

Explorative Design as an Approach to Understanding Social Online Learning Tools

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Abstract—The everyday availability and use of technology has changed education as much as it has changed everything else. For 8 years now, we have used technological interventions to change a setting where we teach up to 800 participants per semester in a class, in order to make it more interactive, engaging, and interesting for the students. We document a snapshot from this ongoing process. Aurora is an online system that has been developed from simple experiments with existing tools and software to bring interaction to the crowd of learners. Over the years, it has turned into a solid and extensive collection of tools for online teaching, learning, and communication. This article traces the development of Aurora over two consecutive years. We document the structure of the system we developed, the insights from an academic year of using it, changes designed and implemented, and first evaluations of the use of the revised version.

Index Terms—Asynchronous Interaction; E-Learning; E-Portfolio; Electronic Note Taking; Explorative Design

I. INTRODUCTION

Introductory remark: This article is an extended and substantially revised version of [1].

The Web 2.0 [2] changed online culture and transformed it from a passive consumer culture to a participatory culture. This shift also influenced the process of teaching and learning, which is since referred to as E-Learning 2.0. The notion of E-Learning 2.0 is that Web 2.0 technologies are adapted and integrated in E-Learning systems [3]. Knowledge can be created, shared, remixed and re-purposed by communities of practice [4]. Students are part of this process, collect sources and participate in the communities, by sharing their own ideas and findings. Brown and Adler [5] describe a new age of education, in which lifelong learning is not only needed but also supported by the participatory architecture of the Web 2.0. They speak of a new learning approach, '...characterized by a demand-pull rather than the traditional supply-push mode...' of obtaining knowledge. They emphasize the importance of social learning in the new online learning environment, pointing out, that the traditional teacher-student relationship is exchanged by a peer-based learning relationship.

Siemens [6] built on this change of learning culture and devised his theory of connectivism. He states that learning in the digital age is the self-driven process of building up networks of knowledge. Nodes in a network can be data sources,

communities or people and are connected to the network with strong and weak links. Weak links are more interesting since they can open doors to new areas of knowledge, diversity and innovation. Siemens points out that the life-cycle of 'correct' facts is getting shorter, and new knowledge is created faster, so memorizing facts is not yielding desired results anymore [6]. More important is the 'Know-where', which describes where knowledge can be found quickly rather than learning the knowledge itself by heart.

In this paper, we present an E-Learning System with the aim of letting students take responsibility of their own learning process. The system is an attempt to create a holistic learning platform, valuing not only assigned course work, but also social interactions and additional content students create or discover over the course of a semester. We wanted to avoid to develop another system increasing the distance between teacher and students. Instead, our goal was to start from the rather difficult situation of very large classes, where contact between teacher and student is short and rare, and transform it so that students have a feeling of more immediate involvement, more contact, and more personal mentoring. To achieve this, we put concepts such as social interaction, participation, and exchange at the center of our design efforts.

Aurora is a learning platform that consists of three modules that can interconnect with each other. Firstly, the Dashboard is an administrative tool, containing an administrative Newsfeed as well as widgets to enhance communication between all participants of the course and maintain an overview of the course progress as well as interesting developments around the course topics. Secondly, the Slides module is used during and after lectures as backchannel and basis for upcoming discussions around course topics. Thirdly, students are provided with a pool of activities they can choose from in the Portfolio. We chose the word 'activity' rather than 'exercise' for work assignments, since we want to motivate students to actively pursue their work for this course and we want to avoid the vocabulary usually associated with course work to try to increase motivation. The Discuss module is used for discussions surrounding the topics that are covered in the courses. The name Aurora is not an acronym, nor has it any deeper meaning. We used the name because it refers to something beautiful, and because it sounds appealing.

The remainder of this paper is structured as follows: The next section 'Overall Goal' will give an idea of our motivation and process to create a new e-learning system as well as explain why we chose to develop the system ourselves instead of taking existing tools. Subsequently, in the section 'Components', each module of Aurora is described and compared with existing solutions from literature. The description is followed by a preliminary 'Evaluation' and 'Conclusion so far', in which we describe how the evaluated data influenced future designs. The section 'Iteration and Redesign: Another Version of Aurora' presents a new design of the e-learning platform *Aurora* that was used in the summer semester 2014. The biggest change of this redesign is discussed in the section 'Challenges', which is a new module replacing the Portfolio module. Finally, a section 'Future Plans' outlines upcoming iterations of the platform.

II. OVERALL GOAL AND APPROACH

At the Vienna University of Technology, lecture participation is sometimes in the high three-digit numbers. Traditionally, this would mean that lectures have to be endured with a passive and consuming stance. Around 2005, we set out to explore new ways to make lectures more interactive. We started by appropriating existing systems like IRC and Twitter to facilitate backchannel communication and interaction for students visiting large lectures. Early on, we were fascinated by the idea that we could time-sync this information to the slides. This would enable students to understand the backchannel as a means of taking (collaborative) course notes that became attached to the individual slides of the lecture. We also started to replace the then prevailing passive HTML web pages for course information with blogs, which seemed an ideal fit for some years.

As we better understood the necessities of the context, we faced two possible directions for the further development: use existing systems and services to piece together a larger system, or implement a whole new system according to our needs and ideas. Comparing these two approaches, we found several advantages of the latter over the former. One advantage is that in a custom system, we could make sure that students get by with a single login, as compared to multiple logins in a setting where several existing services are stitched together. Also, if we build the system ourselves, we can experiment much more freely with the organisation, structuring and interaction of the system, compared to pre-existing solution. Finally, as we are part of an informatics faculty, this approach also gave us an opportunity to offer meaningful master theses projects to our students.

So, as we better understood the necessities of the situation, we supplanted the use of an existing blogging solution with a custom-made Newsfeed implementation that was heavily inspired by the structures and aesthetics of social media systems like Facebook or Twitter, still offering us more control over composition and access for us.

By and by, we replaced all passive elements of the information infrastructure for our large scale courses with interactive

components, we also set out to change the way we evaluate student performance in order to come to a final grade. This led to a somewhat idiosyncratic redefinition of a portfolio system that we implemented.

All these systems are currently being actively developed and refined in an effort to explore new ways of teaching and learning for a generation that grew up with ever-present Internet access and for the most part played a lot of games [7]. We redesign our systems year after year after understanding what works and what does not. We pursue this research in the spirit of design as research, or explorative design. One core idea is that with each version, new concepts become evident that were not yet visible last year, be it from use, from formal or informal evaluation, or because we reflect on our progress from the feedback we get from students.

