Toward a Second Screen Peer Discussion Derivative

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Abstract – **Peer Instruction is a teaching concept conceived to increase students' success in STEM courses (science technology engineering, and mathematics). The concept has been successfully applied to non-STEM courses, however it is more or less limited to on-site courses. Extending courses into the online medium allows students to design their learning based on their interests and demand while maintaining structured presentation and/or discussion of learning material. Peer Instruction's 'peer discussion' phase cannot be non-trivially transferred into the online medium. Such transfer would allow for added value to on-site classes, especially for GEMS (girls in engineering, mathematics, and science) as well as challenged students as barriers keeping them from participating in discussion can be significantly reduced. Potential solutions to facilitate the transfer lie in heavily investigated solutions like clickers, or audience response systems. However, these solutions primarily aim at large audiences, namely readings. Our research investigates transferability of concepts into smaller on-site classes, namely tutorials. It discusses experimental results and concepts for a tech-enhanced peer discussion derivative utilisable in tutorials while providing anonymity and barrier-free access to discussions. At the same time, cognisant incidental utilisation (CIU) is impelled in order to maintain a focus on the actual on-site activities, only providing added value. This added value of tutorials is presented to the students by means of a second screen experience.**

Index Terms – Cognisant Incidental Utilisation, Peer Discussion, Second Screen, Tech-enhanced Education.

INTRODUCTION

Traditional university courses suffer from students opting for online just-in-time knowledge acquisition, for example from unstructured knowledge hubs like YouTube, but also structured ones like Khan Academy. This is often true when resources are limited and interactions between students and lecturers are not individually possible. Therefore, transferring classic didactical concepts into the online media as well as supporting second screen [1] has become increasingly important in order to increase students' motivation, attendance, class preparation, participation, and achievement [2]-[4]. Students need to be supported in their choice of learning in order to maximise learning success, rather than contradicting those choices. For on-site courses, Mazur introduced Peer Instruction as a means of improving students' interactivity [5]. Peer Instruction can be divided into three main phases: *presentation*, *ConcepTest* (knowledge assessment), and *peer discussion*. Depending on the results of the ConcepTest, topics are either revisited, discussed, or concluded. There are no hard thresholds, but a rule of thumb suggests 30% ConcepTest success as the lower threshold (revisit topic), and 70% success as the upper threshold (conclude topic). Anything between leads to a peer discussion during which students discuss with their peers and try to convince each other of their understanding of the topic. This is intended to raise examination of arguments and understanding, hence elevating key components of self-regulated learning [6]. However, the entire concept was developed for on-site activities, especially readings in Physics. During the peer discussion phase the lecturer is supposed to roam through the classroom, listen in on students' discussions, note good and bad arguments, and take these up in the conclusion phase, directly correlating with the students' mistakes and merits. The concept has since been transferred into other fields, especially spanning all areas of STEM, (science, technology, engineering, and mathematics) including GEMS (girls in engineering, mathematics, and science), STEAM (science, technology, engineering, arts, and mathematics), and METALS (mathematics, engineering, technology, logic, and science), and application in other fields has also proven to be effective. However, these applications were in general limited to on-site, mainly off-line settings.

Transferring Peer Instruction into the online medium is a non-trivial task. While presentations and ConcepTest can be easily transferred with today's technological means, peer discussions in the envisaged way cannot. Abundant research has been conducted into discussion systems. Lecturers have used feedback systems like clickers [7]-[10], personal response systems [11], and audience response systems (ARS) [12]-[15] in order to facilitate the ConcepTest online and kick-off the peer discussion phase. The border between ConcepTest and peer discussion may become fuzzy, however without attaching a forum, chat, or similar real-time communication and/or collaboration tool, a real discussion cannot emerge. Most of the tools developed and tested so far aim at actual Peer Instruction, namely utilisation in readings, thus were developed for larger groups, including all pros and cons of large group collaboration systems. Application in smaller, classroom-like settings such as tutorials or seminars are scarce. Similar considerations apply to placements or laboratory training. However, we want to focus on tutorials.

