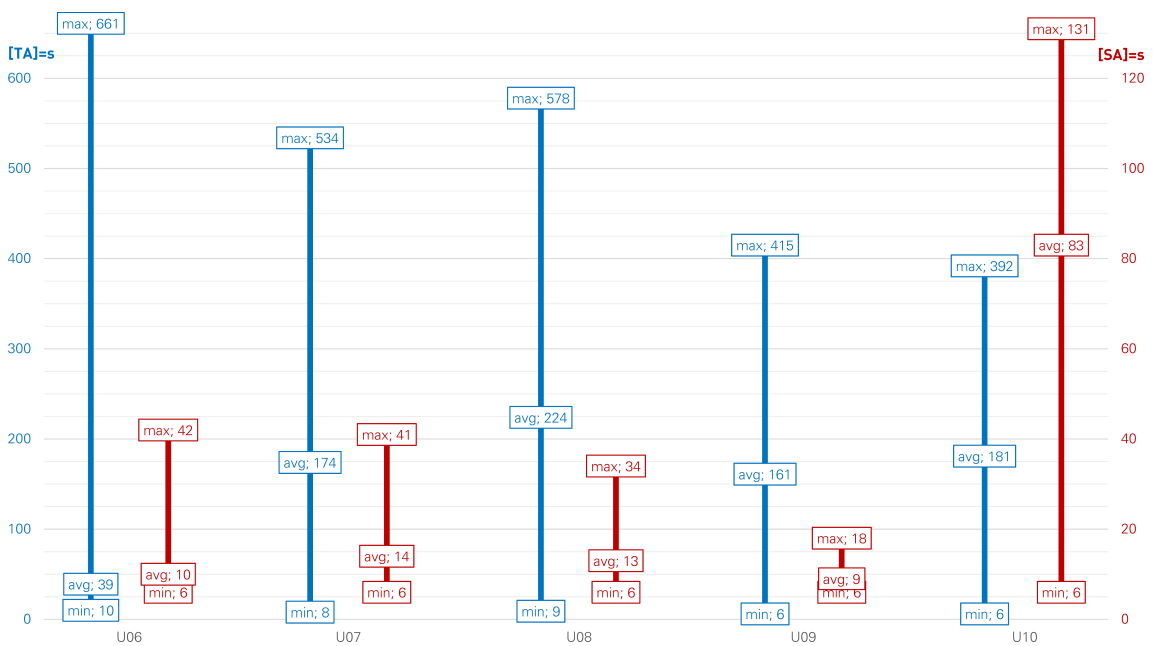


Figure 7.1.3: Utilisation over the tutorial units for *total activity* (TA) and *single activity* (SA) data. (X-axis: tutorial units; left Y-axis: TA time in seconds; right Y-axis: SA time in seconds)

As expected, the minimum time spent on single activities was six seconds due to the technical limitations of the user tracking. However, the deviations of minimum and maximum times are likely related with tutorial unit contents. The measurements clearly show that unit U10 heavily relied on Q&A tool utilisation. The average and maximum single activity times are significantly elevated. In combination with the total times, longer consecutive utilisation is observable, allowing the conclusion that the students were engaged in continued discussions. However, overall tool

utilisation time decreased significantly in comparison to the other units. Within the other units, single activities were restrained to approximately twelve seconds (averaged over all values from all three units). However, total activity time was inconclusive. The average total time in unit U06 was significantly lower than in U08. Naïvely dividing total activity time by single activity time produces an average of seventeen distinguishable activities per average system user. This seems to be an oddly high value and superficially cannot be explained in lack of targeted enquiry. However, the distribution of the logged activity times matches the tutor’s observations of the tutorial conduct and show that the students actively engaged in Q&A tool utilisation during the discussion of the first tutorial task, namely one on Ethernet performance. This task is known to be difficult for students as varying values for variables need to be observed in permuting combinations. This task is regularly object of discussion in pre-exam preparations⁴⁶. Therefore, elevated Q&A tool utilisation can be clearly identified as the pivotal factor in the high activity time of unit U08. With respect to all units excluding U06, overall total activity revolves around three minutes (or 3.3% of class time). In combination with the approximated twelve seconds of single activity time this allows the conclusion that the provided tools were more or less utilisable as CIU.

At first glance, the most questionable result is unit U06. The average total activity time is significantly lower than in all other units. Considering that this tutorial unit introduces the Internet Protocol with subnets and routing, known difficult topics often object of pre-exam preparation activities, this is very ominous. However, when considering that the Q&A tool was not available until unit U07 (↔ Table 4.3.1), the low total activity average occurs in a different light. The available tools (LDA and ARS) did not allow for elevated tool utilisation, except for active ARS feedback on lowered speed and raised perspicuity.

	LDA	PDS	V-IWB	ARS	EVA
U04	.00	.00	.00	.25 *	.22 *
U05	.02	.15	.00	.29 *	.14
U06	.05 *	.37 *	.00	.10	.10
U07	.01	.15	.00	.16	.08
U08	.00	.14	.00	.15	.26 *
U09	.00	.10	.70 *	.20 *	.13
U10	.00	.49 *	.00	.10	.07
U11	.00	.21	.80 *	.09	.02
U12	.00	.20	.00	.08	.52 *
AVG (unpromoted)	.01	.14	.00	.10	.09
AVG (promoted)	.05	.43	.75	.25	.33
AVG (total)	.01	.20	.17	.15	.17

Table 7.1.4: Utilisation of the ETv2 prototype based on manual enquiry. Tutorial units promoting certain tools are highlighted with an *.

As programming tasks were outsourced to and conducted by a small team consisting of only one graduate student and one doctorate student, in the second iteration the prototype did not include automatic user tracking as the core functionality was imperative to the experiments. Therefore, only data from manual enquiries is available. This data suggest that tool utilisation is heavily dependent on tutorial content. Iff the tutorial conduct’s design stipulates tool utilisation, for example including a task to be solved via V-IWB, utilisation is rather high and constant over the course of the semester. During tutorial units in which the tools were not actively promoted, average utilisation was significantly lower than in units in which tools were promoted. Having

⁴⁶ Traditionally, one to three special facultative prep-rooms are offered. Students *can* attend any time they want for as long as they want and prepare for the exam alone or with fellow students. Tutors are available in the rooms and answer questions or provide input to discussions. However, no material is presented by the tutors to the attendees. Instead, active micro-teaching is pursued.

simple 'yes' or 'no' answers to the utilisation question and 'yes' by all students equalling 1, the utilisation data averaged over all tutorial units yield: LDA .01 vs. .05, PDS .14 vs. .43, V-IWB .00 vs. .75, ARS .10 vs. .24, EVA .09 vs. .34 (↔ [Table 7.1.4](#)). However, these numbers are not adjusted for quota of students who had access to a second screen device and access to the tools, and those who did not. The latter may have answered 'no', obviously because they were unable to use the tools. The significantly high utilisation of the evaluation tool after its promotion in the final tutorial unit can be explained by an additional end-of-semester boost.

[Table 7.1.4](#) also shows that –with the exception of promotions– uncoerced utilisation gradually decreased with each tutorial unit, subject to the students' overall motivation and their sense of usefulness of the tools provided. Notably, introduction of new tools (with a formal briefing by the tutor) yielded short-term increases in utilisation, namely the students 'just had a look' at the promoted tool, but afterwards utilisation quickly decreased again. Another notable effect is the inverse correlation between overlapping promotions of ARS and EVA, and V-IWB and ARS, where the collision led to decreased utilisation compared to collision-free promotion.

In oral feedback students supported the idea of being able to retroactively revoke the anonymity of their contributions in order to attribute contributions to their persons. Even though the prototype did not include such functionality, the students were aware of the idea due to explanations of targeted future functionality during interviews. However, they noted that the revocation itself should be a decision of the students themselves and strictly optional (that is voluntary). By having revocation of anonymity optional, students would not have to fear that their identity might be divulged arbitrarily. Otherwise, this would prevent some students from utilising the tools as it would not be certain whether their anonymity was maintained under all circumstances, or not.

7.2 MOTIVATIONAL ASPECTS

Students were asked to provide feedback on the prototypes via an anonymous free text [HTTP](#) form within the prototypes any time at their leisure. Additionally, anonymous hand-in of paper based feedback as well as verbal feedback was permitted after each experimental tutorial and before the successive tutorial. A formal paper based questionnaire was conducted in the twenty-fourth calendar week of 2014. Seven students were orally interviewed after the V-IWB experiment. Auxiliary data could be derived from minute papers students handed in. These minute papers were actually designed for utilisation in their traditional context, but some students opted to provide feedback on the tutorial *and* the prototypes. Averaging over provided feedback, three distinct data ascertainties were defined. The first (14-A1) was placed between U04 and U05, the second (14-A2) between U07 and U08, and the last (14-A3) in the last week of tutorials. On a scale ranging from 'very bad' (1) to 'very good' (9), students overall attested to indifferent motivation toward the readings (although a slightly positive trend is discernible), and an overall slightly positive motivation toward tutorials. However, dissecting the tutorials along the established test groups, the tech-enhanced tutorials show a slightly higher motivation (+0.6 by 14-A1; +1.1 by 14-A3) in comparison to 14-G3. Due to insufficient pool size the control group could not be included in the comparison. The data-base is provided in [Table 7.2.1](#).

Tool utilisation does not appear to have a significant influence on motivation. A slightly more positive tendency over the already slightly positive motivation is observable (by about .5 points). In light of motivation being an influential effect within the visible learning results (effect size: .48), this is precarious. Exam results and utilisation show some benefits of tool utilisation, but motivation could only be slightly elevated. This could either mean that tools do not influence motivation, or that the tools *tested here* have no influence on motivation. This might be a question to be answered by GUI design studies. As a starting point, a random non-representational set of three students from 14-G2 were asked which prototype motivated them more, *RNUW* or *ExerciseTool*. All three students stated to perceive *ExerciseTool* as more motivating.

data source	\bar{X}	σ_x	\bar{X}	σ_x	\bar{X}	σ_x	\bar{X}	σ_x	\bar{X}	σ_x	\bar{X}	σ_x	\bar{X}	σ_x		
	before first reading		after first reading		current reading		before first tutorial		after first tutorial		current tutorial		reading Δ tutorial		tutorial Δ reading	
14-G1	6.43	2.62	5.05	1.99	5.24	1.98	6.30	2.01	5.77	2.14	6.14	2.11	1.87	.64	2.24	.72
14-A1	not asked	not asked	not asked	not asked	5.22	2.11	not asked	not asked	not asked	not asked	6.65	2.03	1.79	.67	2.51	.78
14-A2	not asked	not asked	not asked	not asked	inapplicable		not asked	not asked	not asked	not asked	6.64	2.02	1.81	.69	inapplicable	
14-A3																
14-G2	6.12	2.02	5.55	2.02	5.57	2.04	6.31	2.11	6.00	2.62	6.16	2.45	1.88	.64	2.31	.71
14-A1	not asked	not asked	not asked	not asked	5.51	1.98	not asked	not asked	not asked	not asked	6.31	2.32	1.87	.62	2.26	.76
14-A2	not asked	not asked	not asked	not asked	inapplicable		not asked	not asked	not asked	not asked	6.42	2.08	1.83	.71	inapplicable	
14-A3																
14-G3	6.35	2.19	5.07	1.82	5.26	1.88	6.22	1.79	5.81	2.24	5.56	2.02	1.87	.68	2.17	.77
14-A1	not asked	not asked	not asked	not asked	5.28	2.04	not asked	not asked	not asked	not asked	5.57	2.03	1.84	.69	2.22	.79
14-A2	not asked	not asked	not asked	not asked	inapplicable		not asked	not asked	not asked	not asked	5.51	1.99	1.85	.69	inapplicable	
14-A3																
14-CG	* insufficient data (pool size 4)															

∇ : 1... yes, 2... neither, 3... no

Table 72.1: Characteristics of motivation in the first iteration

Interestingly, neither do readings motivate to attend tutorials, nor do tutorials motivate to attend readings. This is independent of tool utilisation as all three test groups show comparable results. In fact, cross-motivation is so bad that one needs to assume that readings might keep some students from attending tutorials and vice versa. However, statistics on enrolment and attendance show that approximately 40% of enrolled students attend readings and 60% attend tutorials. At first glance, these numbers match the assumption on cross-motivation, but the same statistics show that about two thirds of the tutorial attendees attend the readings. Therefore, it must be assumed that the questions on cross-motivation were misleading, having the students interpret the questions as *how much more* they were cross-motivated. Another influencing factor could be another question being asked, namely whether students perceived reading and tutorial material to be coordinated. Astonishingly, this question was largely answered indifferently ($\bar{X} = 5.16$, $\sigma_X = 1.89$). This is a surprise as all materials – as mentioned earlier – were rearranged in 2013; readings and tutorials were closely coordinated. Nevertheless, this perceived lack of coordination may have influenced the students' answers on the cross-motivation questions. It might have been that readings and tutorials did not leave sufficient amount of unanswered aspects that invited to seek for answers in the respective other activity. This impression is supported by the fact of having tutorial tasks more often reference readings' contents than vice versa, for example a tutorial task involved students modifying a slide from the corresponding reading's presentation.

As mentioned earlier, the *ETv2* prototype did not provide automated user tracking. Targeted text-based feedback was not available, either. However, aside from the established anonymous hand-in of paper based feedback as well as permitted oral feedback, students were able to provide feedback on the tutor's performance in the new evaluation tool of the prototype. From the free text feedback on the tutor some reasonable cautious conclusions regarding the prototype are possible. A formal paper based questionnaire was conducted in the twenty-fifth calendar week of 2015, and fourteen students were orally interviewed over the course of the semester. Once again, auxiliary data could be derived from minute papers students had handed in. As in the previous iteration, three distinct data ascertainment were defined by averaging over provided feedback. The first (15-A1) was placed between U03 and U05, the second (15-A2) between U06 and U08, and the last (15-A3) between U09 and U11. Students provided a slightly positive, but indifferent motivation toward the readings, and an overall slightly positive motivation toward tutorials, both based on a scale ranging from 'very bad' (0) to 'very good' (9). Confirming the previous results, dissecting of the tutorials along the established test groups, the tech-enhanced tutorials show a slightly higher motivation in comparison to the other groups. The data base is provided in [Table 7.2.2](#).

The pressing question at hand is whether a pool size of fourteen students for the formal questionnaires is sufficient to warrant conclusions to be drawn. In the author's opinion this is not the case. Nevertheless, the derivable data from that pool *can* be utilised in order to support or even verify the conclusions drawn from the other sources. However, these conclusions should be considered with caution.