As approaches such as participatory design, contextual inquiry and user involvement are deeply rooted within the institute this project is created in, we used multiple approaches to make sure the interests and perspectives of students are considered in the design process. Those approaches include:

- offering the users a continuous feedback channel that was constantly monitored by project members, making sure that all issues are responded to accordingly;
- offering opportunities for students to do bachelor or master projects within the project, exploring new directions and implementing novel ideas;
- organising user testing sessions during active development with students from previous semesters as testers;
- starting the semester with a week labelled as trial run, where feedback was especially appreciated;
- offering exercise activities framed within the content of the lectures using Aurora where students could reflect on the concept, features and design of the system, and propose redesign ideas;
- obtaining structured feedback using questionnaires widely distributed among the students;
- organising semi-structured feedback rounds at the end of each semester in order to talk to the participants about what worked well, what did not work so well, and what was missing. These sessions routinely turned into co-design sessions where new ideas were proposed, discussed and evaluated.

Following this path for some years now, we have come to a place where individual components have been published about, but we never set out to describe the system as a whole. This is what this paper sets out to do.

III. COMPONENTS

Aurora is a collections of different components, each of which takes on a vital role for the lecture to run smoothly. There needs to be a place to publish information about how the lecture is run and how it is graded, a place for the lecture content and a place for work to be done by the students that is evaluated by staff. In the following sections, we describe each of the solutions we implemented for these requirements in detail. Each section is preceded by a literature review of

relevant other work in the same design space, in order to provide an overview of how others previously approached similar problems.

A. Dashboard

Dashboards are often used in complex system to provide participants with an overview of activity on these platforms. The role of a dashboard is variable, depending on the context of its application. Dashboards have been used to track activity from different applications in a complex system [8]; to create peripheral awareness, provide navigation, and a system-wide inbox [9]; to create awareness of group members' actions and to convey the status of shared artifacts [10]; and to provide multiple views of a large dataset in a system [11]. More specifically, in an e-learning context, dashboards have been used for self-monitoring for students and to improve teachers' awareness [12]; and to help students to relate their learning experience to that of their peers or other actors in the system [13].

In Aurora, the Dashboard is the first page every student is presented with when logging into the system. It is a collection of widgets, containing the Newsfeed, an individual course status overview, showing colleagues, groups, current links and additional contact information. The page draws together course-relevant information related to the content from other websites, as well as information from other components of Aurora.

In former versions of Aurora, we included a statistics page to enhance students' peripheral awareness. The page provided a statistical overview of the data that is distributed over the whole system. Students could, for example, look up who of their peers was involved in a lot of discussions, or who got a lot of stars, which could be awarded for good comments by other students and members of the staff. At the start, seeing an overview of the work done in the system had a motivating impact on students and staff alike. Especially dedicated students could easily be singled out and earned a good reputation and trust among their peers. However, it also created a ranking among the students, which changed a lot at the start, but after a while it was very hard to move up ranks, which had a negative effect on some students. Since we did not want to strengthen competitiveness in the course, we first decided to hide the statistics view from students, and, in later versions, the view has not even made it into the system because of a lack of time and resources for the development.

1) *Newsfeed*: The Newsfeed is a largely organizational message board, but can also be used for content related postings. The lecture staff can use the Newsfeed to publish course updates and other relevant news for the students. Questions, annotations, complaints and praise can also be posted here, and can be answered by other actors in the system. Students post content related comments as well, but are asked to first look for a suitable slide in the Slides section to provide context for the content, before blindly posting it in the Newsfeed.

Information from other components is collected and posted via sticky notes at the top of the Newsfeed. Students are

informed if someone answered to one of their postings in the Slides section and can jump directly to the posting via link. If students get points for a good comment in the Slides section or for a newly marked activity in the Portfolio, they are notified here. Direct messages show up on top of the Newsfeed section, and can be sent by either colleagues or team members.

The Newsfeed enhances direct communication between students and staff and also provides a forum for discussions about the course design. It can be searched or filtered to see either only staff postings, only organizational postings, or only content related postings. Students can subscribe to Newsfeed postings via RSS to integrate them into their everyday online environment.

2) *Additional widgets*: The Progress Bar widget is a tool students can use to get an overview of their progress in each of their classes. Each lecture has an overview of the student's activity status. It shows the amount of points received in the lecture through activities and comments, as well as the total amount of points. Additionally, it shows how much work the student has handed in but that has not yet been graded, and the how much the student can still hand in until the end of the semester.

In the Colleagues widget, users can add other students to their course network and, on acceptance, see their avatars and further information. They can write direct messages to their colleagues as well as see all their colleagues' comments in the Newsfeed and the Slides highlighted. This intends to create a feeling of connectedness within the course and motivate to interact with others regularly.

Some activities in the Portfolio can be worked on in teams. The Teams widget shows a list of all existing teams the student is a part of. Each entry contains the name of the project the team is working on, the possibility to send a message to all team members, and a list of the other team members.

The Current Links widget displays a list of recent articles and interesting websites - supplementary reading material of topics covered in the course. The collection of links is compiled in a blog using soup.io and integrated into the Dashboard via RSS.

Furthermore, the Dashboard lists contact information to correspond with the staff directly. Students are invited to ask all course relevant questions directly in the Newsfeed so that other students can profit from the answers as well, but some issues (e.g., personal problems) need to be taken up with the staff directly.

B. Slides

There is some research on how to offer interactivity in large lectures. One approach are 'Audience Response Systems', also called 'Clickers'. Kumar and Rogers pioneered such systems in their 1976 'Olin Experimental Classroom' [14] that featured a feedback channel for students in the form of 12 buttons. Today, clickers are commercially developed products, offering a number of potential benefits to large lectures. Caldwell [15] summarized the literature on using clickers in lectures. Recently, software clickers have begun to appear, based on

the fact that most students bring a network-connected device, most prominently mobile phones, to lectures, but this approach is still mostly experimental [16] [17].

Of course, more elaborate backchannel communication systems have been tried as well, such as ActiveClass [18], Fragmented Social Mirror [19] or ClassCommons [20]. The development and evaluation of these systems overlaps with the development of the approaches presented here, first published in 2008 [21].

It can be argued that backchannel communication during lectures is potentially distracting, diverting the attention from the speaker to unrelated things. On the other hand, students regularly bring their laptops to class in the hope of finding productive use, but often end up being distracted by other things that are available on their computer. We have observed that supplying students with a backchannel that is centered around the lecture itself brings some of that attention back, and while it creates 'bubbles of diversion' from the lecture itself, at least these bubbles are focused on the content of the lecture.