When transferring the promising concept of Peer Instruction into smaller courses with different goals – such as tutorials –, the former mentioned systems fail to deliver. The aim of such courses often is not presentation and initial comprehension of material, but it is practice and consolidation. Due to the expectable smaller group sizes in tutorials, students are, compared to readings, not able to 'hide in the mass', so provision of anonymity is important, as it increases motivation and participation. Especially students of challenged opportunities such as girls in IT or visually impaired students often have difficulties in equal participation in group activities dominated by the majority. Especially visually impaired students are unable to partake in hand-written activities like sharing notes during peer discussions.

Providing an anonymous, barrier-free online tool maintained at the students' own alma mater allows for conservation of generated/accumulated knowledge on one hand, and data avoidance and data minimization on the other hand, also preventing transfer of data to external entities. At the same time all students can feel invited to utilisation at minimised risk of exposition. If tool utilisation is possible with their own devices serving as second screen, challenged students can find easy access, especially eliminating the potentially aggravating need to ask for assistance with lent devices, or setting up assistant software on them.

In this paper we will present a concept for an online system serving a tech-enhanced peer discussion derivative that is anonymously and in parallel utilisable during tutorials by means of second screen.

TERMS

Tutorials are a type of class distinguishable from readings, placements, and seminars. Their aim is to provide students a learning environment in which given tasks are presented with a standard sample solution by means of discussion and derivation with a tutor as well as fellow students. Mainly, knowledge presented in readings is to be practiced and consolidated by means of tutorials. Commonly, the tutor conducts a tutorial by deriving solutions under consideration of students' contributions, rather than simply presenting the solution discussion-free, especially allowing for intentional making of errors and discussing common sources of such errors. This is very important in STEM as students often do not understand the necessity of certain correct solutions unless they have actually made the corresponding error (like understanding the need for semaphores in order to prevent mutual exclusion situations).

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 [1]. The term is heavily utilised in the entertainment industry, for example in the planning of promotions accompanying television programmes. In context of tutorials we use the term analogously to describe the utilisation of technical display devices such as laptop computers, smartphones, or tablets, but without having the tutorials being designed for or relying on these devices. The devices are meant as an amendment to tutorials that shall remain conductible without those devices, however the devices provide additional functionality to the tutorials, for example by providing students a more interactive and immersive tutorial experience.

In our scenario, tutorials in a 'computer networks' undergraduate course, the main means of tutorial conduct remains to be the black- or whiteboard, occasionally accompanied by overhead projector and/or LCD projector. The 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 want to, not when the device calls for their attention.

GROUNDWORK

Based on experiments and experiences with ARS systems in readings (for example AMCS [13]-[15]) and an analysis of the characteristics of readings and tutorials [16], we identified three classes of cognisant incidentally utilisable (CIU) tutorial tools: instant feedback, collaboration, and student questions. A combination of aspects of collaboration and student questions yield tools feasible for documented and reproducible discussions amongst students, and occasional tutor interaction. There is a very familiar concept of interaction, namely the Peer Instruction phase peer discussion. Both concepts have in common that students discuss among peers. Further, they share chances for tutors to 'listen in' on students' discussions. The three major differences are *a)* students are enabled to discuss with students not physically seated in their direct vicinity, *b)* tutors are able to inspect discussion contents in real-time as well as retrospectively as well as in their entirety (the tutor no longer has to decide to focus on one peer discussion, potentially missing errors made in others), and *c)* students are able to discuss anonymously (if the tool provides anonymity). Especially a) and c) hold potential for providing better volition and faster occurrence of fiat tendency in the next learning phase, and b), time permitting, allows the tutor to realise all mistakes and merits in argumentation, yielding better materials to the conclusion phase of Peer Instruction.