As in the first iteration, tool utilisation does not appear to have a significant influence on motivation. Once again, a slightly more positive tendency over the already slightly positive motivation is observable, but the motivation in general remains below the level of the first iteration. This may encourage the conclusion that tools do not influence motivation, or – as assumed earlier – that the tools *tested here* have no influence on motivation. However, one significant difference should be noted. While students were alluded to the possibly positive impact of tool utilisation on the exam results regularly in the first iteration (especially within all written tool descriptions within the prototypes), this time they were only orally alluded to this fact in a few exercises. This may correspond with Mazur's observations on students' willingness to participate in ConcepTest. Only when the students were alluded to impact on exams (as a reminder, exam questions were supposedly similar to ConcepTest questions), their willingness was sufficiently high and could be maintained on said level. It is fair to assume that the motivation to utilise the tools could be significantly increased by simply making the benefits more obvious to the students. However, these benefits must be related to measurable effects such as exam outcome, as the results clearly show that hints toward usefulness in self-regulated learning, better understanding of material,

data source	before first reading		after first reading		current reading		before first tutorial		after first tutorial		current tutorial		reading → tutorial		tutorial → reading	
	\bar{X}	σ_x	\bar{X}	σ_x	\bar{X}	σ_x	\bar{X}	σ_x	\bar{X}	σ_x	\bar{X}	σ_x	\bar{X}	σ_x	\bar{X}	σ_x
15-A1	6.38	2.09	5.55	2.13	5.99	2.09	6.39	1.99	6.02	1.98	6.05	2.65	1.89	.62	2.33	.67
15-G1	not asked	not asked	not asked	not asked	5.97	2.21	not asked	not asked	not asked	not asked	6.22	2.25	1.88	.64	2.36	.71
15-A3	not asked	not asked	not asked	not asked	5.91	2.08	not asked	not asked	not asked	not asked	6.27	2.34	1.86	.69	2.44	.76
15-A1	6.24	2.37	5.44	2.20	6.02	2.31	6.12	2.04	6.14	2.14	6.13	1.98	1.88	.59	2.31	.70
15-G2	not asked	not asked	not asked	not asked	5.98	2.16	not asked	not asked	not asked	not asked	6.20	1.97	1.86	.61	2.33	.71
15-A3	not asked	not asked	not asked	not asked	5.93	1.98	not asked	not asked	not asked	not asked	6.30	2.00	1.84	.60	2.37	.77
15-A1	6.29	2.02	5.22	2.10	5.91	2.06	6.42	2.08	5.89	2.51	6.01	2.00	1.88	.59	2.42	.79
15-G3	not asked	not asked	not asked	not asked	5.93	2.27	not asked	not asked	not asked	not asked	6.01	1.99	1.87	.66	2.34	.74
15-A3	not asked	not asked	not asked	not asked	5.90	2.15	not asked	not asked	not asked	not asked	6.00	2.11	1.84	.72	2.37	.76
15-CG *	insufficient data (pool size 9)															

v: 1... yes, 2... neither, 3... no

Table 72.2: Characteristics of motivation in the second iteration

et cetera are insufficient. This correlates with observations of 'bulimia-learning', which has significantly increased after the Bologna Reforms of higher education in Europe. Bulimia-learning describes having to learn a lot of presumably useless material in short times, then 'puking' it into an exam without having learned anything on a long-term basis. Within that, material that has been hinted to be important for the exam was significantly more present in the 'puke' than other material. As this is an external influence due to educational surroundings, the investigated tools obviously have no impact on this 'puke motivation'. Nevertheless, the tools could foster a better understanding of the importance of some knowledge (for example algorithms), be it by direct recognition of the importance, or be it by a subliminal learning-by-doing effect.

The cross-motivation data validate the observations of the previous iteration, as well. Neither do readings motivate to attend tutorials, nor do tutorials motivate to attend readings. However, the previous assumption that readings and tutorials did not leave sufficient amount of unanswered aspects that invited to seek for answers in the respective other activity could be validated by simply asking the students. From eighteen randomly interviewed students, fourteen stated they were certain to pass the exam if they were to attend only one, readings or tutorials. Of those fourteen, two stated they attended the tutorials exclusively, at most only glancing at the lecture slides (available as a download) once in a while or during tutorials.

Notably, the results of the second iteration generally confirm the results of the first iteration. The interesting unanswered aspects of value and cross-motivation should be investigated in the future. Especially whether the bulimia-learning effect can be intelligently counteracted with modifications of the tools and their availability/scope. Hopefully, deviating cross-motivation data can be obtained from other courses, namely such in which readings and tutorials are synchronised in a way that knowledge required to pass the exam is only obtainable by attending both.

PART III APPRAISAL

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8 LESSONS LEARNED

'In life, there are no mistakes, only lessons.'

Vic Johnson



LESSONS LEARNED

Testing tools in actual on-site classroom settings such as tutorials should provide more realistic results than experiments conducted in laboratory conditions. However, on-site testing bears side effects that should be considered as they influence results. Independent of the nature of the results, they do have an impact on the scientific community and research that should be considered. Therefore, some lessons learned from the conducted on-site experiments shall be briefly discussed in this chapter.

The very first lesson to be learned is to apply actual corporate software lifecycle principles to the tools tested. If results born out of real utilisation are desired, the tools must be presented as a real ready-to-use software solution. Having tested tools that can be described as *early beta* or at best as *pre-RC*⁴⁷ (↪ [chapter 5](#)) one must clearly admit that the results are influenced by benevolent utilisation patterns (↪ Hawthorne effect [Ada84]). Students seem to have wanted to support a success story rather than a research failure. Had the tools been presented within a commercial product, students would probably have not been as forgiving with errors and bugs. Moreover, the quantity and quality of results would have been reduced in comparison. The results could have even degraded to a level at which no significant information could have been derived. However, as nice as it is to have results to work with, they do have an ambiguous connotation. It is uncertain whether the utilisation data is representative for release tools rather than researched/tested tools. Correspondingly, it is not confirmed whether motivational data are valid for different types of tool designs, as the tool versions investigated focussed more on functional aspects rather than user retention, for example by having optimised workflow or eye-candy GUI.

Anonymity is a driving force for student motivation. Students need to be able to hide in the mass. They have to be able to have their questions and problems addressed without being exposed to judgement by their peers or teachers. Special reasons of concern seem to lie in fears of any action that may be perceived negatively by teachers to affect the students' exam performance badly, that is teachers would down-grade them. However, anonymity must have well defined limitations, for example in order to eliminate sources of misconduct. The lesson to be learned here is that well conducted, not necessarily well defined, provision of anonymity increases students' willingness to act in their own best interest, for example utilising provided tools.

Very similar to the first lesson learned, the conduct of experimentation and interviewing was not optimal. In contrast to having on-site experiments, after-class questionnaires and interviews, as well as off-site interview sessions, it would have been beneficial to have also conducted some of the experiments under laboratory conditions – especially with defined tasks, for example following a certain workflow – in order to gain better understanding of the students' expectations and thoughts of the investigated tools. Additionally, this would have allowed conclusions on which aspects are applicable under which conditions, and when and what assumptions can be made for on-site activities based on controlled environment results. This is important if tools are to be developed to RTM/GA⁴⁷ state before ever being made available in on-site sessions to students. From this point of view, the conducted research was a very successful beta test, but no actually retainable lifecycle information for a future RC/RTM/GA⁴⁷ continuation that would make further alpha or beta testing obsolete are available.

As next lesson to be learned tool cross-dependencies emerged. Of course, most of the initial assumptions could be verified or extended, making it seem as if there has not been anything new to be learned by conducting these experiments. However, this point of view does not pay respect to the fact that some tools go well together while others impede each other. Likewise, the sheer number of tools available simultaneously influences their effectiveness. A very clear result to be recognised is the simple fact that it is better to concentrate on very few (maybe two) tools per tutorial unit and foster their benefits rather than providing a multitude of tools

⁴⁷ RC, RTM, and GA are abbreviations from the software release life cycle, which also contains familiar software states such as 'alpha' and 'beta'. Release Candidate; Release to Manufacturing; General Availability

unmanageable for students as well as teachers. The hard truth is obvious: while the tools' functionalities, workflows and designs were optimised with respect to their individual CIU fulfilment, their combined effect on CIU was not considered until actual testing commenced. As some tools are aimed at such distinct educational aspects, they are per design not combinable, but other tools that are seemingly well fitted for combined utilisation also suffered. In the second iteration of tests these cross-effects were attempted to be addressed by focussing on certain tools and testing their compatibility, promoting certain tools and having the combined tool tag along. Yet, this made a demand of prior CIU analysis even more obvious. If these experiments are to be repeated/extended/advanced in the future, a well constructed utilisation plan respecting the aims of the involved tools as well as CIU needs to be created prior to experiment conduct.

The ideal source for ideas and demands with respect to different learning scenarios are the involved parties themselves. Most of the investigated tools were considered out of the teacher's perspective and applicable student interests. A greater consideration of students' interests in tool selection would have been beneficial for both parties involved. For example, it was assumed that learning demand assessment would benefit students and would therefore be a worthwhile tool for them. However, in reality the students only acknowledged the tool's existence and did not actually utilise it frequently, as the focus of the provided tool did not meet student need. While the provided tool focussed on providing a confidence-based assessment on learning topics, students wanted a tool focussed on inspection and verification of understanding, namely a tool allowing independent off-site work on tasks similar to the ones discussed on-site. Of course, this is not what a didactics-familiar tutor would call an assessment of *learning demand*, but one of *learning progress* or *internalisation*. Basically, the students desired a training tool, not an assessment tool. The lesson to be learned here is that students should not only be allowed a right to a say in the matter of tool realisation, but also in the matter of tool selection. This is imperative when fostering self-regulated learning and educating young adults to be self-reliant; their opinions and values must be considered and appreciated. The so learned lesson seems to collide with the first lesson discussed earlier. This collision dissolves when envisaging a future in which tools are not objects of research but actually readily available solutions. If students select tools to be utilised with their teachers, a valuable extension to learning process supervision (→ [subsection 2.1.3](#)) with benefits for students and teachers can be envisaged.

Having investigated three different ways to make tools available to students, some valuable insight on tool provision could be gained. The simplest variant of simply providing a tool without any further promotion or explanation requires no additional introduction. This is useful as long as the considered tools are self-explanatory and their *raison d'être* is obvious to the students. Not only the nature of service, but also the benefits for the students with respect to learning success, exam preparation and/or success, or learning environment influence must be easily identifiable. For example, this is true for the investigated evaluation system. However, such tool provision may violate CIU. The next variant, namely introducing tools and providing a brief explanation of their functionality and benefits, addressed CIU issues and provides students with a better understanding of not only what tools are designed for and how and when to use them, but it also fosters an understanding of consequences and self-reliant decision making. This variant works best if combined with an integration of the pertained tools into the curriculum. That way, the tutor providing the introduction to the tools is better aware of the tools' effect on and within the tutorial. Benefits and influence on exams can also be better visualised in a so provided context. Finally, the last variant promotes tools: similar to 'app of the week' approaches in smartphone app stores, a 'tool of the week' is able to provide augmented promotion of the benefits of tool utilisation. However, this variant only works if a tool is the sole object of promotion, that is there is no in-parallel promotion of multiple tools. Additionally, the pertained tool must be well included in the tutorial unit's conduct. The hard lesson to be learned here is that this in general only works if the tool is required for a task, its utilisation being mandatory. Unfortunately, that violates the initial specification of having the tools only amend tutorials, being provided on a CIU-based and voluntary utilisation that allows tutorials to be successfully attended even if students opt not to utilise tools. Nonetheless, the benefit gained from promoted tools surmounts the benefits of tools made available under the two other variants. Therefore, this should be considered in future if the voluntariness of tool utilisation should be abandoned in certain learning scenarios for

the benefits of learning success. This however yields the problem of tool access, especially for students not possessing or unwilling/unable to bring their own second screen devices.

The influence of the conducting tutor on tools' acceptance and utilisation should not be underestimated. On one hand, while the tutor must be willing to adapt their conduct of the tutorials with respect to the tools to be utilised, the presentation of the tools and their benefits must positively reflect the tutor's own motivation to utilise. If the students realise that the tutor themselves only reluctantly includes certain tools in their tutorial, the students will probably not be well motivated to utilise the affected tools, either. On the other hand, the tools must match the overall tutorial fashion of the tutor. If the tutor is very textual, visual tools may seem misplaced and vice versa, or if they are a fast speaker and compress loads of information into short amounts of time, tools requiring too much attention (like the peer discussion system) are inept. This leads to the inconvenient lesson of incomparableness of tool acceptance and utilisation for different tutors. Only considering the bare data, general similarities (for example with respect to motivation) can be observed, but results deviate in the details. A better approach would have been to collect information on the tutors' fashion to conduct tutorials in order to classify the research results correctly. Thus, statements on tool suitability, utilisation and students' motivation should be re-evaluated in due consideration of different fashions of tutorial conduct.

A rather expected lesson is related to quality and reproducibility of research results. As is custom at universities, parts of doctorate research are 'outsourced' into undergraduate and graduate research theses. Of course, this can produce excellent research conducted by excellent students, but it can also lead to dead ends and unexpectedly bad results. Also, different students assigned with the same or similar task may produce different results. As aggregation of these bad and/or differing results into one valid result set is not always possible, part of the research work needs to be repeated by the doctorate candidate themselves, for example students sometimes require deadline extensions making on-time availability of required research results a futile effort. Thus, the lesson to be learned is –especially if one requires it to be conducted properly– to not out-source important research, but to do it oneself in the first place.

A lesson that should have been obvious and not learned is that all students are different. Duh! Nevertheless, even though ranting over bad or irreproducible results provided by students (previous lesson) may ease explaining of research deficits, sometimes results gained from student group A are inapplicable to student group B. Let all surrounding conditions be equal, even then the students' personalities and backgrounds differ. This should normally be addressed by adaptability of tools, which was considered to some extent during the conducted research. But, too much adaptability endangers comparability and consolidation of the individual students' result sets into one applicable research result set. For future reference, it may be worthwhile to consider the Pareto principle and address those twenty percent of the students and their effects that dominate eighty percent of the research results. That way, even with encouraged adaptability the research yield results that are applicable to the majority of the target group.

And finally, the hardest lesson to be learned: never ever attempt to implement educational tools 'on the fly'! It was a noble idea to allow students to provide feedback and ideas with respect to the to be implemented tools and then provide updated tools in a timely fashion. However, changing GUIs and workflows leads to derogatory effects, especially violating CIU principles as students must constantly relearn when and where to find what functionality. And stating the obvious at the very end, one is unable to fulfil everybody's expectations. If one promises timely adaptations of the tools based on feedback, the demotivating aspect of having feedback and ideas not implemented or even considered is poison for motivation. This affects not only tool acceptance and utilisation, but also the willingness to participate in questionnaires and interviews.

9 DISCUSSION

'In one case out of a hundred a point is excessively discussed because it is obscure; in the ninety-nine remaining it is obscure because it is excessively discussed.'

Edgar Allen Poe



DISCUSSION

After the conclusions on the very general level of lessons subjectively learned in the previous chapter, an objective approach to discussing the results must follow. For this, an outlook and a prospective impact for the educational community will be provided. The applicability of the results in other research fields as well as some thoughts on teaching psychology in particular will thereafter lead to some thoughts on Google Classroom and BPS Opal.

9.1 WORKING THESES' VALIDITY

Starting off the discussion, a review of the initial working theses shall be conducted. As a reminder, four theses (↪ Working Theses 1 through 4) were defined as a golden thread for the research conducted. Even though only superficially addressed in the presented research results, the working theses remained the driving force of the research. All four aspects, namely integration, transitivity, incidentalness, and anonymity could be investigated, providing valuable results.