Slides consist of two major components, Livecasting and Studio. Livecasting lets participants add notes to individual slides of a lecture, either in the style of a backchannel conversation, or privately. Once the lecture is finished, slides and comments are available in a combined view in the Studio. Participants can keep adding comments, links etc. in the Studio, so that the lecture slides become the focal point of discussion and exchange for participants and lecturers alike.

1) *The Livecasting component:* During a lecture, the lecturer runs a script on her computer. By pressing the next slide button on an accordingly conFig.d remote, she triggers a script that sends the number and title of the newly displayed slide to the Livecasting server (Fig. 1). Additionally, the script retrieves the lecture notes of this slide in the presentation document and scans them for a custom-made meta-syntax signifying information that is meant to be posted with the same slide. These text-lines include explanations, enhanced quotes, references and other links, activities and discussion starters.

Students load a web page that changes with each slide the lecturer shows, offering them fields to enter public comments and private notes. Information entered into either of these fields ends up being attached to the slide that was visible when the participant started typing. Like in a chat system all connected participants can see the public comments entered by other participants, and they can reply to these comments, creating ad-hoc discussions of the lecture content. To ease the cognitive load, a participant's own comments are colored yellow. Additionally, students have the opportunity to mark slides as 'liked', 'important' or 'unclear' with a single click.

2) *The Slides Studio:* Once the lecture is over, the lecturer makes slide-by-slide images of his presentation available to the Slides module (Fig. 2). While this can also be done before the lecture, we decided not to show the slides because of the obvious spikes in network traffic this would generate whenever a new slide is shown. The slides, all the participants' comments as well as the lecturers automatically posted comments are

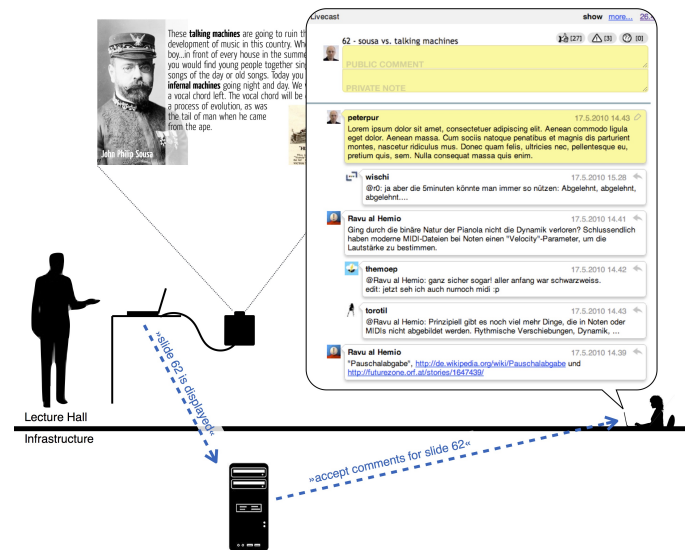


Fig. 1. Structure of the Livecasting setup. While the lecturer talks about a slide, connected students are offered text entry fields where they can attach public comments or leave private notes with the slide. Because public comments are immediately visible to all other students, this creates a setup similar to an instant messenger that is contextualized by the slide currently projected for everybody to see.

then made available in the Studio.

Here, participants and lecturers can post comments even after the lecture is finished. In the Studio, the slides are arranged horizontally, sorted by their time of appearance in the lecture. The comments attached to each slide are laid out vertically, with the earliest comments up on top (usually, these are the comments posted by the script on the lecturers computer immediately when the slide is shown), with reply threads sorted in the same way.

Participants can give praise to good comments by clicking the star next to the avatar of the author, in which case the star turns yellow and shows the number of clicks it has accumulated. Lecturer can use this same mechanism to award points to outstanding comments. In this case, the star is distinguished with a green glowing outline, making its commendation visible to everybody.

While lecturer's comments are generally displayed in the same way as student comments but distinguishable by a light-blue color, there are two lecturer-posted types that stand out from the rest: discussion starters and activities. Comments of both these types are arranged between the slide and the 'private notes' border, thus standing out even when scrolling through the slides quickly.

Discussion starter comments typically contain a questions and an invitation to discuss this question in the comments of the slide. We use this mechanism to initiate discourse on the content of slides worth of discussion, and to initiate discourse between lectures, asking participants to discuss upcoming content. Activities contain a brief explanation of an activity, linking into the Portfolio system where an elaborate description of this activity can be found. This gives the lecturer

The screenshot displays the Slides Studio interface with a presentation titled 'VU Basics of Human Computer Interaction'. The main content area shows several slides: 'arpnet 1969', 'arpnet 1971 (struktur)', 'arpnet 1973', 'dec minicomputer, dennis ritchie, ken thompson', '1979: usenet startet', and 'usenet steckbrief'. Below the slides, there are sections for 'private notes' and 'public notes'. The 'private notes' section contains several yellow-highlighted comments from users like 'peterpur', 'Maxim Kammerer', 'Saxenheini', 'steppenhahn', 'derdritte', 'adfaafasdg', 'Saxenheini', and '1147460'. The 'public notes' section shows comments from 'peterpur', 'ladyD', 'steppenhahn', 'ladyD', and 'peterpur'. The interface also includes a search bar, a 'load all comments' button, and a 'slides & comments' tab.

Fig. 2. Slides Studio, where all slides and comments become accessible to participants and lecturers alike. Note that your own notes are colored yellow.

an opportunity to announce new activities that derive from the content of a slide. Activities comments link students to the Portfolio of Aurora, where they hand in their work for review and evaluation.

C. Portfolio

In areas like HCI or Informatics and society, it is hard to conduct written exams, and once you have more than a couple of hundred students, it becomes impractical to the point of impossible to conduct oral exams. We started to abandon tests and exams at some point when we made the observation that the prospect of a written exam changed what we taught. This compromises the whole idea of teaching and learning a subject matter, especially at the university level.

For a couple of years now, research papers have been explaining the theoretical sense the adoption of ePortfolios would make. Advantages implied are, among others, 'improved reflection, increased student engagement, improved learning outcomes, and increased integration of knowledge' [22]. The paper quoted gives a comprehensive overview over ePortfolio research, and points out the lack of empirical support for many of the asserted advantages.