THE PEER DISCUSSION DERIVATIVE

Object of our topical investigations is an online-based anonymously utilisable peer discussion derivative. Basically, it is a pumped-up Q&A system, but rather than only being able to ask questions and have answers provided, the system is designed to provide fully fledged, dynamic, real-time, text-based discussions. Students as well as tutors are able to contribute questions, answers, and comments. All student contributions are anonymous and non-attributable. Even though users are required to register a pseudonym and a password for system access, the pseudonym is not attached to contributions. In addition to the pseudonym and the users' own password, they required an access key provided by the tutor during the tutorial in order to not only successfully login to the system, but also be granted access to the discussion functionality. This was intended for provision of a benefit for students actually attending classes, intentionally providing an incentive by excluding stay-at-home students. Tutors' contributions are always attributable (tutors' name and/or picture attached). Further, all contributions can be voted on by providing up-votes (+1) or down-votes (-1). The sum of all votes is displayed next to contributions, for example +4. All contributions are organised in topics, having a creator (initial question or comment) and replies (answers or comments). The decision whether a contribution is a question, comment or answer is at the contributing user's discretion. Users are able to change the type of contribution retroactively (exception: creators cannot be changed to be replies, and vice versa). Besides being able to vote on contributions, users are also enabled to mark answers to their own creators as 'helpful', if they perceive an answer as sufficient. Replies to other users' creators cannot be marked as 'helpful', only voted on. Based on all votes and 'helpful' markers, the topics are organised in an ordered topic stream. The sorting is dominated by decreasing order along the absolute value of the vote sum as well as the presence of 'helpful' markers. As long as no up-votes or 'helpful' markers were given on contributions, students are able to withdraw their own contributions. Topic creators can only be withdrawn as long as they have not received replies.

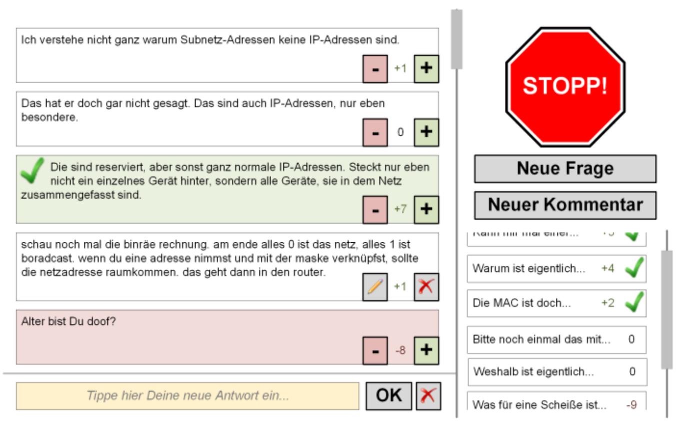

FIGURE 1
SCREENSHOT OF THE DISCUSSION TOOL PROTOTYPE.

An exemplary screenshot of a student's view within the prototype is provided in figure 1. Displayed is the view utilising the standard CSS (cascading style sheet, a technology to design websites by adding style information to the mark-up language's tags), however other display types are possible by means of other CSS files, especially pure-text for the visually impaired. The model and controller remain unaffected by changes of the view's design. In the standard view, the left hand side shows the current discussion. The second contribution from the bottom is one of the student's own contributions (note the edit and withdraw buttons). The contribution above that has been marked as helpful. The contribution on the far bottom has received a very negative score of -8 as it does not help the discussion (the content translates 'Dude, are you retarded?'). The topic has more contributions outside the displayed visible area, accessible via the scrollbar on the right. The text area on the far bottom allows the student to add another reply to the topic. On the right hand side an emergency brake is visible on the top, intended for students to announce issues to the tutor (we do not describe its functionality here as it would significantly change this paper's scope). The buttons below the emergency brake allow the creation of new questions and new comments. In the scrollable area in the bottom right is the (minimised) topic stream. The screenshot is missing the navigation area with further buttons (for example the back button) which was provided to the students above the area depicted in the screenshot.