The findings on virtual interactive whiteboard systems are very promising with respect to the integration hypothesis (↪ Working Thesis 1). Considering that on-site activities are conjunct with a real-time aspect of utilisation and results discussion, V-IWBs provide a significant benefit compared to online courses. Of course, online courses can include scheduled interactive human-to-human activities, but that eliminates the crucial point of such online courses, namely being able to learn whenever and wherever one wants to. If students are required to schedule interactive activities, the only benefit remaining is being location-independent. And this remaining benefit is precarious as the availability of the peer discussion system as a side channel to on-site activities fosters timely and content-correlated lines of thought and activities that are impossible in solitary, off-site and online scenarios. Nevertheless, with respect to the hypothesis itself verification as well as refutation are both possible. The ideal probably lies somewhere in between: the combination of on-site and off-site online activities assumably is beneficial for students. In the sense of distinguishing university courses from (free) online courses, this means that so designed university courses are able to provide a better controlled learning environment with a possibly increased chance of achieving qualifications. Considering these benefits, students may opt to pursue accountable university courses rather than unaccountable online courses, even though their liberties in university learning scenarios are reduced.

The research conducted shows a clear support of aspects of self-regulated learning as well as learning process supervision. Providing tools under consideration of cognisant incidental utilisation fosters autonomous and self-reliant decision making, especially about when and how to make use of the tools. This of course is the core of Working Thesis 2. On a meta-level, autonomous behaviour is also applicable to the focus of each individual tool. For example, the peer discussion system provides students with a means of discussing autonomously with their peers while still having the security of a supervision if needed. Considering peer instruction as an originator for a tutorial design providing the peer discussion system, it is obvious how easily peer instruction can actually be transferred into the online medium. The same is true for group learning activities, which are supported by all peer activities supporting tools, for example the virtual interactive whiteboard system, but also for solitarily utilisable tools such as the learning demand assessment system, which of course supports learning process supervision.

Cognisant incidental utilisation not only supports Working Thesis 2, but also Working Thesis 3, as the impact of tools – measured by their perceived benefit as well as exam success – increases with accumulated utilisation, which can only occur if students are able to identify the benefits of tool utilisation and are hence actually willing to make use of the provided tools more or less regularly. If the tools do not require too much attention and their utilisation is possible in parallel to the actual on-site activities of tutorials, utilisation barriers are significantly reduced. This of course

is the textbook constraint for feasible incidental utilisation. With respect to [Working Thesis 3](#) this means that a positive correlation is observable.

Finally, [Working Thesis 4](#) was an at least partially false hypothesis on anonymity. It appeared reasonable, especially considering the nature of the experimental environment (↪ [Appendix A](#)) in combination with claims of privacy concerns following Edward Snowden’s public disclosure of global surveillance programmes, which coincidentally occurred early near the start of the research presented within this dissertation. However, the experiments clearly provided evidence for the opposite. Students wish for retroactive de-anonymisation in order to attribute positive contributions to themselves. This makes sense in light of performance goals defined in self-regulated learning. It also supports the mastery concept, especially with aggregation of de-anonymised contributions within a user profile, adding up to a mastery claim based on repeated and positively appraised performance. A principle inspection of this aspect was assigned to an undergraduate student and is discussed in their elaboration [[Rup16](#)]. Nevertheless, anonymity allows students to ask questions they would normally not, for example questions they think of as being ‘stupid’. These types of questions may actually contribute to intensified platform utilisation; they could even be imperative.

The claims on verification of the working theses are summarised in [Table 9.1.1](#).

	hypothesis	verified
Working Thesis 1 (Integration)	Iff integrated into the curriculum, tools yield a unique feature to distinguish university courses from (free) online courses.	✓
Working Thesis 2 (Transitivity)	Encouragement of autonomy can be easily transferred into the online medium iff didactics concepts are preserved in tools selection and/or implementation.	✓
Working Thesis 3 (Incidentalness)	The impact of tool utilisation correlates with the feasibility of incidental tool utilisation.	✓
Working Thesis 4 (Anonymity)	While capability of anonymous tool utilisation provides additional incentive for <i>regular</i> tool utilisation by students, provision of anonymity is required for <i>intensified</i> tool utilisation.	✗

Table 9.1.1: Summary of the working theses’ verification results.

9.2 RESEARCH COMMUNITY: IMPACT AND OUTLOOK

The research conducted in real settings and the results gained therefrom strongly reflect the experimental and computer scientific origin of the undertaking. Improving the quality of the scientific contribution should be addressed in the near future, for example by conducting laboratory condition experiments, maybe extending tests to different learning scenarios, other degree programmes (even non-MINT), and more educational facilities. The presented results should be considered a basis for a solid starting point of further research. Its contribution is not of major significance that would lead to it dominating the field in the next years. For some researchers it may provide proof to some of their theories, for others it may be total rubbish that is still able to stand as a bad example for a wrong approach. Some may consider the result interesting/unexpected as they emerged from a ‘wrong’ assumption or foundation from their science’s point of view. Nevertheless, it provides a bridge to connect aspects of computer science with aspects of

didactics. It especially shows that existing concepts, technologies and solutions can be experimented on in new combinations thereof. Some didactical assumptions hold up, some do not; the same is true for computer science. Topical areas of research such as cognitive activation benefit of contributions from different research fields, for example audience response systems, which are also addressed within this dissertation. Other areas could prove to be accessible in the future by the systematic approach of computer science, such as *adaptive control of thought theories* (ACT; for example [Yat07]). Vice versa, IT tools can be significantly improved by applying models like ACT-R (for example [And07]), which is the theory of a cognitive architecture for simulating and understanding human cognition, especially focussed on how humans organise knowledge. It strives to be capable of performing a variety of cognitive tasks like human perception, thought, or action. Including such an approach into the user model of an IT system will definitely improve system performance and acceptance.

The very positive results for peer discussion systems and virtual interactive whiteboard systems are a valuable contribution to peer instruction research as they postulate future transfer of the didactical concept into off-site and online scenarios by applying existing IT concepts. The next required steps will definitely include investigations into the combinability of those two systems, for example a canvas-based discussion system. As a small contribution, a corresponding master thesis investigating this idea has been assigned prior to the submission of this dissertation.

Back-referencing the global picture (↪ [chapter 4](#)), the area of interest depicted in figures 4.1.1 and 4.1.2 was actually defined too narrowly. Research fields contributing to the area of interest outgo the mentioned computer science, educational psychology, and didactics. Didactics themselves are an intersection of various fields. Therefore, it would have been fair to include more aspects of these fields in the research scope. As this was not the case, it is fair to assume that the research conducted can be devolved into these contributing fields in reverse. Thus, the findings will foster kindled research within the area of interest itself and all contributing fields.

9.2.1 Significance to Learning Psychology

In general, research is subject to the conventions of its field. Of course, this is also true for psychological research. The way the findings of this dissertation were obtained contradicts the psychological approach to some extent. A loosely defined didactics model, the learner modelled as a system user, and functional descriptions of tools were put together in a type of product specification defining expectations toward a target system. Of course, this very experimental approach reflecting the first iteration of the software development cycle aimed at providing a starting point for future iterations of intensified repetition of similar experiments. However, such an approach is a nightmare to serious psychology. Before conducting experiments solid models have to be defined. The task of experiments is to validate/falsify theories, not the other way around where the evaluation of experiments leads to theories. To cut a long story short, the experiments conducted produced some findings born out of computer science that have some significance to learning psychology. The next step is to refine these findings into a proper psychological model, which in return will entail follow-up experiments. Ideally, a well defined psychological model of all aspects of the conducted research is conceivable. At the very least, learning psychology has a pool of findings that need to be discussed in the foreseeable future. This is even more true as research in the intersection of learning psychology and computer science has been conducted in the past, however mostly inspired from psychology's side. Now, research inspired from the other field has been conducted at that intersection, possibly yielding aspects based in computer science that have not yet been considered.

Similar considerations should be observed when extending to cognitive psychology. Within that, mental chronometry is a core paradigm of experimentation, making use of response time measurements to infer the content, duration, and especially temporal sequencing of cognition. Among other things, it aims at the mechanisms underlying cognitive processing. This could be taken advantage of by repeating the conducted experiments, however replacing the CIU aspects by chronometric aspects.

9.3 POSSIBLE EXTENSION OF EXISTING SOLUTIONS

The experiments and research results presented in this dissertation base on an independently developed prototype solution that included implementations of existing tools (with the exception of the emergency brake). However, it would be interesting to know if and how these findings are applicable to other existing platform solutions, for example BPS OPAL or the earlier introduced Google Classroom (↪ [section 3.5](#)).

BPS OLAT is a centralised learning platform distributed by Bildungsportal Sachsen GmbH (BPS), where OPAL (Online Platform for Academic Learning) is an OLAT derivative used by Saxonian universities, including TU Dresden. The OPAL platform is a commercial product whose developers regularly implement additional features or update existing ones. It includes⁴⁸ subsystems for material management, discussion forum, mark evaluation, mathematic and chemical formulas, test versioning, real-time collaboration (Adobe Connect), and many more. Courses can be easily created from templates. Looking at the tools investigated within this dissertation, OPAL is also able to provide ARS functionality for readings with external plugins, for example there is an in-use implementation at TU Bergakademie Freiberg. OPAL's feedback system allows for a limited degree of per-course evaluation. The discussion system included in OPAL is not designed for parallel utilisation, especially not for peer instruction settings or during other on-site activities such as tutorials. OPAL does not include any LDA functionality. However, OPAL can be extended to provide e-assessment with the ONYX system (also from BPS), providing a starting point for LDA. Finally, OPAL does not provide any type of V-IWB capable of shared bulletin operation. OPAL's factory-standard set of functionalities could be amended/extended based on the results presented within this dissertation. The results may aid BPS' software development process in

- making readings *and tutorials* easier accessible to an OPAL-based ARS,
- allowing evaluations on time-bases ranging anywhere from *per-unit* to *semestral*,
- supporting actual peer instruction peer discussions via a discussion system capable of real-time, on-site and in-parallel discussions,
- providing peer instruction ConcepTest via BPS' ONYX system,
- supporting students in their learning demand assessment, and
- enabling canvas-based on-site and off-site learning activities by provision of V-IWB operating as shared bulletins.

The consideration of the results within the requirements analysis and design phases of the software development process should be fairly simple. Merely the support of second screen devices could be challenging within OPAL.

As mentioned in [section 3.5](#), Google Classroom is a platform striving for paper-less classrooms. The currently provided functionality⁴⁸ allows for absolute paper-less conduct of school teaching. It was also successfully deployed at U. S. colleges, therefore university tutorials should also be accessible. However, Google Classroom has yet proven to be in support of peer instruction. Intuitively, this should not be a problem, but restrictions apply that can be addressed by the results of this dissertation. Reproducible real-time discussions are possible with the current functionality, however limitations for certain scenarios such as brainstorming are currently impossible. Also, canvas-based activities are currently only supported by sharing of images or by utilising the very limited drawing tools of Google Docs; these are hardly V-IWB shared bulletins. At the moment, the evaluative aspect is a one-way road from the teacher to the students, that is assessment. Students are unable to provide evaluative feedback or otherwise influence their learning setting within the platform. Thus, if not fully-fledged ARS functionality, at least an evaluation tool should be provided. Finally, the learning demand assessment relies absolutely on the teachers' assessments of the students' learning progress. Self-regulated learning is not fostered. The findings presented within this dissertation could be utilised for a simplified and accelerated improvement of Google Classroom. This is even more true in this case as Google's solution well-nigh obtrudes second screen utilisation.

⁴⁸ The described limitations apply as of 4 January 2016.

10 CONCLUSION

'It's more fun to arrive a conclusion than to justify it.'

Malcolm Forbes



CONCLUSION

Addressing low attendance and the high drop-out rate among the ever increasing number of university freshmen, the impact of existing concepts and tools for tech-enhanced education was investigated in several experiments. The goal was to increase motivation to attend on-site courses, namely tutorials, and foster understanding of the importance of fundamental classes, making on-site activities more attractive.

Oriented along a set of important visible learning effects experiments were conducted in order to analyse the impact of tools for audience responses, emergency braking, evaluations, assessment of learning demands, peer discussions, and (virtual) interactive whiteboards. All tools were investigated under the consideration of cognisant incidental utilisation and an initial assumption of necessary anonymity. The tool selection represents a cross-section of established IT solutions with topical didactics research and concepts, namely learning process supervision, peer instruction, and self-regulated learning. As the tools were designed to maximise consideration of cognisant incidental utilisation, provision via second screen was pursued in order to minimise potential negative influences on their learning performance.

The chosen tools can be organised in three classes: tech-enhanced, anonymous peer discussion, anonymous control facilities, and learning demand assessment. The first includes any type of tool allowing students to interact with their peers during class. The second allows students to influence their learning environment. Finally, learning demand assessment supports students in self-assessment for their self-regulated learning.

In two consecutive instalments of a 'computer networks' course the three classes of tools were investigated by providing platform prototypes utilisable via second screen devices. As most second screen devices provide access to the Internet, a client/server architecture prototype platform was implemented in order to facilitate the chosen tools. Additionally, this takes advantage of the fact that most students use their mobile devices in class to access services provided over the Internet. Clients can be either web applications within a browser, or native apps implemented for the mobile devices' operating systems; the implemented prototype covers web applications. The entire system is utilisable anonymously; students are only required to generate a freely selectable pseudonym and a password.

10.1 SUMMARY OF SCIENTIFIC CONTRIBUTIONS

The audience response system and its 'emergency brake' specialisation showed clear limits for cognisant incidental utilisation as well as time correlation of feedback. Fully-fledged ARS are unsuitable for tutorials; emergency brake systems could be identified to be well better suited. In combination with pre-defined textual reasons as well as individually assignable free-text reasons, the emergency brake was well accepted by the students. Allowing automated creation of justifying new topics in the peer discussion system enables students to immediately discuss the validity of the emergency brake's utilisation among their peers.

The evaluation tool allows to span the bridge between immediate (real time) feedback and single end-of-semester pen-and-paper evaluation sheets that provide feedback at a too late time. This gap cannot be filled with audience response systems and emergency brakes as these are only able to address a limited range of quality aspects and are bound to close temporal correlation. The evaluation system allows provision of prompt feedback on a variety of quality dimensions to the tutor and benefited both sides, especially as students perceived their evaluator feedback to lead to adaptations in tutorial conduct.

The learning demand assessment tool based on targeted confidence questions on the tutorials' tasks before and after each tutorial unit. From the difference in confidence and in correlation with related topics, the tool was able to calculate a learning demand assessment for each student. This way, they were supposed to be able to receive a suggested topic learning repetition sequence at any time, especially near the end of the semester, thus optimising their learning efforts for exam preparations. However, no significant utilisation occurred, clearly pointing out that the investigated design is unsuitable and should not be considered in future research.

The peer discussion system closely follows the concepts of knowledge exchange hubs, including topics, questions, answers, comments, votes, and 'helpful' markers. The tool was well received by students and proved utilisable in two distinct settings: as a peer discussion means for anonymous discussion during the discussion phase of peer instruction, and in tutorials with low activating interaction between the tutor and the students. Six different combinations of availability settings ranging from general availability through brainstorming to topic-centric were investigated.

The virtual interactive whiteboard is the transferring of the classic interactive whiteboard into the online medium. It allows for all students to contribute to canvas-based knowledge exchange. Selected contributions, for example particularly bad or good ones, can be shared with the entire group of students. Good content-oriented, visually guided discussions can develop on that basis. The virtual interactive whiteboard system is also capable to support single- and dual-phase brainstorming sessions.

The experiments with the before-mentioned tools show that it is very important to define very clear and strict utilisation rules for the students. Even a slight unclearness immediately leads to violations of cognisant incidental utilisation, and that in return to reduced tool utilisation or significantly reduced learning success.