The module we call Portfolio is not really an ePortfolio in the strict sense of the word. While we explicitly ask the students to upload artifacts that show what they have learned, we offer a large catalog of predefined activities that can be handed in here (Fig. 3). These activities include a broad range of tasks, from simple applications of theoretical content, to actions reflecting their own prior projects, to complex design exercises. Many of those activities would make viable exercises in a traditional deadline-based context, while others would be quite unsuitable for such an environment. The catalog also contains meta-activities such as finding new sources, suggesting new activities, and organizing round table discussions with experts in the field. No single activity yields

substantially more than 10% of the final grade, so that students will be exposed to a broad range of topics.

Additionally, we attached a commenting section to each of the activities, designated as 'Q&A'-area, where students can ask questions regarding the activity that will be answered by the course organisers.

Participants hand in their work using the portfolio system of Aurora. We do not set any specific deadlines other than the end of the semester, and we do not expect them to follow a specific order. The only requirement they have to meet is to make sure that their work is distributed throughout the semester, instead of congested at the end. To this end, we devised a system to keep students on track by pushing them to regularly hand in work over the semester.

Each students has to reach a certain amount of credits in order to successfully finish the course. Each activity is worth a given amount of credit points that, when handed in, count towards the final grade. During the semester, students manage a certain contingent of 'possible points' they can hand in at any given moment. The number of credit points of each activity handed in are subtracted from this contingent, leaving the student with only a small amount of points left to be handed in at that time. Each day though, the contingent is replenished a little, to the point where it is full. If the student does not hand in activities before the contingent is totally refilled, they start losing those points. On the other hand, as long as the student does not have the needed amount of points in their contingent, they cannot hand in new activities. That way, students have to continuously hand in activities over the semester, but can chose when to do so. They get enough points to easily finish the course, even if they loose some of those points along the way. This system basically makes sure that if students waited too long into the semester, they would be unable to accumulate enough credit to complete the course.

The Portfolio includes an easy-to-use review component for the course admins to review and evaluate the participants'

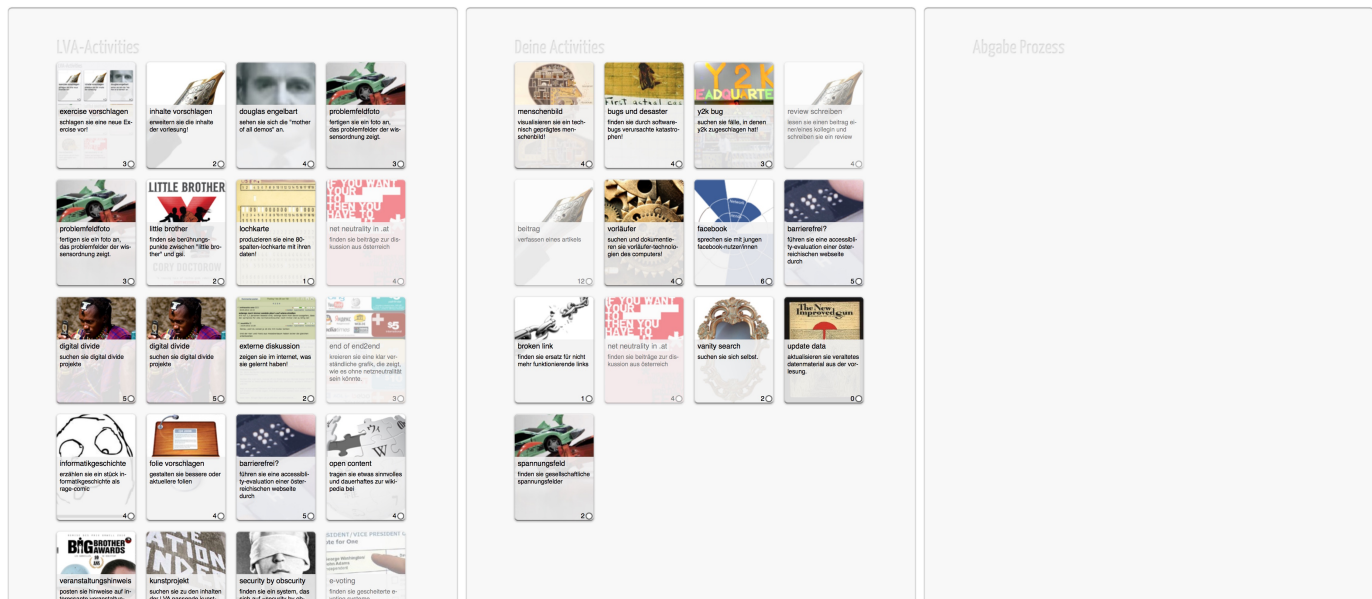


Fig. 3. Portfolio view of a participant, with the catalog of available activities, shown as cards, in the left column, a working area in the middle titled 'Deine Activities' (Your activities), and the area for hand-in in the right column. A student would drag an activity card from the catalog into the working area to elaborate, and later drop it into the hand-in column for evaluation.

work, with the notable addition of enabling students to hand in repeated submission of work that failed to meet the standards. It also includes a double blind peer review component that makes part of the assessment process into an activity by itself on the premise that if you do an honest review of somebody else's work, you will learn a lot. This functionality was used for an activity where students wrote in-depth articles of some more or less freely chosen course content, targeted at an imaginary journal. The articles were then double blind peer reviewed by other students.

The organisational approach described here tries to abandon the usual scattering of deadlines through the semester, giving the students a lot of autonomy in their work, which self-determination theory deems essential for intrinsic motivation [23].

D. Discourse

Discussion systems are widely used online, also in an educational context. Research shows that discussions foster active student participation and knowledge transfer [24], train critical thinking skills [25], and are used as a communication channel between students and teachers [26]. In the context of this project, a discussion system has been created, with an emphasis on redesigning threaded discussion systems to effortlessly join long discussions and easily follow single discussion threads. The effect of layout generally ([27], [28], [29]) and of layout in discussion systems ([30], [31]) has been discussed before.

In our opinion, traditional online discussion forum systems share a couple of common problems. For example, as the number of postings grows, readers lose track of all the places where they posted something. This often leads to users reducing their involvement in order to retain the feeling of control.

Another problem is that intense discussions between individual participants can quickly derail a discussion, making useful and on-topic contributions hard to find. Problems like these seem to come from the way information is presented to the user, suggesting that a better visual structure and more adequate interactive organisation could improve on these problems. Thus, we set out to design and implement a completely new system for online debates.