EXPERIMENTAL ARRANGEMENT

We tested out prototypes with different functionalities activated or deactivated in the summer semesters of 2014 and 2015. In both years we selected two tutorial groups of roughly twenty-five students as experimental groups (conducted by the same tutor) and three (2014) or seven (2015) tutorial groups of similar size as control groups. The control group tutorials were conducted by the experimental groups' tutor as well as three other tutors in order to eliminate effects originating in the person. Each tutorial instalment had eleven (2014) or twelve (2015) units of four to six exercise tasks. As we did not experiment every week, we have test results from twenty-three of the forty-eight tutorial units of the experimental groups. We gathered utilisation data by automatic user tracking as well as by oral interviews and pen & paper questionnaires which also provided information on motivation and willingness to use the prototype, perceived learning value, et cetera.

As casually mentioned earlier, the tutorials investigated were part of our undergraduate course on 'computer networks'. Typically, it consists of a single weekly 90-minutes reading in conjunction with a set of up to eight weekly 90-minutes tutorials which all cover the same material. Students are encouraged to attend the reading and one of the tutorials every week, but attending is at their own discretion. Some students take the liberty to attend the same tutorial several times a week in order to have the material discussed with different tutors. This is allowed as long as the tutorial's attendance does not exceed the room's legal capacity; students who have enrolled in a specific tutorial take priority over 'multi-attenders' who are asked to leave the room once it is over capacity.

On average, the group of students is aged 20.5 years, 90% male, 98% student at Technische Universität Dresden (the other 2% consist of senior academy, and other universities within Dresden), and attends the course for the 1.2nd time (students of did not take the final exam or have failed in a previous year can repeat the course twice). Roughly two thirds attend the course because it is mandatory, the other third takes benefit of facultative general studies, or subsidiary subject options (the term 'mandatory' does not apply to their attendance as they may opt not to take the final exam).

75% of the students indicated to be interested in the contents of the course, independent of their reasons for attending. The gross of students is enrolled in one of the three degree programmes ‘computer science’, ‘media computer science’, or ‘information system technology’, but an exact number is unavailable as some students did not provide specific information on their degree programme or are enrolled in multiple degree programmes. The majority of students taking the course as a subsidiary subject are enrolled in the ‘physics’ degree programme.

Typically, all tutorial rooms are equipped with blackboards and overhead projectors, and can accommodate thirty students. Beyond that, the majority of the rooms is equipped with LCD projectors and WLAN. Thus, a wide variety of networking-capable devices is supported, and contents can be shared via projection. As a rule, the seating arrangement allows discussions among the students.

FIRST RESULTS

During the early experiments we derived some preliminary results on the process of decision making with respect to tool utilisation and decided to investigate further into the range of functions for our discussion tool. We modified the ability to withdraw contributions to include definable thresholds: students were enabled to withdraw their contributions as long as the vote score and/or marker count were below the defined threshold. Having the threshold equal to zero reproduced the original behaviour. As all contributions were organised into a topic-based display, we added a hierarchy by sorting the topics by their state of answer (open questions first, then comments, then answered questions), and then by value of vote score (sum of combined up- and down-votes). Thus, tutors were enabled to more easily identify important or pressing topics. If time constraints called for it, tutors were enabled to answer the top n (let $n \in \mathbb{N}$) important issues on-site, while postponing less urgent issues to a later online (and off-site) answering session.

As to be expected, our experiments provided proof for the considered scenario – having the discussion tool embedded in Peer Instruction’s peer discussion phase – with respect to CIU violations. When students mainly utilise the discussion tool for their discussions, they cannot do so incidentally (on a scale ranging 1 ‘not at all’ to 5 ‘absolutely’, distraction was levelled at 3.8). However, we identified a scenario other than planned Peer Instruction, namely *low interactivity tutorials* in which the tutor is pre-occupied with other tasks, for example due to volume of material to be discussed, or attending to issues of many individual students, being forced to neglect group discussions. The low interactivity scenario also includes settings in which students are limited to asking questions or present solutions at the black- or whiteboard themselves, especially meaning that the tutor would not activate individual students by asking targeted questions, providing meta-cognitive prompts, et cetera.