The tools investigated for tech-enhanced, anonymous peer discussion proved to be very successful in raising exam success. Solid evidence could be gained for peer discussion tools to be very useful in low interactivity settings. Further findings provide evidence for peer discussion tools allowing highly skilled students to reduce their idle time. Similar evidence could be found for the virtual interactive whiteboard, which is very useful for graphic-reliant tasks.

Strong evidence showing that both ends of feedback solutions must be served in anonymous control facilities: first, a strongly time-correlated (almost immediate) issue indication, and second, a time-decoupled unit-level evaluative feedback means. The first end clearly showed the limits of audience response systems in context of tutorials and the resulting demand for a reduced emergency brake tool. For the second end, it could be verified that an issue indicator is not sufficient for the students to point out all issues that may arise, re-confirming the demand for fully-fledged evaluation tools.

The positive results for tech-enhanced, anonymous peer discussion and anonymous control facility tools are only achievable under clear definition of utilisation rules, strict enforcement of the defined rules, as well as corresponding tutorial conduct. Any deviation results in directly measurable negative influences. In this sense, not only the students are required to carefully utilise tools (under cognisant incidental utilisation), but also the tutors are required to observe the defined rules and react to feedback.

10.2 FUTURE WORK

As the findings show that the research conducted only scratched the tip of the iceberg and is far from being finished, the next unfolding steps should be briefly discussed.

Following the argumentation provided in the previous chapter, it should be obvious that the experiments conducted should be analysed or repeated in the other fields involved in the area of interest (→ figures 4 and 4.1.2). Within computer science, it should be investigated how combined tools perform under the same or similar scenarios, namely a combined tool for discussions and graphical contributions should be considered. The assertion is that PDS and V-IWB can be combined into a single tool by making use of current HTML 5 technology. A master student has started their research into this concept, but results will not be available until after the time this dissertation has been submitted. Similar deliberation is true for preset combinations of tools.

Tool-supported learning demand assessment remains an important contribution to self-regulated learning and learning process supervision. However, further investigation into its mechanics and user dynamics is required in order to provide educated statements on its feasibility for and overall influence on platform acceptance and utilisation.

Transferability of the findings into other types of well established on-site and off-site activities, for example laboratory or placement, should be investigated. Additionally, feasibility of tool utilisation in promising modern approaches such as studios (for example [Bro05]) should be investigated. Furthermore, provision of all types of activities out of one platform is required in order to unify and further enhance the user experience.

Continued investigations into the retroactive revocation of anonymisation as desired by students should be conducted. The concepts of privacy, online personas and identifiability have been under investigation for a few years now, but are still new in context of tech-enhanced learning [Rup16]. As for the combined PDS/V-IWB tool, a master student has started their research into this concept, but once again the results will not be available until after the time this dissertation has been submitted. Impartial of the receivable result, the system design outline is extensible to pay respect to the concept. Having an anonymity and de-anonymisation concept integrated into the system design allows intensified research into the above mentioned LDA related research tasks, however extended by e-assessment tools, which have not been considered within this dissertation. The structure of the extension is depicted in Figure 10.2.1 (→ next page).

The complex of problems associated with the peer discussion system requires continued intensive investigation. The open question of varying group sizes and potentially mandatory automated group splits during peer discussion phases demands conclusive investigation. Further, suitability of PDS for single- as well dual-phase brainstorming needs to be proven.

As a final remark, it should be noted that didactics research driven by IT interests seems to become suitable for mainstream product development. On 11 January 2016, roughly three months after all bases of this dissertation were declared final and only two days before submitting the first dissertation revision to the reviewers, Apple Incorporated announced their commercial product *Apple Education* as part of their latest operating system update (iOS 9.3).

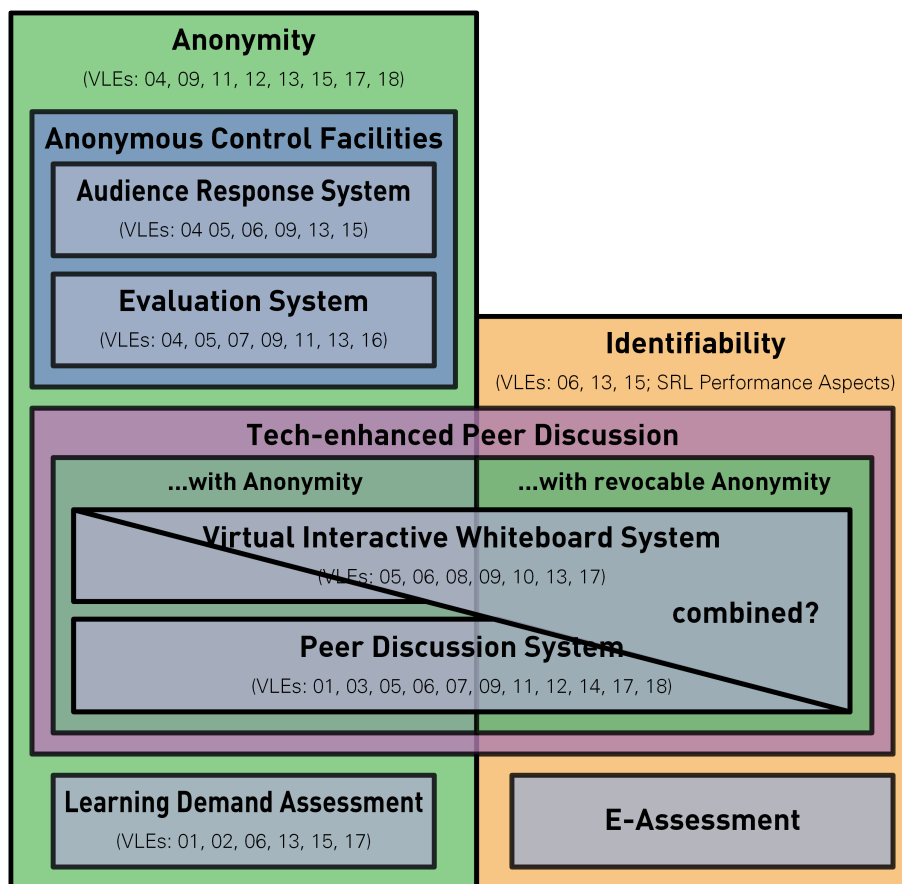


Figure 10.2.1: Possible further extension of the discussion and control design. Added components are learning demand assessment on the side of anonymity, and general e-assessment on the side of identifiability. – It is yet to be determined whether the peer discussion system and the virtual interactive whiteboard system are combinable.

PART IV APPENDIX

「理由は百年にブリッジをするためにどのような取り到するための一夜の信仰の翼を取るだけ。」

神のメモ - アリス



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A EXPERIMENTAL ARRANGEMENT

Based on a preliminary appraisal of the insights gained in chapters 2 and 3, some assertions can be readily derived. This is exactly what happened early during the investigations at the basis of this dissertation. In consequence, an iterative process of assertions, validation experiments, and conclusions was conducted. Based on the initial assertions (scattered throughout the investigated tools in \leadsto chapter 5), two experimental prototypes for verification by testing and appraisal were implemented in the summer of 2014. Based on the experimental results revised assertions were conceived in 2014, which in return led to the implementation of a third prototype in the summer of 2015. The experimental results of 2015 allowed conceiving further revisions to the assertions. Finally, those second revision assertions formed a strong foundation for the concept presented in part II. Of course, the concept could have been derived from the preliminary appraisal directly, but the confidence in the conceptual outline is significantly higher as it is based on actual experimental foundations rather than only related work applied in differing settings.

For better verifiability, the foundation of the experimental setups shall be briefly described before attending to the assertions. All experiments were conducted in the tutorials of the *computer networks*⁴⁹ course at TU Dresden in the summer semesters of 2014 and 2015. The same is true for the verification experiments that were presented in part II. The course is part of the regular curriculum of the computer science, media computer science, information and systems technology, and *wirtschaftsinformatik*⁵⁰ bachelor and diploma programmes, as well as teaching degree programmes with computer science modules, and is only conducted in the summer semester. In the winter semester only a resit exam is offered. The course language is German and it only consists of readings and tutorials, no placements or term papers. With a limited set of exceptions, students attend the course in the fourth or sixth semester of their degree programme. The readings and tutorials are conducted on a weekly basis in twelve ninety-minute units. Due to the amount of students and the desire to have tutorials not serving more than thirty students per instalment, a single weekly reading serving all students attending the course is accompanied by eight or more tutorial instalments each week. Students are required to enrol in instalments and should attend the same instalment every week, but they are at liberty to attend alternative instalments below capacity limit⁵¹. Typically, the summer semester at TU Dresden has a lecture period of fourteen or fifteen weeks (lecturing weeks) with the readings starting in the first lecturing week and the tutorials commencing in the second or third. For the computer networks course

⁴⁹ Its original German title is 'Rechnernetze'.

⁵⁰ 'Wirtschaftsinformatik' is a German word, best translated to 'economy computer science'. However, it is an English noun; the situation is similar to 'kindergarten' or 'schadenfreude'.

⁵¹ It should be noted that some instalments have *more than* thirty students attending. It is at the tutor's discretion to decide whether the tutorial can be reasonably conducted, or not. The right of owner or occupier of premises to undisturbed possession allows tutors to dismiss students not enrolled.

readings as well as tutorials are organised into twelve units on defined topics. Due to public holidays and social events during the semester the tutorials may be halted for a week – even though a unit could take place – in order to keep the multiple tutorial instalments synchronous (that is, covering the same unit in the same week). Additionally, by halting the tutorials are prevented from overtaking the readings so that topic knowledge is always presented *before* it is trained and consolidated. Typically, Wednesdays, Thursdays and Fridays are prone for public holidays and social events, hence tutorials – especially those on Mondays or Tuesdays – may skip a week in order not to hurry ahead of the ones directly affected by the public holiday or social event. Alternatively, facultative consultations can be scheduled instead of regular tutorials. In the past years, computer networks readings have been scheduled to conduct on Thursdays, hence the reading is also affected by outage. Considering all halting and outages, tutorials on topics are scheduled one week, at most two weeks, after the reading the topics were presented in. Thus, readings conclude in the antepenultimate or penultimate lecturing week, while tutorials conclude in the last lecturing week.

The tutorials themselves are conducted in lecture rooms accommodating a maximum of twenty-five to thirty-two students, depending on layout and age of the lecture room. In rare cases tutorials are conducted in art rooms or lecture halls. Those exceptions were intentionally excluded from the experiments in order to guarantee best possible comparability. Exemplary lecture rooms are outlined in [Figure A.0.1](#) and [Figure A.0.2](#).



Figure A.0.1: Example of a modern lecture room layout. Parallel utilisation of OHP and blackboard or LCD projector is possible. The tutor can utilise the computer in the lectern, or bring their own laptop computer, or even use both to separate presentation and feedback.

The lecture rooms provide shared tables for two or three students that are aligned in parallel, facing the blackboard. Normally, there are only few power points, mainly to supply OHPs. Unless a distribution socket is brought by a student, only the teacher and four to six students (depending on the room) have access to electrical power. Except for countable few lecture rooms – which were all excluded from the experiments –, all lecture rooms provide access to properly dimensioned campus WLAN. All lecture rooms are equipped with blackboards and OHPs, but only lecture rooms mainly utilised for MINT courses provide LCD projectors. Experiments were carried out in lecture rooms with and without LCD projectors. However, it should be noted that lecture rooms without an LCD projector demanded the tutor to either not utilise tools demanding presentation of computer generated content to the group of students, or to employ a special OHP bonnet in order to utilise the OHP like an LCD projector. It should be noted that the OHP bonnet provided a significantly worse image due to lower resolution and brightness issues; nevertheless, it was sufficient for comparable results.

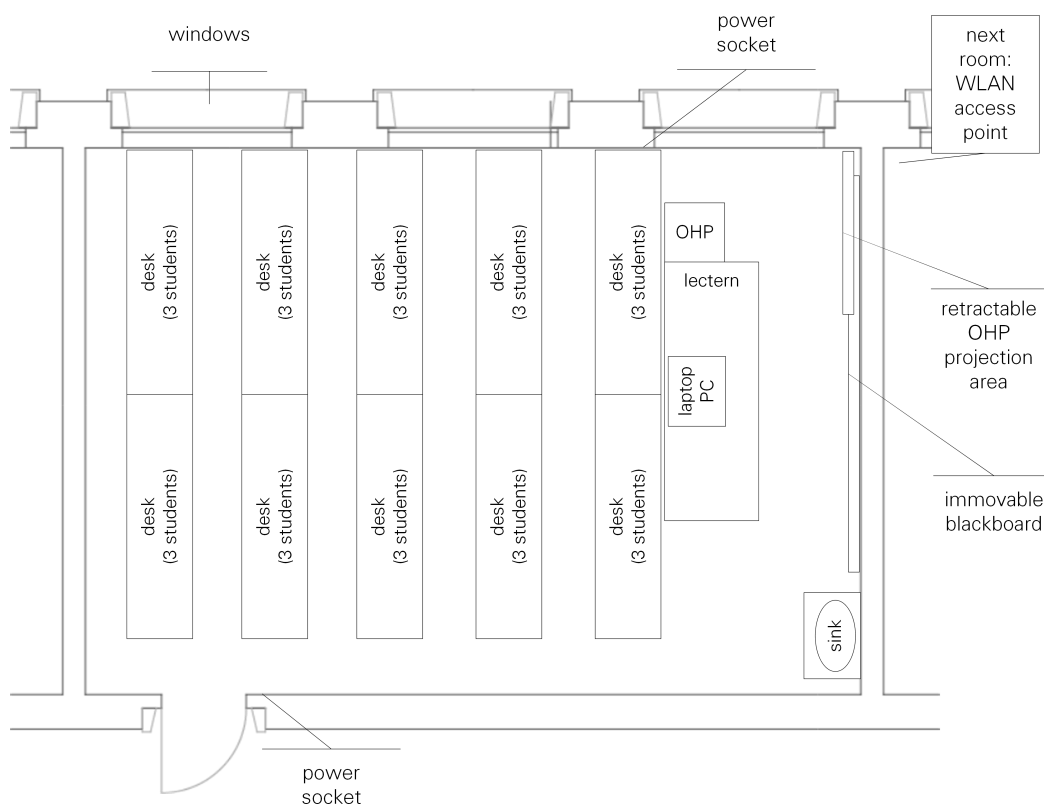


Figure A.0.2: Example of a dated lecture room layout. Parallel utilisation of OHP and blackboard is limited. An LCD projector is not available, which is why a special OHP fixture is required to project material generated on a computer. The tutor can only bring their own laptop computer, which needs to display presentation and feedback.

Tutorials are not compulsory, so students are free to attend or absent. Also, students are neither required nor forced to attend through the entirety of tutorials; they may appear delayed or leave prematurely. The only requirement is for students not to disturb the tutor or fellow students.

The students attending the tutorials are comprised of roughly the same mix every year. W.l.o.g., information ascertained with a paper questionnaire (↪ subsection B.3.1) in June 2013 ($n = 80$) can be considered valid for the student group composition. The uncertainty due to yearly fluctuations can be considered a negligible error as the fiducial error due to students handing in incomplete or blank forms has a larger impact. Nevertheless, in light of reproducible results surveyed in

June 2014 ($n = 76$), April 2015 ($n = 95$) and June 2015 ($n = 68$), the results can be considered representative for the group of students attending computer networks tutorials. –For all of the following data it should be noted that they are derived from non-blank information only. For example, from the eighty forms handed in in 2013, only seventy-eight contained information on the participating students’ gender.