Discourse is an asynchronous, multi-threaded discussion system, that can be used for on-topic discussions among students. Lecture staff can post discussion starters or additional material to a slide. Students can navigate to the discussion via a link, which opens an infinite discussion canvas, inspired by Scott McCloud's *Infinite Canvas* idea [32]. There, each discussion is displayed in two dimensions: vertically and horizontally. The vertical axis is used for new ideas, thought and inputs into the discussion. Each comment can be replied to, which in turn creates the second, horizontal dimension: replies are displayed in a new column to the right of the original reply. Only one thread of the discussion can be opened horizontally at any given time. Fig. 4 shows an example of an open discussion thread.

A more detailed description of this format as well as an elaborate evaluation of the effect of this specific layout and interaction on the content of the discussion can be found in [33].

IV. EVALUATION

Our focus in evaluating these components is a better understanding how we can advance the system. We do not have an ultimate goal, but we use both the design process, in the sense of 'doing for the sake of knowing' [34], and the evaluation to understand how the system should be enhanced,

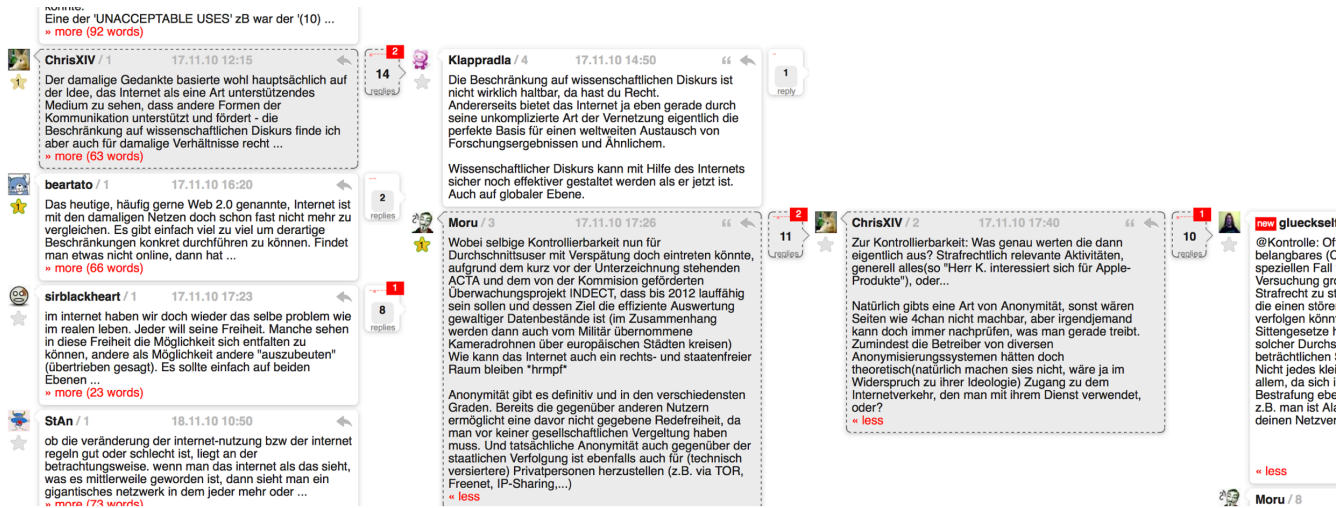


Fig. 4. A horizontal discussion thread. Selected items are displayed grey and with a dashed outline. Information boxes on the top right of each comment provide a quick overview of the rest of the discussion thread.

revised and changed in order to satisfy our needs as teachers as well as the needs of the students as learners. We understand that each step in this process changes the situation, leads all participants to new and often unforeseeable behaviour, which in turn influences and challenges all the assumptions we made to come to this point. This is why we refer to this process as explorative (or exploratory) design.

TABLE I. The table shows how many people were involved and how many certificates were handed out in the lecture. Note: columns do not add up because teachers and students could be associated with both courses.

	Profs	Predoc	Tutors	Students	Certificates
BHCI	3	1	6	733	442
IST	1	1	4	521	337
Total	3	1	10	842	779

This partial evaluation is based on data from two courses, Basics of Human Computer Interaction (BHCI) and Interactions of Society and Technology (IST), which took place in the summer semester of 2013. A total of 11.793 activities was handed in over the course of the semester, 7126 in BHCI and 4667 in IST. The staff of both courses combined consisted of 3 professors, 1 predoctoral fellow and 10 tutors, exact numbers can be found in Table I. Students only got a certificate if they handed in at least one activity. Every student who ultimately received a certificate handed in 15 activities on average. In the Slides section, 1283 slides were posted distributed over two courses with 23 lectures in total, and 3975 comments were written during and after these lectures.

A. Portfolio evaluation

Fig. 5 shows a pie chart of the time it took to grade activities. One third of the activities were graded after a week, which would be an acceptable amount of time for students to wait for feedback. Given the student-staff ratio, we tried to achieve a maximum waiting time of three weeks until every activity is graded. As can be seen in Fig. 5, we were not able

to reach that goal, as only two thirds of handed in work was evaluated within the given time frame. The final third of the pie chart consists of activities that took 4 and more weeks to be graded. Considering the importance of feedback in order to keep students motivated and continuously working [35], 4+ weeks seems too long a time to hear back on one's work.



Fig. 5. Time it took to grade an exercise, calculated in weeks

We suspect that this fluctuation in delay can actually be explained by queue modeling in game theory. Activities tend to be handed in unequally distributed time, leading to an overload that causes congestion and that is then almost impossible to resolve within the given resources until the end of the semester.

B. Slides evaluation

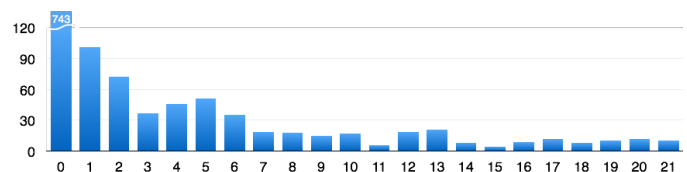


Fig. 6. How long after a slide was posted (Day 0) are students interacting with it via the comment stream. Note that the first column had to be shortened as indicated for reasons of scale.