In the low interactivity setting the tool was well received by the students as it allowed students to follow the tutorial, but also – at their discretion – anonymously discuss issues with their peers (on a scale ranging 1 ‘not at all’ to 5 ‘absolutely’, distraction was levelled at 2.0). They neither interrupted the tutor, nor students currently not utilising the tool, hence respecting CIU. Having students discuss issues with their peers in parallel to low interactivity tutorials, lead to fewer misconceptions and misunderstandings of the material (on a scale ranging 1 ‘not at all’ to 5 ‘absolutely’, positive impact on knowledge consolidation was levelled at 4.1). CIU was observed as students tended to discuss only when they had an issue to discuss (87% of the students), or if they had idle time (74% of the students). Typically, strong performing students helped solve issues.

Astonishingly, despite the anonymity, the discussion tool was utilised in ordered manner; any attempt to ‘troll’ was swiftly regulated by the rest of the user group. Contributions unwanted or considered disturbing by the majority of the user group were relentlessly down-voted, making the system remove them from prominent display position. Obviously realising the futility of their attempts to troll, trolling users ceased and desisted from trolling quickly.

After our successful tests with low interactivity tutorials we modified the discussion tool to enable tutors to limit the tool’s capabilities by selecting pre-defined combinations of settings. Currently, our discussion tool supports six distinct pre-defined combinations of allow/disallow settings on creators, replies, votes on creators, as well as votes and markers on replies. In table 1 the six combinations are provided.

TABLE 1
PEER DISCUSSION SYSTEM’S SETTINGS COMBINATIONS

Name	Settings				Scenario
	creators	*replies*	*vote on creators*	*vote on & mark replies*	
PDS1	✓	✓	✓	✓	Default
PDS2	×	×	✓	✓	pause discussions
PDS3	×	✓	✓	✓	limit to existing discussions; force/push a conclusion
PDS4	✓	×	✓	✓	questions and comments only, no discussions
PDS5	✓	✓	×	×	brain-storming
PDS6	×	×	×	✓	votes on entire topic only

As to be expected, the different combinations were differently suitable for tutorial conduct. The default combination *PDS1* as well as the ‘pause’ combination *PDS2* proved to be most intuitive and did not require any forethought by or explanation to the tutors as well as the students.

Combination *PDS3* was not well received by the students during tutorials as they were unable to announce new issues (only 18% in favour). However, they attempted to attach issues to existing topics (20% unrelated replies), often receiving unclear up- and down-votes (66% votes that neither tutor nor students were able to attribute in absolute certainty). Nevertheless, students deemed *PDS3* worthy as a standard setting for after-class continuation of discussions (76% in favour). That way, students and tutors would be able to bring open issues to a conclusion in after-class sessions, without having new issues been added.

PDS4 was designed for quick gathering of open issues without students engaging in discussions. Students stated that this combination was only sensible if the tutor reacted to issues in due time (on a scale ranging 1 'immediately' to 5 'at the end of the tutorial', sensible reaction was levelled at 1.3), or if the setting was available ahead of tutorials in order to have issues declared *before* the start of a tutorial unit (stated as free text feedback on 30% of questionnaires turned in). This would support the pre-class reading phase of Peer Instruction as students would be able to provide open issues arisen from the pre-class reading activity, or tutors could prepare leading questions that would support students in the reading phase. However, this was not possible during our initial tests as access to the discussion system was restricted by the required access key. Some students suggested to provide a pre-class key only utilisable for *PDS4* scenarios (20% of received feedback on this issue).

Unfortunately, we have not tested *PDS5*, yet. The tutor simply forgot the brainstorming activity in the tutorial we planned to test it. However, students' oral feedback on the idea suggests to disable withdrawal of contributions. Even if students desired to withdraw, their contribution still might provide further ideas for the other students. This is especially true for single-phased brainstorming (gathering and recording at the same time, potentially influencing each other), but should also apply to dual-phased brainstorming (individual unswayed collection of thoughts, followed by aggregation of results in a second phase).