The average student (\leadsto [Table A.0.3](#)) attending the tutorials is a 20.6 years old male enrolled at TU Dresden and attends the course for the first time. Roughly two thirds of the students attend because they consider it a required course. A slightly larger group considered the presented, exercised and consolidated material to be relevant for successfully passing the exam. Only a quarter of the students stated to be actually interested in the material. Additionally, the two questionnaires in 2015 show that attendance decreases slightly over the semester, raising the percentage of students attending due to exam compulsion and interest. It could not be proven beyond reasonable doubt whether perceived interest and exam compulsion are correlated, or not.

parameter	2013/06		2014/06		2015/04		2015/06	
	$\bar{X}^{13 6}$	$\sigma_X^{13 6}$	$\bar{X}^{14 6}$	$\sigma_X^{14 6}$	$\bar{X}^{15 4}$	$\sigma_X^{15 4}$	$\bar{X}^{15 5}$	$\sigma_X^{15 6}$
age	20.6	2.26	20.5	2.23	20.6	2.27	20.4	2.29
gender*	.93	n/a	.92	n/a	.88	n/a	.86	n/a
affiliation [Ⓟ]	.06	n/a	.03	n/a	.02	n/a	.01	n/a
iteration [Ⓣ]	1.16	.42	1.14	.37	1.21	.48	1.19	.44
mandatory [∇]	.36	n/a	.33	n/a	.31	n/a	.31	n/a
exam [∇]	.32	n/a	.29	n/a	.30	n/a	.26	n/a
interest [∇]	.75	n/a	.78	n/a	.73	n/a	.72	n/a

*: 0... female, 1... male Ⓟ: 0... TU Dresden, 1... other
[Ⓣ]: 1... first, 2... second, 3... third or more ∇: 0... yes, 1... no

Table A.0.3: Composition of the student group over the considered setup

The questionnaires also asked the students to express their motivation to attend readings and tutorials on a scale from ‘very poor’ (0) to ‘very good’ (9) for the time before and after the first reading and tutorial, and at the time of the questionnaire. Motivation seems (\leadsto [Table A.0.4](#)) indifferent with a slight positive tendency, but a demotivational trend can be observed for the time around the first reading and tutorial as well as over the course of the semester. Additionally, the students were asked whether the readings motivate to attend the tutorials and vice versa.

motivation	2013/06		2014/06		2015/04		2015/06	
	$\bar{X}^{13 6}$	$\sigma_X^{13 6}$	$\bar{X}^{14 6}$	$\sigma_X^{14 6}$	$\bar{X}^{15 4}$	$\sigma_X^{15 4}$	$\bar{X}^{15 5}$	$\sigma_X^{15 6}$
before first reading	6.41	2.11	6.44	2.29	6.36	2.07	not asked	
after first reading	5.15	2.01	5.22	2.22	5.43	2.11	not asked	
current reading	4.55	1.93	\leadsto Table 7.2.1		\leadsto Table 7.2.2			
before first tutorial	6.35	1.92	6.30	2.01	6.39	1.99	not asked	
after first tutorial	5.66	2.03	5.77	2.14	6.01	2.33	not asked	
current tutorial	5.63	2.20	\leadsto Table 7.2.1		\leadsto Table 7.2.2			
reading \rightarrow [∇] tutorial	1.85	.69	\leadsto Table 7.2.1		\leadsto Table 7.2.2			
tutorial \rightarrow [∇] reading	2.10	.77	\leadsto Table 7.2.1		\leadsto Table 7.2.2			

∇: 1... yes, 2... neither, 3... no

Table A.0.4: Motivation to attend readings and tutorials over time, as well as cross-motivation from reading to tutorial and vice versa.

For the summer semester of 2013 the learning material for the readings as well as tutorials was completely revised. Apart from error corrections the material remained unchanged for all three years of experimentation. In [Table A.0.5](#) all topics of the computer networks course are listed with respect to possible types of student contribution. The abbreviations within the table shall remain unexplained as they are impertinent to the matter; the important information is, there are seventy-six possibilities to contribute diagrams, forty-three of them UML diagrams. This suggests graphical feedback possibilities to be valuable.

In 2014 the tutorials had to be curtailed in order to be realisable in only eleven units; unfavourable distribution of public holidays and social events did not allow conduct of twelve units. For this reason, selected topics from distributed systems (WebDAV) and mobile computing (DHCP, GSM) were excluded from the compulsory curriculum and were also excluded from the final exam. The impact of this one-time exclusion on comparability of results should be negligible, especially as tutorial units eleven and twelve did not show significantly different results compared to the other units considered. The same considerations need to be respected for the early tutorial units one to three. Within those the prototypes were either not utilised in order for the students to get accustomed to the learning environment, or the results significantly deviated due to it being a familiarisation phase during which the students had to learn how to use the prototypes. Respecting both ends of questionable results, all experimental results to be considered must be derived from units four to ten. Investigations into the initial familiarisation phase as well as the influence of the 2014 curtailing are explicitly excluded from the scope of the conducted experiments, and all results therefrom are excluded from consideration, too. The so described setup allows for control group testing, making experimental findings reliable and comparable.

unit	task topic	diagram					check & supplement		analyse		prose
		topology	UML		other	formula	table	DIY example	wireshark trace		
			sequence	state	schema	graph					
U01 ↙	computer network structures	•					•	•			
	services and protocols		•		•			•		•	
	service elements		•	•				•			
	OSI reference architecture		•		•		•				
U02 ↙	Nyquist Theorem						•				
	PCM				•		•				
	modulation				•			•			
	line encoding				•		•			•	
	multiplexing				•		•	•		•	
U03 ↙	Ethernet	•	•		•		•				
	switches	•					•				
	transparent bridges	•			•					•	
	Wireless LAN						•				
U04 ↙	WiMAX							•		•	
	RPR	•									
	Carrier Ethernet	•			•					•	
	MPLS	•			•			•			
	SONET/SDH and OTN				•		•				
	VPN	•		•					•	•	

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unit	task topic	diagram					check & supplement		analyse		prose
		topology	UML sequence	state	schema	other graph	formula	table	DIY example	wireshark trace	
U05 ↪	frame alignment				•			•			•
	ECC				•		•	•			
	parity bit				•			•			
	CRC		•				•				
	Stop-and-Wait Protocol		•		•						•
U06 ↪	Shortest Path Routing	•				•		•			
	IP frames				•					•	•
	IP addresses and subnets	•			•		•				
	routing	•	•		•			•			
	overload control		•		•						•
U07 ↪	service instances: QoS		•								
	Sliding Window Protocol		•		•			•			
	TCP		•	•				•		•	
	protocol comparison							•			
U08 ↪	Ethernet performance				•		•	•			
	fairness		•								•
	overload monitoring				•		•	•			
	performance increase				•		•				
	DTN	•			•						
U09 ↪	DNS	•			•			•			•
	E-Mail										•
	WWW				•					•	•
	SNMP		•					•			
	interaction of UDP, TCP, HTTP and DNS		•		•			•			
U10 ↪	Encoding				•		•	•			
	VoIP	•			•			•			•
	RTP				•					•	
	VoIP codecs		•		•		•				
	video conference systems	•					•				
U11 ↪	RPC	•	•								•
	distributed transactions	•	•	•							•
	Web Services									•	•

continued on next page ↪

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unit	task topic	diagram					check & supplement		analyse		prose
		topology	UML sequence	state	schema	other graph	formula	table	DIY example	wireshark trace	
	WebDAV		•						•		
← U12	mobile communication networks				•					•	
	DHCP		•	•				•		•	
	Mobile IP	•	•		•			•			
	sum	18	20	5	32	1	20	24	1	6	21
	share	.327	.364	.091	.582	.018	.364	.436	.018	.109	.382

76 diagrams,
therein 43 UML (56.6%)

Table A.0.5: Comprehensive list of task topics in the computer networks tutorials at TU Dresden with indication of possible types of student submissions.

B QUESTIONNAIRES

B.1 PLATFORM FEEDBACK SHEET

The platform feedback sheet (PFS) was an A4-sized feedback sheet similar to a blitz survey utilising a five-step Likert scale ranging from ‘-’ (‘totally disagree’; numerical 1) to ‘+++’ (‘absolutely agree’; numerical 5) for answers. Note that item twelve to fourteen were added to the PFS in the second iteration of experiments.

- PFS-Q01: The learning demand assessment tool will help my exam preparations.
- PFS-Q02: The learning demand assessment tool helps me assess my learning progress.
- PFS-Q03: The [2014: real-time feedback system; 2015: emergency brake] positively contributes to the tutorial.
- PFS-Q04: The tutor reacted appreciably to [2014: real-time feedback; 2015: stop requests].
- PFS-Q05: The tutor reacts to [2014: real-time feedback; 2015: stop requests] in the expected manner.
- PFS-Q06: Real-time feedback can be submitted intuitively during the tutorial.
- PFS-Q07: The [2014: Q&A; 2015: discussion] system positively contributes to the tutorial.
- PFS-Q08: The [2014: Q&A; 2015: discussion] system allows me to ask questions I would normally withhold.
- PFS-Q08a: The [2014: Q&A; 2015: discussion] system makes answers accessible I would normally not receive.
- PFS-Q09: The [2014: Q&A; 2015: discussion] system disturbs the tutorial.
- PFS-Q10: The whiteboard system positively contributes to the tutorial.
- PFS-Q11: The whiteboard system helps me better understand the material.
- PFS-Q12: [2015: The evaluation system positively contributes to the tutorial.]
- PFS-Q13: [2015: The tutor reacts to the evaluation in the expected manner.]
- PFS-Q14: [2015: The evaluation system allows me to emend the tutorials.]

The original German versions of the PFS are provided in the following two subsections.

B.1.1 Original PFS in 2014

Plattform-Feedback

Vielen Dank, dass Du Dir die Zeit nimmst, Dein wertvolles Feedback zur Plattform zu geben. Bitte gib an, wie sehr Du den folgenden Aussagen zustimmst, wobei -- „ich widerspreche absolut“ und ++ „ich stimme voll zu“ entspricht; 0 drückt eine neutrale Meinung aus. Solltest Du Aussagen nicht verstehen oder keine Angaben dazu machen wollen, überspringe sie einfach.

Das heutige Datum ist: . . 2 0 1

		--	-	0	+	++
1.	Die Lernbedarfsermittlung hilft mir bei der Klausurvorbereitung.					
2.	Die Lernbedarfsermittlung hilft mir, meinen Lernfortschritt zu überprüfen.					
3.	Das Echtzeit-Feedback wirkt sich positiv auf die Übungen aus.					
4.	Der Tutor reagiert merkbar auf Echtzeit-Feedback.					
5.	Der Tutor reagiert wie erwartet auf Echtzeit-Feedback.					
6.	Echtzeit-Feedback lässt sich intuitiv während der Übung geben.					
7.	Das Q&A-System wirkt sich positive auf die Übungen aus.					
8.	Das Q&A-System erlaubt Fragen zu stellen, die ich sonst in Übungen nicht stellen kann/möchte/darf.					
8a.	Das Q&A-System gibt mir Zugriff auf Antworten, die mir in Übungen sonst unzugänglich sind.					
9.	Das Q&A-System stört den Übungsablauf.					
10.	Das Whiteboard-System wirkt sich positiv auf die Übungen aus.					
11.	Das Whiteboard-System hilft mir, den Stoff besser zu verstehen.					

Bitte lass diesen Fragebogen einfach an Deinem Sitzplatz liegen oder lege ihn auf das Pult sobald Du den Raum verlässt. Solltest Du den Fragebogen zu Hause ausfüllen wollen, lege den ausgefüllten Fragebogen einfach vor oder nach der nächsten Übung auf das Pult.

B.1.2 Original PFS in 2015

Plattform-Feedback

Vielen Dank, dass Du Dir die Zeit nimmst, Dein wertvolles Feedback zur Plattform zu geben. Bitte gib an, wie sehr Du den folgenden Aussagen zustimmst, wobei -- „ich widerspreche absolut“ und ++ „ich stimme voll zu“ entspricht; 0 drückt eine neutrale Meinung aus. Solltest Du Aussagen nicht verstehen oder keine Angaben dazu machen wollen, überspringe sie einfach.

Das heutige Datum ist: . . 2 0 1 5

		--	-	0	+	++
1.	Die Lernbedarfsermittlung hilft mir bei der Klausurvorbereitung.					
2.	Die Lernbedarfsermittlung hilft mir, meinen Lernfortschritt zu überprüfen.					
3.	Die Notbremse wirkt sich positiv auf die Übungen aus.					
4.	Der Tutor reagiert merkbar auf Notbremsungen.					
5.	Der Tutor reagiert wie erwartet auf Notbremsungen.					
6.	Die Notbremse lässt sich intuitiv während der Übung auslösen.					
7.	Das Diskussionssystem wirkt sich positive auf die Übungen aus.					
8.	Das Diskussionssystem erlaubt Fragen zu stellen, die ich sonst in Übungen nicht stellen kann/möchte/darf.					
8a.	Das Diskussionssystem gibt mir Zugriff auf Antworten, die mir in Übungen sonst unzugänglich sind.					
9.	Das Diskussionssystem stört den Übungsablauf.					
10.	Das Whiteboard-System wirkt sich positiv auf die Übungen aus.					
11.	Das Whiteboard-System hilft mir, den Stoff besser zu verstehen.					
12.	Das Evaluationssystem wirkt sich positiv auf die Übungen aus.					
13.	Der Tutor reagiert angemessen auf die Evaluation.					
14.	Das Evaluationssystem ermöglicht mir, die Übungen zu verbessern.					

Bitte lass diesen Fragebogen einfach an Deinem Sitzplatz liegen oder lege ihn auf das Pult sobald Du den Raum verlässt. Solltest Du den Fragebogen zu Hause ausfüllen wollen, lege den ausgefüllten Fragebogen einfach vor oder nach der nächsten Übung auf das Pult.

B.2 MINUTE PAPER

The minute paper utilised was an A5-sized feedback sheet containing four areas for feedback. The original minute paper was in German, so a translation correct with regard to content is provided here. All questions correspond to the title of the minute paper, 'Today's Tutorial', hence all questions should be visualised in context of 'today's tutorial'.

- What did you like or dislike?
- What did you miss?
- Any thoughts on the learning platform?
- Anything else you wish to share?

Die heutige Übung

Bitte nimm Dir eine Minute, um dieses Blatt auszufüllen. Es reichen ein oder zwei Sätze pro Frage. Die Abgabe ist freiwillig; lass es einfach ausgefüllt oder leer an Deinem Sitzplatz liegen. – Dankeschön!

Das heutige Datum ist: . . 2 0 1

Was hat Dir gefallen oder nicht gefallen?

Was hast Du vermisst?

Irgendwelche Gedanken zu Lehr-/Lern-Plattformen?

Möchtest Du noch etwas loswerden?

B.3 MOTIVATION AND UTILISATION QUESTIONNAIRES

Several pen & paper questionnaires were handed out to the students at the beginning of tutorials in order to obtain information on the students' motivation to attend readings and tutorials, and to utilise the provided tools. Further, the questionnaires were used to collect information on platform utilisation. The questionnaires were printed on A4-sized paper. Paper quality involved was environmentally friendly paper (recycling paper) as well as normal paper in order to eliminate influence produced by perceived value of paper quality.

The original German questionnaires are provided in the following subsections, followed by their respective English pure-text translations. The German abbreviation *LLP* ('Lehr-/Lernplattform') used in the questionnaires translates to 'education platform' or 'teaching/learning platform'.