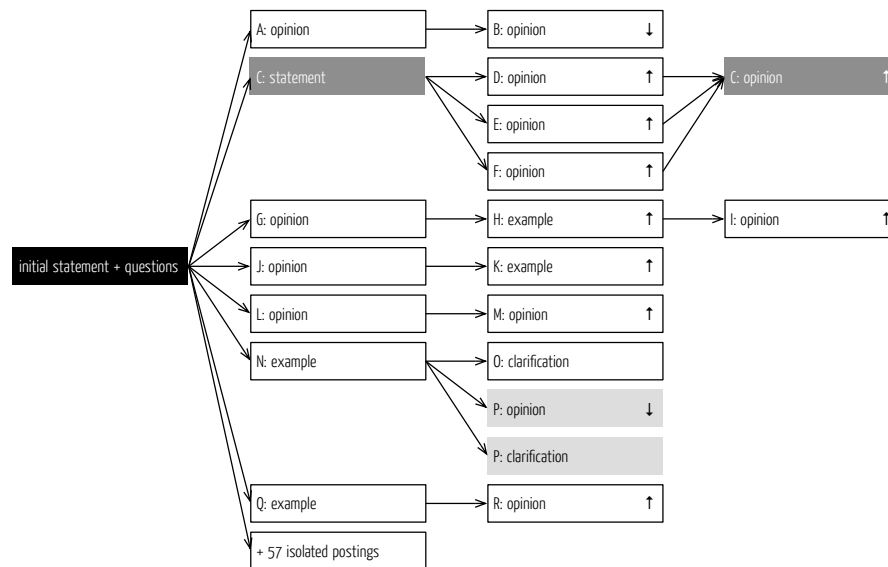


Fig. 7. The structure of a discussion in the traditional discussion, using the Slides Section

In Fig. 6, the comment data was analyzed to find out if and how long after the lecture students engage with the content by writing comments and discussing it in the Studio. The graph shows that most comments are written during the lecture, but there is a long tail (going up to 75 days) after the original slide was presented. Approximately 120 comments were posted even after the semester was over.

Especially interesting for us is the peak a couple of days later, as well as the 'long tail' of posted content after the lecture that can be seen in Fig. 6. An evaluation of these 'late' postings show that students came back to post information they find relevant, like news coverage, examples, references, etc. or to partake in discussions they have started with another postings. We see this as a successful feature of the system, as it induces reflection on and occupation with the content of a lecture for quite some time after the lecture is over.

C. Discourse evaluation

Two types of discussion systems have been used in two consecutive years; the first system used was the Slides Studio of Aurora, which features a traditional, one-level deep vertical representation of the comments. The second system used was the Discourse module. In each year, students were invited to join in voluntarily, and were rewarded credits towards their final grade for well written comments. For example comments that were argued conclusively and that featured links to additional material and sources.

We evaluated the outcome of 5 corresponding pairs of discussions on the same topic, one held in the vertical discussion section, the other in the 2-dimensional counterpart. For each of these discussions, we mapped the course of the debate as a tree structure, the results of which can be examined online at http://igw.tuwien.ac.at/designlehren/discourse_evaluation.html. One of these evaluations is presented here in this section, for more details, please refer to [33].

The discussion presented here was held on the topic of *phishing*. We analysed the structure using a qualitative content analysis based on Mayring [36]. Each posting was coded as either *Statement* (facts proved with sources), *Opinion*, *Question*, *Answer*, *Material*, *Example*, *Clarification*, or *Insight* (for details to these categories, please refer to [33]). Overall, most postings were identified as *Opinion*, which are position postings without sources. In the traditional threaded 'vertical' discussion format we also found postings of the type *Statement*, *Example* and *Clarification*. In Discourse on the other hand, discussions seemed to be more diverse in the types of postings that students wrote, much more engaging with more students contributing more than one posting, and much more in-depth as indicated by the fact that we found even comments coded as *Insight*, which are realizations of something that was so far unknown to them.

Fig. 7 shows the structure of the 1-dimensional threaded discussion. It was attended by 63 students and contained 77 postings, 57 of which were isolated postings. Only about 17% of the comments were written as a reply to someone else. Of the 63 participants, only 10 wrote more than 1 comment, and only 2 students ended up writing 3 comments each. The average amount of comments per students was 1.2, so most just wrote one isolated posting and left the discussion straight away.

The structure of same discussion in *Discourse* can be seen in Fig. 8. It was joined by 29 students and resulted in 50 comments, 19 of which were isolated postings. 50% of all comments created in the discussion were in reply to other comments. 8 students wrote more than 1 comment, 5 of them more than 3. Overall, each student wrote 1.7 comments.

The overall impression is, that *Discourse* leads to students being more involved in the discussion and even coming back to read up on new postings. The content seems more diverse

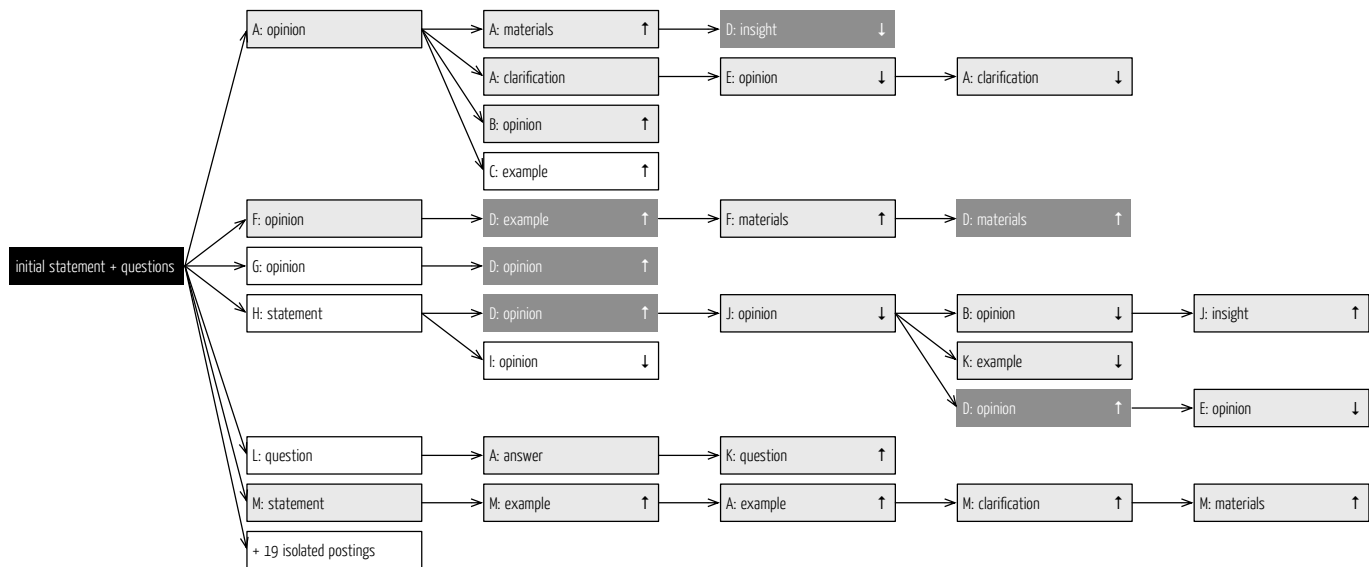


Fig. 8. The structure of a discussion using *Discourse*

and, in some cases, even signifies that learning occurred due to the discussion. The difference in the amount of isolated postings (19 vs. 57) shows that in *Discourse*, more students were motivated to find the correct discussion thread to post their own comment to, rather than just write isolated postings with no connection to what happened in the discussion until then.