Finally, *PDS6* was intended to force students to vote on entire topics rather than single contributions, thereby making it easier for the tutor to identify important issues by their topic's positioning within the ordering of the topic stream. However, neither students nor tutors received this well (only 3% in favour). Students disliked being forced to vote on creators, especially if this involved scrolling up over the entire screen (on a scale ranging 1 'not at all' to 5 'absolutely', usability was levelled at 1.7). Additionally, they criticised that such voting would provide a false perception of the creator itself, for example turning an acceptable and important question into a rejected contribution due to a very negatively perceived reply like an insult (stated as free text feedback on 15% of the questionnaires turned in). Instead, topic voting should be either decoupled from single contribution voting, or discarded entirely as two voting mechanism would be too distracting. Tutors disliked *PDS6* as it did not provide a reliable state of issues (on a scale ranging 1 'confusing/hindering' to 5 'organised/helpful', presentation of issues was levelled at 1.2). Often, important issues were ousted by less important issues with fewer replies, as these were easier to vote on for students than issues that already had dozens of replies.

Overall, students expressed a welcoming attitude toward the discussion tool, even in the settings with negative test results. Especially the anonymity as well as inclusion of visually impaired students was well appreciated. From the students providing their gender in questionnaires, 67% of female students felt invited to share comments, questions, problems and answers without bias. Assuming 'gender-less' students to actually be female, the quota is 62%.

CONCLUSIONS AND NEXT STEPS

The discussion derivative proved to be a useful tool to facilitate peer discussion within tutorials conducted as Peer Instruction as well as low interactivity scenario. Especially the non-restrictive scenario with questions, comments, answers, votes and 'helpful' markers enabled, as well as the 'pause' scenario disallowing new contributions were well accepted. Beyond that, valuable feedback for restricting settings for brainstorming and pre-class reading scenarios was gained.

We should conduct investigations aimed at determining minimum and maximum participant counts for our concept to not only steadily work, but also consistently motivate student interaction. Recommendations on which functions should, could or mustn't be available should be given to tutors automatically. They could base on simple set reduction questions. – A master thesis will be dedicated to these investigations starting February 2016.

As some students requested retrospective revocation of anonymity, we want to investigate its feasibility, suitability, and impact. We could have students with high contribution rates and/or positive assessment be able to attribute their contributions to themselves. By doing so, good students willing to help others could be motivated as their standing within the group of students could improve. Currently, we envisage this as a three-step process. First, thread-level attribution would attach a random but unique identifier to all or selected contributions of a user, for example an automatically generated per-thread avatar image. Second, partial revocation would attach a user's pseudonym to all or selected of their contributions. Lastly, total revocation would –if provided beforehand– attach a user's real name to all or selected of their contributions. The process needs to be vetted on per-thread, per-course as well as platform level. Combinations of the three steps could also be interesting.

Another worthwhile investigation should be conducted on which tool combinations allow our discussion tool concept to be utilised efficiently. Some of the other tools we have investigated so far (virtual interactive whiteboard, emergency brake, live evaluation, learning demand assessment) may benefit, others may suffer in combination.

PROTOTYPE AVAILABILITY AND FUTURE

Our test platform is currently in closed development. Implementation tasks are assigned to undergraduate and graduate students in placements or bachelor/master theses. Experiments are conducted in conjunction with another platform utilised for readings, but availability is limited to university-internal testing. The prototypes are available to any teaching member of Technische Universität Dresden from any of fourteen faculties in the five schools. As a next step, both prototypes are going to be integrated into a single platform servicing both, readings and tutorials (the corresponding master thesis' processing time starts in February 2016). The new prototype is supposed to support localisations, mainly extending the current user interface to *also* support English. After that, the prototype is planned to be made available under an open-source or an academic free-to-use license.

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