Christoph Uschkrat provided the first page of the second utilisation questionnaire used in 2015 (→ [subsection B.3.5](#) on page [XXXII](#)).

B.3.1 Motivation 2013 and 2014

Fragebogen zur Teilnahmemotivation

Vielen Dank, dass Sie sich die Zeit nehmen, diesen Fragebogen auszufüllen. Der Fragebogen umfasst dreizehn Fragen. Sollten Sie Fragen nicht verstehen oder nicht beantworten wollen, überspringen Sie sie einfach. Bitte versuchen Sie aber, die Fragen 1 und 12 zu beantworten.

Die Ergebnisse dieser Umfrage sollen der Erstellung eines Lern(enden)modells für eine auf die Lernenden optimierte, zur Teilnahme motivierende und fachspezifischen Lehr-/Lernplattform dienen.

1. Weshalb besuchen Sie die Lehrveranstaltung „Rechnernetze“? (Mehrfachantworten möglich)
- Pflichtveranstaltung Stoff ist prüfungsrelevant Interesse am Stoff Dozent
 Langeweile „Alle anderen gehen auch hin“ / „Als Student macht man das“ weiß nicht

2. Wie schätzen Sie Ihre allgemeine Motivation ein, die „Rechnernetze“-Vorlesung zu besuchen?

„schlecht“ ⇔ „gut“

Vor der ersten Vorlesung:

--	--	--	--	--	--	--	--	--	--

Direkt nach der ersten Vorlesung:

--	--	--	--	--	--	--	--	--	--

Zur aktuellen Vorlesung:

--	--	--	--	--	--	--	--	--	--

3. Wie schätzen Sie Ihre allgemeine Motivation ein, die „Rechnernetze“-Übung zu besuchen?

„schlecht“ ⇔ „gut“

Vor der ersten Übung:

--	--	--	--	--	--	--	--	--	--

Direkt nach der ersten Übung:

--	--	--	--	--	--	--	--	--	--

Zur aktuellen Übung:

--	--	--	--	--	--	--	--	--	--

4. Falls Sie in Frage 2 und/oder 3 eines oder mehrere der grau hinterlegten Kästchen angekreuzt haben, begründen Sie bitte kurz, was Ihre Motivatoren bzw. Demotivatoren waren.

5. Motiviert Sie die Vorlesung, an der Übung teilzunehmen?

ja nein weder noch

6. Motiviert Sie die Übung, an der Vorlesung teilzunehmen?

ja nein weder noch

7. Das Fach „Rechnernetze“ entspricht Ihren Erwartungen...

„gar nicht“ ⇔ „absolut“

...an das Themengebiet:

--	--	--	--	--	--	--	--	--	--

...die Lehrinhalte:

--	--	--	--	--	--	--	--	--	--

...den Dozenten:

--	--	--	--	--	--	--	--	--	--

...die übungsleitende Person:

--	--	--	--	--	--	--	--	--	--

Bitte wenden.

8. Falls Sie in Frage 7 eines oder mehrere der grau hinterlegten Kästchen angekreuzt haben, beschreiben Sie bitte kurz, weshalb Sie Ihr Kreuz bzw. Ihre Kreuze so gesetzt haben.

9. Die Vorlesung und Übung im Fach „Rechnernetze“ sind gut aufeinander abgestimmt und unterstützen sich gegenseitig?

„stimme gar nicht zu“ „stimme voll zu“

10. Wünschen Sie sich mehr Interaktivität?

„Interaktivität“ meint hierbei beispielsweise die Möglichkeit, Benachrichtigungen zu Themen zu abonnieren. Nicht jeder kann 90 Minuten durchgehend aufmerksam zuhören; Sie würden gezielt aufmerksam gemacht werden, wenn für Sie wichtige Inhalte präsentiert werden. Sollten Sie sich z. B. für das Internet Protocol interessieren, würden Sie in Echtzeit eine Benachrichtigung auf Ihr Handy/Tablet/Notebook erhalten, wenn der Dozent eine dafür wichtige Folie präsentiert.

ja nein weiß nicht / egal

11. Falls Sie bei Frage 10 „ja“ angekreuzt haben, welche Formen von Interaktivität können Sie sich vorstellen? Welche davon empfinden Sie als sinnvoll und für welche könnten sich begeistern?

12. Haben Sie vor diesem Semester die Lehrveranstaltung „Rechnernetze“ bereits besucht?

ja nein keine Angabe

13. Haben Sie im Kontext der Lehrveranstaltung „Rechnernetze“ Kommentare zur Motivation?

Nun noch ein paar statistische Fragen, dann haben Sie es geschafft.

Sie sind: männlich weiblich keine Angabe

Ihr Status ist: Student/in der _____
 Schüler/in Gasthörer/in Seniorenuniversität
 Sonstiges, nämlich _____

Wie alt sind Sie: _____

Für Rückfragen zur Umfrage wenden Sie sich bitte an tenshi.hara@tu-dresden.de.

English Translation

Thank you for taking time to fill out this questionnaire. The questionnaire includes thirteen questions. Should you not be able or willing to answer questions, simply skip them. However, please try to answer questions 1 and 12.

The results of this questionnaire shall be utilised to create a learn[ing/er] model for an optimised toward the demands of the learners' education platform.

1. Why are you attending the lecture 'computer networks'? (multiple responses allowed)
 Compulsory Course Examination relevance Interest in topic Docent
 Boredom 'Everyone else is attending' / 'That's what students do' Don't know
2. How would you rate your overall motivation for attending the 'computer networks' lecture?
[items ranging *poor* ... *good*]
 - Prior to first lecture:
 - Just after the first lecture:
 - At current lecture:
3. How would you rate your overall motivation for attending the 'computer networks' tutorials?
[items ranging *poor* ... *good*]
 - Prior to first tutorial:
 - Just after first tutorial:
 - At current tutorial:
4. If you marked one or more grey squares in question 2 and/or 3, briefly state your motivators or demotivators, please.
[text area]
5. Does the lecture motivate you to attend tutorials?
 Yes No Neither
6. Do the tutorials motivate you to attend the lecture?
 Yes No Neither
7. The subject 'computer networks' meets my expectations...
[items ranging *not at all* ... *completely*]
 - ... towards the subject area:
 - ... towards the course content:
 - ... towards the docent:
 - ... towards the tutor:

[page break]

8. If you marked one or more grey squares in question 7, briefly state the reasons for doing so, please.
[text area]
9. The 'computer networks' lecture and tutorials are well coordinated and support each other?
[scale ranging *totally disagree* ... *totally agree*]
10. Do you want more interactivity?
In this case 'interactivity' means, for example the possibility to subscribe to notifications. Not everybody can stay focussed for 90 minutes; You would be notified when important content is presented. If you are, for example interested in the Internet Protocol, you were to receive a real-time notification on your mobile phone/tablet/notebook when the docent presents a relevant slide.
 Yes No Don't know / Don't care
11. If you marked 'Yes' for question 10, what forms of interaction can you imagine? Which would you think could be useful and which could enthuse you?
[text area]

12. Have you previously attended the 'computer networks' course?

Yes No No response?

13. Do you have comments regarding motivation in the context of the 'computer networks' course?

[text area]

Just a few statistical questions, then you have made it.

You are: male female no response

Your status: Student of _____

Pupil Guest Student Senior Academy

Other, namely _____

What is your age: _____

B.3.2 Motivation 2015

Fragebogen zur Teilnahmemotivation

Vielen Dank, dass Du Dir die Zeit nimmst, diesen Fragebogen auszufüllen. Solltest Du Fragen nicht verstehen oder nicht beantworten wollen, überspringe sie einfach. Bitte versuche aber, die Fragen 1 und 11, sowie die statistischen Fragen zu beantworten.

1. Weshalb besuchst Du die Lehrveranstaltung „Rechnernetze“? (Mehrfachantworten möglich)
- Pflichtveranstaltung Stoff ist prüfungsrelevant Interesse am Stoff Dozent
 Langeweile „Alle anderen gehen auch hin“ / „Als Student macht man das“ weiß nicht

2. Wie schätzt Du Deine allgemeine Motivation ein, die „Rechnernetze“-Vorlesung zu besuchen?

„schlecht“ ⇔ „gut“

Vor der ersten Vorlesung:

--	--	--	--	--	--	--	--	--	--

Direkt nach der ersten Vorlesung:

--	--	--	--	--	--	--	--	--	--

Zur aktuellen Vorlesung:

--	--	--	--	--	--	--	--	--	--

3. Wie schätzt Du Deine allgemeine Motivation ein, die „Rechnernetze“-Übung zu besuchen?

„schlecht“ ⇔ „gut“

Vor der ersten Übung:

--	--	--	--	--	--	--	--	--	--

Direkt nach der ersten Übung:

--	--	--	--	--	--	--	--	--	--

Zur aktuellen Übung:

--	--	--	--	--	--	--	--	--	--

4. Falls Du in Frage 2 und/oder 3 eines oder mehrere der grau hinterlegten Kästchen angekreuzt hast, begründe bitte kurz weshalb.

5. Motiviert Dich die Vorlesung, an der Übung teilzunehmen?

ja nein weder noch

6. Motiviert Dich die Übung, an der Vorlesung teilzunehmen?

ja nein weder noch

7. Das Fach „Rechnernetze“ entspricht Deinen Erwartungen...

„gar nicht“ ⇔ „absolut“

...an das Themengebiet:

--	--	--	--	--	--	--	--	--	--

...die Lehrinhalte:

--	--	--	--	--	--	--	--	--	--

...die Vorlesung:

--	--	--	--	--	--	--	--	--	--

...die Übung:

--	--	--	--	--	--	--	--	--	--

8. Falls Du in Frage 7 eines oder mehrere der grau hinterlegten Kästchen angekreuzt hast, beschreibe bitte kurz, weshalb.

9. Die Vorlesung und Übung im Fach „Rechnernetze“ sind gut aufeinander abgestimmt und unterstützen sich gegenseitig?

„stimme gar nicht zu“ ⇔ „stimme voll zu“

--	--	--	--	--	--	--	--	--	--

10. Wie könnte man Deiner Meinung nach die „Rechnernetze“-Übungen weiter verbessern?

11. Hast Du vor diesem Semester die Lehrveranstaltung „Rechnernetze“ bereits besucht?

ja nein keine Angabe

12. Hast Du im Kontext der Lehrveranstaltung „Rechnernetze“ Kommentare zur Motivation?

Nun noch ein paar statistische Fragen, dann hast Du es geschafft.

Du bist: männlich weiblich sonstiges / keine Angabe

Dein Status ist: Student/in im Studiengang _____

Schüler/in Gasthörer/in Seniorenuniversität

Sonstiges, nämlich _____

Dein Alter ist: _____

English Translation

Thank you for taking time to fill out this questionnaire. Should you not be able or willing to answer questions, simply skip them. However, please try to answer questions 1 and 11.

1. Why are you attending the lecture 'computer networks'? (multiple responses allowed)
 Compulsory Course Examination relevance Interest in topic Docent
 Boredom 'Everyone else is attending' / 'That's what students do' Don't know
2. How would you rate your overall motivation for attending the 'computer networks' lecture?
[item ranging *poor* ... *good*]
 - Prior to first lecture:
 - Just after the first lecture:
 - At current lecture:
3. How would you rate your overall motivation for attending the 'computer networks' tutorials?
[item ranging *poor* ... *good*]
 - Prior to first tutorial:
 - Just after first tutorial:
 - At current tutorial:
4. If you marked one or more grey squares in question 2 and/or 3, briefly state why, please.
[text area]
5. Does the lecture motivate you to attend tutorials?
 Yes No Neither
6. Do the tutorials motivate you to attend the lecture?
 Yes No Neither
7. The subject 'computer networks' meets my expectations...
[items ranging *not at all* ... *completely*]
 - ... towards the subject area:
 - ... towards the course content:
 - ... towards the lecture:
 - ... towards the tutorials:

[page break]

8. If you marked one or more grey squares in question 7, briefly state why, please.
[text area]
9. The 'computer networks' lecture and tutorials are well coordinated and benefit/support each other?
[scale ranging *totally disagree* ... *totally agree*]
10. How do you think could the 'computer networks' tutorials be improved?
[text area]
11. Have you previously attended the 'computer networks' course?
 Yes No No Response
12. Do you have comments regarding motivation in the context of the 'computer networks' course?
[text area]

Just a few statistical questions, then you have made it.

You are: male female other/no response

Your status: Student of _____
 Pupil Guest Student Senior Academy
 Other, namely _____

Your age is: _____

B.3.3 Utilisation 2014

Fragebogen zur LLP-Nutzung

Vielen Dank, dass Sie sich die Zeit nehmen, diesen Fragebogen auszufüllen. Der Fragebogen umfasst zwölf Fragen. Sollten Sie Fragen nicht verstehen oder nicht beantworten wollen, überspringen Sie sie einfach. Bitte versuchen Sie aber, die Fragen 1, 11 und 12 zu beantworten.

Die Ergebnisse dieser Umfrage sollen der Verbesserung der Ihnen vorgestellten (noch weiter zu implementierenden) Lehr-/Lernplattform (LLP) dienen.

1. Nutzen Sie die LLP unter <https://rnuw.de> ?

ja → weiter ab Frage 3

nein → weiter mit Frage 2

2. Weshalb nicht?

kenne/kannte ich nicht keine Lust anderer Grund, und zwar: _____

→ weiter auf der Rückseite mit den statistischen Fragen

3. Wie schätzen Sie Ihre Möglichkeiten ein, die „Rechnernetze“-Übung zu beeinflussen?

„schlecht“ ⇔ „gut“

Ohne LLP:

--	--	--	--	--	--	--	--	--	--

Mit LLP:

--	--	--	--	--	--	--	--	--	--

4. Wenn Sie an den bisher präsentierten Funktionsumfang der LLP denken, welche allgemeinen Gedanken kommen Ihnen sofort in den Sinn?

5. Denken Sie nun an die Möglichkeit, vor und nach den Übungseinheiten Befragungen ausfüllen zu können. Diese Befragungen sollen eine zielgerichtete Prüfungsvorbereitung ermöglichen. Haben Sie von den Befragungen Gebrauch gemacht?

ja Welche Befragungen? nein, weil: _____

6. Denken Sie nun an die Möglichkeit, während der Übungseinheiten Echtzeitrückmeldungen geben zu können. Haben Sie von den Echtzeitrückmeldungen Gebrauch gemacht?

ja → weiter ab Frage 7 Echtzeitrückmeldungen? → weiter ab Frage 11

nein, weil: _____ → weiter ab Frage 11

7. Denken Sie nun an die in den Echtzeitrückmeldungen bewertbaren Dimensionen. Wie sinnvoll empfinden Sie die einzelnen Dimensionen?

„sinnlos“ ⇔ „sinnvoll“

Lautstärke:

--	--	--	--	--	--	--	--	--	--

Geschwindigkeit:

--	--	--	--	--	--	--	--	--	--

Erklärung:

--	--	--	--	--	--	--	--	--	--

Bitte wenden.

8. Falls Sie in Frage 7 eines oder mehrere der grau hinterlegten Kästchen angekreuzt haben, beschreiben Sie bitte kurz, weshalb Sie Ihr Kreuz bzw. Ihre Kreuze so gesetzt haben.