V. LESSONS LEARNED

The main goal of our work is to explore the design space of online teaching and learning support systems. Our approach is best described as explorative design, with the main goal to better understand the context, the players, and their needs. At the same time, we acknowledge that technological interventions also transform the situation, and also, to a lesser extent, the needs of the players. In building and using systems that implement novel approaches to the context of teaching and learning, we in turn have a chance to understand the change such systems bring into the situation, and react accordingly. This approach shifts the focus of evaluation from understanding how and why the approach worked, or failed to work, to understanding and assessing the impact of an approach on a situation, and ultimately to finding new approaches to try. In the end, we are not so much focused on proving that our approach is right, e.g., by showing effectiveness by some abstract learning measurements. Instead, we want to find new and better ways to teach and learn that use the potentials of new technologies, engage and motivate students and tap their self-motivational capabilities.

The following conclusions were drawn from the use of the version of *Aurora* described in this paper so far:

A. Dashboard

The way the *Newsfeed* works to unify all organisational communication as well as general questions and discussions

into one stream is promising. However, more effort has to be put into promoting important messages, which sometimes tend to get lost in the constant stream of incoming comments.

B. Slides

Slides demonstrates the potential to make content more interactive using novel forms of presentation. Discussions form around individual slides, students contribute additional resources and material, use the *Slides* module to pose questions and ask for clarification, and even share entertaining associations. The high granularity in the presentation makes it possible to post such contributions quite targeted, albeit for the price of overview. However, when a couple of hundred participants post comments, overview is hardly something one would expect to preserve.

A recurring critique of some students is the way information is organised in the *Slides* module. Specifically, those students who do not feel comfortable with horizontal scrolling, often due to constraints posed by their computer hardware, expressed a dissatisfaction with the principal structure of *Slides Studio*.

Also, the question prevails whether the slides used in the lecture sorted by date are the ideal organisational scaffold for such conversations. *Slides* often over-emphasise examples and illustrations, as those parts of the lecture often use more slides than abstraction, concepts and ideas, which are thus pushed into the background.

C. Portfolio

The use of a portfolio-based approach in the *Portfolio* module provided for flexibility and versatility unparalleled in prior version of *Aurora*, or compared to a traditional deadline-based course organisation. Many students appreciated the freedom and choice that come with such a system, while some students are clearly overwhelmed with the necessity to show such a

degree of self-organisation and self-discipline. Students did complain that the 'many small exercises' principle causes them to only superficially get in contact with a lot of interesting themes and questions, leaving them without a possibility to delve deeper and engage with some of the themes more in-depth.

At the same time, the tutors were flooded with a very large number (11.000+) of small exercises to evaluate, making it impossible to write explicit feedback and grade the hand-ins in a timely manner. One definite goal for the next version of Portfolio was to find an organisational form that enables us to keep the average waiting time for feedback within a week of hand-in.

On the other hand, it turned out that the 'Q&A' commenting section with each activity description was a advantage for the students. The amount of work generated is minimal compared to the value it has. For example, ambiguities in the description of an activity could be cleared up here quite efficiently and without generating version conflicts in the description.

D. Discourse

Discourse worked exceptionally well, resulting in more focused discussions, heightened participation and more interesting conclusions. Unfortunately, the student who implemented Discourse as part of his master thesis left at the end of the semester, leaving a system that worked reasonably well within the technical context of the old version of Aurora, but was very hard to incorporate into the substantially rewritten version that we used in the following year.

VI. ITERATION AND REDESIGN: ANOTHER VERSION OF AURORA

After the evaluation of our experiences with the version of Aurora described in the paper so far, we set out to reorganise, redesign and implement a new version of Aurora. The resulting version has been developed during winter semester 2013 and used during summer semester 2014. In the following, we will briefly describe the changes planned, the redesigns taken and first results from the use of this new version.

A. Dashboard and Newsfeed

Based on last year's version, Newsfeed was improved in several places (Fig. 9). We added a dynamic filtering mechanism that lets user selectively shrink and expand individual Newsfeed postings based on criteria, resulting in views that e.g., show only comments posted by course admins, only new postings, or only top level postings. Especially the 'new comments' filter was highly effective, showing all contributions posted since this filter was last activated.

We added an opportunity to up- and down-vote individual postings, inspired by social media sites like reddit.com. Additionally, we added an element that allowed comments to be 'bookmarked', with an aggregation of all bookmarked comments in a separate view. These changes were effective for all instances of commenting in Aurora, not only in the Newsfeed.

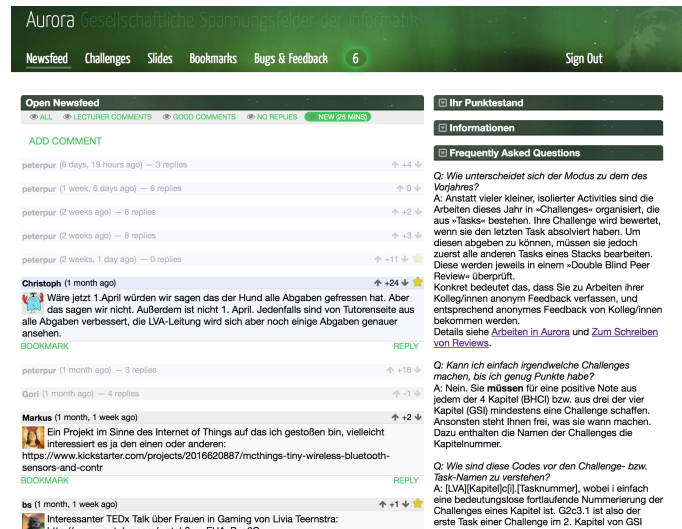


Fig. 9. The Dashboard in the new version of Aurora. The left column is allocated to the Newsfeed, the right column offers the other dashboard widgets such as the points overview and general information widgets (collapsed) and the FAQ widget. The notifications widgets was granted a privileged spot in the menu bar of Aurora, here indicating 6 unseen notifications.