9. Die Dimension „Erklärung“ wurde ein den vergangenen Tests selten verwendet. Dies ist sicherlich der unpräzisen Definition dieser Dimension geschuldet. Was verstehe Sie unter der Bewertungsdimension „Erklärung“?

10. Wenn Sie die Dimension „Erklärung“ durch eine andere ersetzen könnten, welche wäre das?

11. Welche weiteren Funktionen können Sie sich für die LLP vorstellen?
Welche wären Sie gewillt zu nutzen?

12. Haben Sie Kommentare zur LLP?

Nun noch ein paar statistische Fragen, dann haben Sie es geschafft.

Sie sind: männlich weiblich keine Angabe

Ihr Status ist: Student/in der _____
 Schüler/in Gasthörer/in Seniorenuniversität
 Sonstiges, nämlich _____

Wie alt sind Sie: _____

Für Rückfragen zur Umfrage wenden Sie sich bitte an tenshi.hara@tu-dresden.de.

English Translation

Thank you for taking time to fill out this questionnaire. The questionnaire includes twelve questions. Should you not be able or willing to answer questions, simply skip them. However, please try to answer questions 1, 11 and 12.

The results of this questionnaire shall be utilised to improve the introduced education platform.

1. Do you use the LLP at <https://rnuw.de>?
 Yes → continue with question 3 No → continue with question 2
2. Why not?
 don't/didn't know it didn't want to other, namely: _____
→ continue with the statistical questions on the reverse
3. How would you rate your possibilities to influence the 'computer networks' tutorial?
[items ranging *poor* ... *good*]
 - Without LLP:
 - With LLP:
4. Thinking of the range of LLP functions you have seen, what thoughts spring to your mind?
[text area]
5. Consider the option to complete surveys before and after tutorials. These surveys are supposed to facilitate focussed exam preparation. Did you use the surveys?
 Yes What Surveys? No, because: _____
6. Consider the option of giving real time feedback during the tutorials. Did you use the real time feedback?
 Yes → continue with question 7 Real time feedback? → continue with question 11
 No, because: _____ → continue with question 11
7. Consider the real time feedback criteria. How useful did you find these criteria?
[items ranging *useless* ... *useful*]
 - Volume:
 - Speed:
 - Explanation:

[page break]

8. If you marked one or more grey squares in question 7, briefly describe why you did so, please.
[text area]
9. The criterion 'explanation' has not been used a lot in past trials. Likely, this is because of its unprecise definition. How do you interpret the feedback criterion 'explanation'?
[text area]
10. If you could replace the criterion 'explanation' with another, what would it be?
[text area]
11. What further functions can you imagine for the LLP?
Which would you use?
[text area]
12. Do you have comments regarding the LLP?
[text area]

Just a few statistical questions, then you have made it.

You are: male female other/no response

Your status: Student of _____
 Pupil Guest Student Senior Academy
 Other, namely _____

What is your age: _____

B.3.4 Utilisation 2015, Rev. I

Fragebogen zur LLP-Nutzung

Vielen Dank, dass Du Dir die Zeit nimmst, diesen Fragebogen auszufüllen. Der Fragebogen umfasst zwölf Fragen. Solltest Du Fragen nicht verstehen oder nicht beantworten wollen, überspringe sie einfach. Bitte versuche aber, die Fragen 1, 12 und 13, sowie die statistischen Fragen zu beantworten.

1. Nutzt Du den Prototypen unter <https://exercisetool.inf.tu-dresden.de/> ?

ja → weiter ab Frage 3

nein → weiter mit Frage 2

2. Weshalb nicht?

kenne/kannte ich nicht keine Lust anderer Grund, und zwar: _____

→ weiter auf der Rückseite mit den statistischen Fragen

3. Wie schätzt Du Deine Möglichkeiten ein, die „Rechnernetze“-Übung zu beeinflussen?

„schlecht“ ↔ „gut“

Ohne LLP:

■	■	■	■	■	■	■	■	■	■
---	---	---	---	---	---	---	---	---	---

Mit LLP:

■	■	■	■	■	■	■	■	■	■
---	---	---	---	---	---	---	---	---	---

4. Wenn Du an den bisher präsentierten Funktionsumfang der LLP denkst, welche allgemeinen Gedanken kommen Dir sofort in den Sinn?

5. Denke nun an die Möglichkeit, während der Übungseinheiten Diskussionen in der LLP führen zu können. Hast Du von den Diskussionen Gebrauch gemacht?

ja → weiter mit Frage 6

Diskussionen?

→ weiter mit Frage 9

nein, weil: _____ → weiter mit Frage 9

6. Wie bewertest Du die verschiedenen Einsatzmöglichkeiten der Diskussionen?

„sinnlos“ ↔ „sinnvoll“

Fragen stellen:

■	■	■	■	■	■	■	■	■	■
---	---	---	---	---	---	---	---	---	---

Kommentieren:

■	■	■	■	■	■	■	■	■	■
---	---	---	---	---	---	---	---	---	---

Bewerten:

■	■	■	■	■	■	■	■	■	■
---	---	---	---	---	---	---	---	---	---

7. Die Diskussionen könnten von der Übung ablenken, bieten Dir aber einen anonymen Kommunikationskanal. Wie bewertest Du die Ablenkungs- und Anonymitätsgrade?

„gering“ ↔ „hoch“

Ablenkung:

■	■	■	■	■	■	■	■	■	■
---	---	---	---	---	---	---	---	---	---

Anonymität:

■	■	■	■	■	■	■	■	■	■
---	---	---	---	---	---	---	---	---	---

8. Falls Du in Frage 6 und/oder 7 eines oder mehrere der grau hinterlegten Kästchen angekreuzt hast, beschreibe bitte kurz, weshalb Du Dein Kreuz bzw. Deine Kreuze so gesetzt hast.

9. Denke nun an die Möglichkeit, vor und nach den Übungseinheiten Befragungen ausfüllen zu können. Diese Befragungen sollen eine zielgerichtete Prüfungsvorbereitung ermöglichen. Hast Du von den Befragungen Gebrauch gemacht?

- ja → weiter mit Frage 10 Fragebögen? → weiter m Frage 11
 nein, weil: _____ → weiter ab Frage 11

10. Wie bewertest Du die Fragebögen hinsichtlich ihrer Sinnhaftigkeit?

„sinnlos“ ⇔ „sinnvoll“

Wissen vor der Übung einschätzen:

--	--	--	--	--	--	--	--	--	--	--	--

Wissen nach der Übung einschätzen:

--	--	--	--	--	--	--	--	--	--	--	--

Zur Klausurvorbereitung:

--	--	--	--	--	--	--	--	--	--	--	--

11. Wenn Du eine Funktion aus dem Prototypen entfernen könntest, welche wäre das?

12. Welche weiteren Funktionen könntest Du Dir für den Prototypen vorstellen? Welche davon wärest Du gewillt auch zu nutzen? (ggf. wann?)

13. Hast Du sonstige Kommentare zur LLP?

Nun noch ein paar statistische Fragen, dann hast Du es geschafft.

Prototyp genutzt mit: Laptop Handy/Tablet _____

Du bist: männlich weiblich sonstiges / keine Angabe

Dein Status ist: Student/in des Studiengangs _____
 Schüler/in Gasthörer/in Seniorenuniversität
 Sonstiges, nämlich _____

Dein Alter ist: _____

Für Rückfragen zur Umfrage wende Dich bitte an tenshi.hara@tu-dresden.de.

English Translation

Thank you for taking time to fill out this questionnaire. The questionnaire includes twelve [thirteen; this is a typo in the German original] questions. Should you not be able or willing to answer questions, simply skip them. However, please try to answer questions 1, 12 and 13.

1. Do you use the prototype at <https://exercisetool.inf.tu-dresden.de/> ?
 Yes → continue with question 3 No → continue with question 2
2. Why not?
 don't/didn't know it didn't want to other, namely: _____ → continue with the statistical questions on the reverse
3. How would you rate your possibilities to influence the 'computer networks' tutorial?
[items ranging *poor* ... *good*]
 - Without LLP [educational platform]:
 - With LLP [educational platform]:
4. Thinking of the range of LLP functions you have seen, what thoughts spring to your mind?
[text area]
5. Consider the option to lead discussions within the LLP during tutorials. Did you participate in discussions?
 Yes → continue with question 6 Discussions? → continue with question 9
 No, because: _____ → continue with question 9
6. How do you rate these applications of the discussion feature?
[items ranging *useless* ... *useful*]
 - Ask Questions:
 - Comment:
 - Rate:
7. These discussions can distract from the tutorial, but offer an anonymous platform. How do you rate the degree of distraction and anonymity?
[items ranging *low* ... *high*]
 - Distraction:
 - Anonymity:

[page break]

8. If you marked one or more grey squares in question 7, briefly describe why you did so, please.
[text area]
9. Consider the option to complete surveys before and after tutorials. These surveys are supposed to facilitate focussed exam preparation. Did you use the surveys?
 Yes → continue with question 10 What Surveys? → continue with question 11
 No, because: continue with question 11
10. How do you rate the usefulness of the surveys?
[items ranging *useless* ... *useful*]
 - Estimate knowledge prior to tutorial:
 - Estimate knowledge after tutorial:
 - For exam preparation:
11. If you could remove a feature of the prototype, which would it be?
[text area]
12. What further functions can you imagine for the prototype? Which would you be willing to use? (where applicable: when would you use it?)
[text area]
13. Do you have further comments regarding the LLP?
[text area]

Just a few statistical questions, then you have made it.

Used prototype with: Laptop Mobile/Tablet _____

You are: male female other/no response

Your status: Student of _____
 Pupil Guest Student Senior Academy
 Other, namely _____

Your age is: _____

B.3.5 Utilisation 2015, Rev. II

Fragebogen zur Rechnernetze-Übung

Allgemeines zu Lehr- /Lernplattformen (LLP)

	stimme gar nicht zu	stimme eher nicht zu	teils, teils	stimme eher zu	stimme voll zu
Die intuitive Bedienbarkeit einer LLP ist sehr wichtig.					
Die Kommunikation unter Studierenden kann durch den Einsatz einer LLP strukturierter verlaufen.					
Während Lehrveranstaltungen sollte eine LLP nicht mehr Aufmerksamkeit als nötig auf sich ziehen.					
Das User Interface spielt für den erfolgreichen Einsatz von LLP eine wichtige Rolle.					
An den richtigen Stellen ist es für die Benutzung einer LLP besser, Bilder bzw. Icons statt Text zu verwenden.					
Die Benutzung einer LLP sollte die Studierenden zum Lernen motivieren.					
Der gezielte Einsatz von LLP kann zu besseren Prüfungsergebnissen bei den Studierenden führen.					

Welche möglichen Features/Funktionen interaktiver LLP könnten dazu beitragen, eine „konventionelle“ Lehrveranstaltung zu verbessern?

Wenn es eine ideale LLP mit entsprechenden Funktionen und perfekter Bedienbarkeit gäbe, könnte diese prinzipiell den Lernerfolg von Studierenden verbessern?

ja nein

weiter auf der nächsten Seite →

Fragen zur in der Übung verwendeten LLP

	stimme gar nicht zu	stimme eher nicht zu	teils, teils	stimme eher zu	stimme voll zu
Die Bedienung der LLP ist einfach und intuitiv.					
Die LLP integriert sich hervorragend in den Übungsbetrieb.					
Ich kann mir vorstellen, die LLP auch im Rahmen von Vorlesungen sinnvoll zu nutzen.					
Das User Interface der LLP ist dem Zweck entsprechend gut umgesetzt worden.					
Das User Interface der LLP gefällt mir gut.					
Die LLP besitzt für den Übungsbetrieb überflüssige Funktionen.					
Durch den Einsatz der LLP nehme ich aktiver am Übungsgeschehen teil.					
Durch die Benutzung der LLP bin ich vom Übungsgeschehen abgelenkt.					
Die LLP steht zu sehr im Vordergrund der Übung.					
Der Einsatz der LLP hat keinen Einfluss auf meine Beteiligung am Übungsgeschehen.					
Die Benutzung der LLP trägt zur Steigerung meines eigenen Lernerfolges bei.					
Die Benutzung der LLP trägt zu einem höheren Lernerfolg der anderen Studierenden bei.					
Fehler/Bugs in der LLP erfordern eine höhere Aufmerksamkeit als nötig wäre.					
Folgende Bereiche lassen sich in der LLP verbessern:					
Design/Layout					
Farbschema					
Fehler/Bugs					
Schriftgröße/Schriftart					
mehr Icons statt Text					

Wie oft hast Du die LLP pro Übungseinheit genutzt?

- maximal einmal
 2- oder 3-mal
 4- oder 5-mal
 6- oder 7-mal
 häufiger als 7-mal

Wie lange hast Du die LLP insgesamt pro Übungseinheit genutzt?

- weniger als 1 Minute
 1–3 Minuten
 3–5 Minuten
 5–10 Minuten
 mehr als 10 Minuten

Wie schätzt Du Deine Möglichkeiten ein, die „Rechnernetze“-Übung zu beeinflussen?

„schlecht“ „gut“

Ohne LLP:

--	--	--	--	--	--	--	--	--	--

Mit LLP:

--	--	--	--	--	--	--	--	--	--

Wenn Du an den bisher präsentierten Funktionsumfang der LLP denkst, welche allgemeinen Gedanken kommen Dir sofort in den Sinn?

Hast Du sonstige Kommentare zur LLP?

Hast Du sonstige allgemeine Kommentare und/oder Kritik?

Die Diskussionen können von der Übung ablenken, bieten Dir aber einen anonymen Kommunikationskanal. Wie bewertest Du dies?

„gering“ „hoch“

Ablenkung:

--	--	--	--	--	--	--	--	--	--

Anonymität:

--	--	--	--	--	--	--	--	--	--

Noch ein paar statistische Fragen, dann hast Du es geschafft.

Prototyp genutzt mit: Laptop Handy/Tablet _____
 nicht genutzt

Du bist: männlich weiblich _____
 keine Angabe

Dein Status ist: Student/in des Studiengangs _____
 Schüler/in Gasthörer/in Seniorenuniversität
 Sonstiges, nämlich _____

Dein Alter ist _____ Jahre

Vielen Dank für Deine Unterstützung!

English Translation

General Questions regarding the education platform (LLP)

[items ranging *totally disagree, somewhat disagree, neither, somewhat agree, totally agree*]

- Intuitive usability of an LLP is very important.
- Communication among students can be conducted in more structured fashion with an LLP.
- During class an LLP should not draw more attention than necessary.
- The user interface plays an important role in the effective usage of an LLP.
- In appropriate places it is better for LLP utilisation to use images or icons instead of text.
- Utilisation of an LLP should motivate students to study.
- Selective use of LLPs [education platforms] can improve students' exam results.

What possible features or functions of interactive LLPs [education platforms] could improve 'conventional' courses?

[text area]

If there was an ideal LLP with corresponding functions and usability, could this improve students' learning success?

Yes No

[page break]

[items ranging *totally disagree, somewhat disagree, neither, somewhat agree, totally agree*]

- The LLP's [education platform's] usability is straightforward and intuitive.
- The LLP is superbly integrated into the tutorial flow.
- I can imagine the LLP being useful during lectures.
- The LLP's [education platform's] user interface is well implemented for its purpose.
- I like the LLP's [education platform's] user interface.
- The LLP includes functions that are unnecessary for tutorials.
- By using the LLP I participate more actively in the tutorials.
- By using the LLP I am distracted from the tutorial.
- The LLP is too paramount in the tutorials.
- Utilisation of the LLP does not influence my participation in the tutorials.
- Utilisation of the LLP improves my learning success.
- Utilisation of the LLP improves the other students' learning success.
- Errors and bugs in the LLP demand more attention than necessary (than it should?).
- The following parts of the LLP could be improved:
 - Design/Layout
 - Colour scheme
 - Errors/Bugs
 - Font size/style
 - More icons instead of text

How many times did you use the LLP during each tutorial?

at most once 2 or 3 times 4 or 5 times 6 or 7 times more than 7 times

How long did you use the LLP overall in each tutorial?

less than 1 minute 1-3 minutes 3-5 minutes 5-10 minutes more than 10 minutes

[page break]

How would you rate your possibilities to influence the 'computer networks' tutorial?

[items ranging *poor ... good*]

- Without LLP:
- With LLP:

Thinking of the range of LLP functions you have seen, what thoughts spring to your mind?
[text area]

Do you have further comments regarding the LLP?
[text area]

Do you have further general comments?
[text area]

The discussions can distract from the tutorial, but offer an anonymous platform. How do you rate the degree of distraction and anonymity?
[items ranging *low ... high*]

- Distraction:
- Anonymity:

Just a few statistical questions, then you have made it.

Used prototype with: Laptop Mobile/Tablet other: _____
 did not use

You are: male female _____

Your status: Student of _____
 Pupil Guest Student Senior Academy
 Other, namely _____

Your are _____ years old

Thank you for your support!

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C.1 AUXILIARY MEANS

While creating this dissertation, the following auxiliary means were used in order to type-set and research the written submission, as well as to implement the proof-of-concept implementation:

- Adobe Acrobat Pro DC (2015.006.30121),
- Adobe Dreamweaver CS5 (11.0.4993),
- Comprehensive T_EXArchive Network, The –<http://ctan.org>,
- CorelDRAW X7 (17.1.0.572),
- Corel PHOTO-PAINT X7 (17.1.0.572),
- dict.leo.org by LEO GmbH (dictionary and online translator),
- Encyclopædia Britannica (digital version),
- friends and acquaintances (proofreading),
- Google-Scholar (search-engine),
- HeidiSQL 9.3.0.5052 (database management tool),
- KITTY 0.66.6.3 (SSH client),
- Microsoft Office 365 University (16.0.6568.2025) (mainly Excel),
- Microsoft Office Visio 2016 (16.0.6568.2025),
- MiK_TE_X 2.9.5846 (L^AT_EX typesetting-tool for Windows),
- Notepad++ 6.9 (editor)
with the following run-dialog on *Alt+F9* it is very useful:

```
cmd /c cd /d "$(CURRENT_DIRECTORY)"
&& texify "$(FILE_NAME)"
&& bibtex "$(NAME_PART)"
&& texify --clean --pdf --run-viewer "$(FILE_NAME)",
```
- Paint.NET 4.0.9 (Final 4.9.5848.30436),
- QR-Code generator by Dominik Dzienia (©2010 – ‘QR-Code’ or ‘Quick Response Code’ is a technology and registered trademark of Denso Wave and is subject to patent protection; Denso Wave has released QR-Code as open source to free usage),
- Sächsische Landesbibliothek – Staats- und Universitätsbibliothek Dresden, and
- Wiktionary (dictionary).

D PUBLICATIONS

During the course of creating this dissertation several research contributions were published. These contributions were either authored, co-authored, or supervised.

D.1 ORIGINAL RESEARCH CONTRIBUTIONS

The following research contributions were authored or co-authored (ones related to topic are marked with *; ones explicitly referenced are indicated):

- Felix Kapp, Iris Braun and **Tenshi Hara**: *Evaluating Lectures through the Use of Mobile Devices – Auditorium Mobile Classroom Service (AMCS) as a Means to bring Evaluation to the next Level*, The 8th International Conference on Computer Supported Education (CSEDU 2016), Rome, Italy *
- **Tenshi Hara**, Iris Braun, Felix Kapp and Alexander Schill: *Toward a Second Screen Peer Discussion Derivative*, The 6th IEEE Integrated STEM Education Conference (ISEC 2016), Princeton, USA *
- **Tenshi Hara**, Felix Kapp, Iris Braun and Alexander Schill: *Comparing Tool-supported Lecture Readings and Exercise Tutorials in classic University Settings*, The 7th International Conference on Computer Supported Education (CSEDU 2015), Lisbon, Portugal *
- **Tenshi Hara**, Thomas Springer, Klemens Muthmann and Alexander Schill: *Towards a reusable Infrastructure for Crowdsourcing*, Second Workshop on Crowdsourcing and Gamification in the Cloud (CGCloud 14), 7th IEEE/ACM International Conference on Utility and Cloud Computing, London, United Kingdom
- Lars Beier, Iris Braun and **Tenshi Hara**: *auditorium –Frage, Diskutiere und Teile Dein Wissen!*, Gemeinschaften in Neuen Medien (GeNeMe 2014), Dresden, Germany * [BBH14]
- Thomas Springer, **Tenshi Hara** and Alexander Schill: *On providing Crowdsourcing as a Service*, First Workshop on Crowdsourcing and Gamification in the Cloud (CGCloud 13), 6th IEEE/ACM International Conference on Utility and Cloud Computing, Dresden, Germany
- **Tenshi Hara**, Marius Feldmann, Yvonne Mußmacher and Alexander Schill: *Zesare: Kompetenzbündelung zur Unterstützung Studierender beim Erwerb studienbegleitender Zertifizierungen an sächsischen Hochschulen –Ein Projektbericht*, Gemeinschaften in Neuen Medien (GeNeMe 2013), Dresden, Germany *

- **Tenshi Hara**, Thomas Springer, Gerd Bombach and Alexander Schill: *Decentralised Approach for a reusable Crowdsourcing Platform utilising standard Web Servers*, The 2013 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp 13), Zurich, Switzerland
- Thomas Springer, **Tenshi Hara**, Gerd Bombach and Sina Grunau: *An integrated System for Indoor and Outdoor Location-based Services (MapBiquitous)*, The 11th International Conference on Mobile Systems (MobiSys 2013), Taipei, Taiwan

D.2 STUDENT THESES

The following list itemises all student works that were supervised during the time of the doctorate this dissertation was created in, that is proseminar and main seminar papers, undergraduate assignment papers, bachelor theses, master theses, and diploma theses (ones related to topic are marked with *; German titles translated into English; ones explicitly referenced are indicated):

- Tommy Kubica: 'Development of a Prototype for Selecting and Deploying technical Tools and Tool Combinations in different Teaching Methods', Master Thesis, pending, submission planned for 22 July 2016 *
- Dominik Rupp: 'Introduction of Pseudonyms into Auditorium Mobile Classroom Service', Main Seminar 'Service and Cloud Computing', Winter Semester 2015 * [[Rup16](#)]
- Thuy Dung Vu: '2-Phase Brainstorming with technical Aids', Proseminar 'Service and Cloud Computing', Winter Semester 2015 *
- Christoph Uschkrat: 'Investigations on Incidentalness of Teaching/Learning Platforms', Bachelor Thesis, handed in 23 October 2015 *
- Finn Schlenk: 'Storing Knowledge – When? By whom? For whom? How long?', Proseminar 'Service and Cloud Computing', Summer Semester 2015 *
- Leo Käßner: 'Blended Learning – Comparing existing Solutions', Proseminar 'Service and Cloud Computing', Summer Semester 2015 *
- Richard Wotzlaw: 'Definition of Crowdsourcing Campaigns', Diploma Thesis, handed in 15 May 2015
- Duoyi Zhang: 'Modularisation of a reusable Crowdsourcing Infrastructure demonstrated by the proxied Client-Server Communication of the SANE', Diploma Thesis, handed in 2 April 2015
- Alexander Martin: 'User Interface Concept for Support of Aspects of self-regulated Learning in the Context of on-demand Knowledge Structures', Master Thesis, handed in 5 January 2015 * [[Mar15](#)]
- Matthias Auer: 'Overview of Design Fundamentals for Learning Interfaces', Proseminar 'Service and Cloud Computing', Winter Semester 2014 *
- Denny Schöppe: 'Notebook Computers in University-level Teaching – Advantages and Disadvantages of Laptop-enhanced Learning', Main Seminar 'Service and Cloud Computing', Winter Semester 2014 *
- Sindy Tiedke: 'You are great with a PC, but I ain't. How do we find Common Ground?', Main Seminar 'Service and Cloud Computing', Winter Semester 2014 *
- Alexander Schmidt: 'Concept-preserving Transfer of selected Didactics Methods into Online Teaching/Learning Platforms', Diploma Thesis, handed in 23 September 2014 *
- Johannes Pfister: 'Learner Votes induced Exercise Presentation', Bachelor Thesis, handed in 23 September 2014 *
- Alrik Geselle: 'Protocol Optimisation in a Proxy Communication', Bachelor Thesis, handed in 22 August 2014
- Frank Thiem: 'Selection and Implementation of a feasible cryptographic Algorithm for an encrypted and signed Proxy Communication', Bachelor Thesis, handed in 4 July 2014

- Tan Dung Nguyen: 'Selection and Implementation of a feasible Distributed Hash Table Algorithm for a distributed Proxy Communication autonomously respecting regional Distributions in MapBiquitous', Diploma Thesis, handed in 21 June 2014
- Sebastian Fehrs: 'Motivation Moments in Learning Platforms', Proseminar 'Service and Cloud Computing', Summer Semester 2014 * [Feh14]
- Lars Beier: 'Evaluating the Use of Gamification in Higher Education to Improve Students Engagement', Diploma Thesis, handed in 11 March 2014 * [Bei14]
- Alexander Martin: 'Topical didactic concepts in online teaching and learning platforms', Main Seminar 'Service and Cloud Computing', Winter Semester 2013 *
- Markus Roth: 'Microlectures –What's that?', Proseminar 'Service and Cloud Computing', Winter Semester 2013 *
- Tommy Kubica: 'Automatable Algorithm for the Evaluation of Crowdsourcing Users and their Submissions', Bachelor Thesis, handed in 30 August 2013
- Tommy Kubica: 'Everything as a Service –Current State and Evaluation', Proseminar 'Service and Cloud Computing', Summer Semester S2013
- Anna-Marie Balcke: 'Teaching and Learning in 2023 –Visions using the Example of Location-based Learning', Proseminar 'Service and Cloud Computing', Summer Semester 2013 *
- Tian Yuyuan: 'RTC for Mobile-Learning: Current State of the Technology', Proseminar 'Mobile and Ubiquitous Computing', Summer Semester 2013 *

E GLOSSARY

Agent, Agency

abstract principle of autonomous beings being capable of acting by themselves and on their own. *Agent* refers to the being, *agency* to the subconcept in the context of autonomy.

AJAX

Aynchronous Javascript and XML; mechanism for implementation of non-blocking web-pages; content can be dynamically requested, delivered and woven into the web-page without forcing a browser refresh.

API

Application Programming Interface; specification to be used as an interface for software components' communication; may include: routines (ready to use or their specification), data structures (ready to use or interfaces), object classes (ready to use or stubs) and variables (instantiated or instantiable).

Framework

a collection of libraries and/or classes for a software (sub)system, intended for durable reusability and reduction of code complexity.

HCI

Human-Computer Interaction; design and use of interfaces between users (humans) and computer technology; includes observation of interactions as well as design of workflows.

HTTP

Hypertext Transfer Protocol; application protocol for distributed, collaborative, hypermedia information systems; foundation of browser-based communication in the World Wide Web; consists of multi-linear sets of objects, networking them by using logical (hyper)links between nodes.

IP address

Internet Protocol address; 32-Bit (IPv4) or 128-Bit (IPv6) binary identifier of network interfaces participating in an IP network (on network layer); can be unique or ambiguous; allows for sub-network formation and addressing.

IWB

Interactive Whiteboard; large (sufficient to serve a classroom) interactive display typically mounted to a wall; contents generated and provided by computer; controlled using pointing means (pen, finger, stylus, chalk, ...) on physical surface of display.

MAC address

Media Access Control address; 48-Bit binary identifier of network interfaces on physical and data link layer; ideally unique and normally assigned by hardware manufacturer, but modifiable, hence not necessarily unique.

MINT

'Mathematik, Informatik, Naturwissenschaften und Technik'; German acronym for a combination of sciences; often wrongly translated/equalised to *STEM* (science, technology, engineering and mathematics); the ideas are very similar, but do not entirely match due to differing emphases on informatics (computer science) and general engineering (which includes informatics) respectively.

Minute Paper

concise note written by students focussing on a single or very few short question(s) presented by the teacher; questions often include what was especially good and especially bad about the topical learning unit; usually distributed and collected at the end of a learning unit.

NFC

Near Field Communication; set of standards to establish close range (touch or touch-like proximity) wireless communication with each other.

NTP

Network Time Protocol; networking protocol used for synchronizing of clocks on distributed computer systems in data networks with variable latency.

OHP

Overhead Projector; projects an illuminated slide by means of a focussing lens and a mirror at a projection screen or wall in order to create a real image.

Second Screen

using a mobile device (tablet, smartphone, ...) to provide an enhanced, often interactive or immersive, experience for content of another perception focus (for example television) [LA13, Mis14, ser12].

UML

Unified Model[ing] Language; a general-purpose modelling language for standardised design of software engineering visualisation.

Unification

let p and q be words or sentences over the same set, let $\text{subst}(\mathbb{U}, p)$ be the result of applying substitution \mathbb{U} on p and let $\text{subst}(\mathbb{U}, q)$ be the result of applying substitution \mathbb{U} on q ; iff an \mathbb{U} exist that holds $\text{subst}(\mathbb{U}, p) = \text{subst}(\mathbb{U}, q)$, then $\text{unify}(p, q) := \mathbb{U}$ is solvable (using an unification algorithm) and p and q are unifiable, meaning they express the same structure over their set.

URL

Uniform Resource Locator; derivate of uniform resource identifier; specific character string that references to an Internet resource.

WLAN

Wireless Local Area Network; a wireless limited range communication network linking at least two devices over a shared medium, often providing Internet access to users' mobile devices within the range of the network.

XML

Extensible Markup Language; markup language defining a set of rules for document encoding; human-readable as well as machine-readable; defined in W3C's XML 1.0 Specification; gratis open standard.

F INDEX

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G MILESTONES

For the conceptual design and implementation of the proof-of-concept in line of the creation of this dissertation, the following milestones were scheduled:

- Milestone N – 1 April 2013
 - enrolment into doctorate programme at TU Dresden
 - analysis of existing platform *Auditorium Mobile Classroom Service (AMCS)*
- Milestone I – 1 August 2014
 - first round of research completed
 - first set of experiments completed
 - first evaluation results
 - first conceptual draft based on evaluation
- Milestone II – 1 August 2015
 - second round of research completed
 - second set of experiments completed
 - further evaluation results
 - refinement of concept based on further evaluation
 - first verification concept
- Milestone III – 19 October 2015
 - concept finalised
 - status talk (intermediate defence; Statusvortrag)
 - specification of final verification tasks
 - specification of final evaluation tasks
- Milestone IV – 14 January 2016
 - verification completed
 - evaluation completed
 - dissertation draft completed
- Milestone V – 18 March 2016
 - dissertation completed
 - submission of the dissertation
- Milestone VI – likely June 2016
 - defence
 - library version of the dissertation completed
 - submission of the library version of the dissertation
 - conclusion of the doctorate

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