One of the minor changes that penetrated the whole system was the optimization of the overall page dimensions to a width of 960px to make Aurora better suited for mobile screens.

B. Slides

The Slides module was effectively unchanged (Fig. 10). Due to technical problems we were unable to reactivate some of the functions of the Slides module in time for the course. Specifically, the Livcasting component did not work, so that comments could only be added after a lecture was finished.

As a consequence, the amount of comments posted in the Slides Studio was much lower than last year.

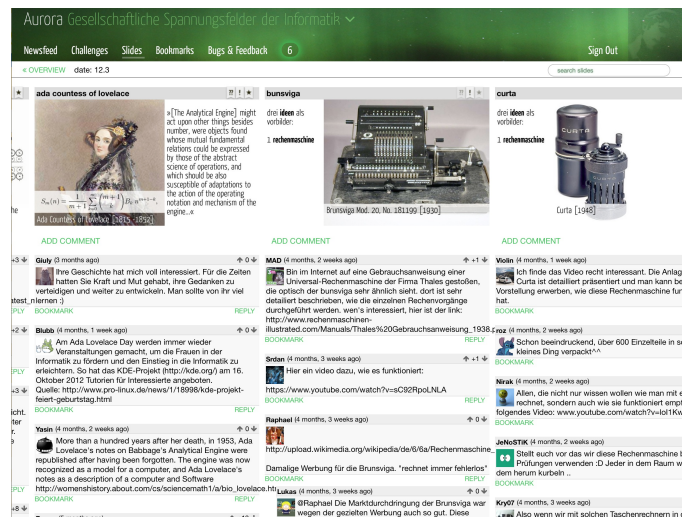


Fig. 10. The Slides Studio in the new version of Aurora.

C. Portfolio

Following the problems with the portfolio approach described above, the principal organisation of the Portfolio module was dropped, and replaced by the 'Challenges' module described below.

D. Discourse

Due to the problems described above, the Discourse module could not be used this year.

VII. CHALLENGES

After abandoning the quite ambitious e-portfolio approach, we introduced a slightly gamified terminology in the following year, with *challenge* as the main metaphor for a complex set of exercises called *tasks*.

In the context of Aurora, a challenge is a chain of exercises called *tasks* where each task (except the first task) requires the completion of the preceding task (Fig. 11). These exercises are usually increasing in their difficulty, and each task is based on the outcome, the skills, or the knowledge gained from the preceding task. Challenges are composed from three to five tasks, with the final task being significantly more work than the preparatory tasks. Typically, a single challenge represents between 10% and 25% of your semester goal.

Students can choose from a catalog of challenges that grows over the semester (Fig. 11 left), following the lecture content. In the end, the catalog comprised of 15 challenges in each course, offering more than 250% of the points necessary to reach the semester goal. The content in each course was divided into four chapters, and students had to choose at least one challenge per chapter to ensure exposure to a balanced set of topics.

As in the previous Portfolio module, we did not set deadlines other than the final end-of-term deadline. Students had to have enough challenges worked through and handed in at the end of the semester in order to fulfill the semester goal. We want to deter students from postponing their work until the end of the semester, so we introduced an organisational constraint, where after handing in a completed challenge you have to wait a number of days until you can hand in another challenge.

The final task represents approximately 50% of the total amount of credits that can be reached in a challenge, and it is evaluated and graded by a staff member or tutor. All preparatory tasks leading up to the final task are submitted into a double blind peer review process, with other course participants as reviewers. Consequently, for every task a student hands in, they have to review three elaborations for the same task handed in by anonymous colleagues. This has the strong pedagogic appeal that you expose students to the work of their peers immediately after they did the same work, leading to not only an exposure to different perspectives on the same material, but also to a guided reflection on their own work.

The double blind peer review process was modelled after the way it is typically organised at conferences; work was assigned randomly to reviewers who were required to answer a couple

of questions covering areas such as completeness, correctness, objectivity or originality of the reviewed work. Finally, reviewers were asked to assess the work on a quadrinomial scale ranging from 'Great work' to 'Unacceptable Work', the latter reserved for plagiarism and empty hand-ins.

Participants can work through all preparatory tasks of a challenge without regard for the reviews received. In order to access the final task of a challenge, it is necessary to have at least two positive reviews for each preparatory task.

To maintain the level of quality, tasks as well as reviews were randomly checked by members of the staff. We injected bad and plagiarized work into the review process, and also informed students about it, in order to be able to detect students who systematically refused to invest adequate time into writing their reviews. Also, we implemented an easy way for students to report meaningless reviews they received.

A. Evaluation of Challenges

1) *Grading Time:* One of the main goals of Challenges was to relieve us of the evaluation overload. Looking back at the semester, we can say that the use of double blind peer reviewing clearly reduced our work load, resulting in a much shorter time-to-evaluation for the students.

If you compare the main pie chart in Fig. 12 with Fig. 5, you will see that the average time for feedback was reduced significantly. We are optimistic that we can reduce it even more, as an organisational mishap in the middle of the semester generated a week of hand-in frenzy, which led to a substantial increase in feedback time; before that week, almost 90% of all hand-ins were evaluated within a week.

Part of that benefit results from a lower number of hand-ins. Instead of up to twenty submissions from each student that had to be graded in the portfolio, we now received six or seven challenges typically handed in by students that subsequently passed. While each challenge consists of three to five separate task elaborations that have to be checked, the reviews attached to all but the final task hand-in helped speed up evaluation and grading significantly.

Additionally, we were now able to provide more substantial feedback to the final task elaboration, as the reduced total number of hand-ins to be evaluated leave more time to compose written feedback. Finally, students no longer complained that it was impossible to engage with some subject matter more in-depth, as challenges provided ample opportunity to delve deeper into any of the offered topics.

2) *Peer Reviewing:* One of the risks of the introduction of peer reviewing is associated with the fact that students could start any challenge at any time, making it unclear whether they would also receive enough reviews for them to be able to start the final task of the challenge in time. To compensate for this, we had a separate list of all hand-ins that did not receive the necessary two reviews 72 hours after hand-in. Tutors regularly checked that list, providing substitute reviews so that students could advance to the final task of the challenge.

As it turned out, this list was empty most of the time. Only towards the end of the semester did the work of the students

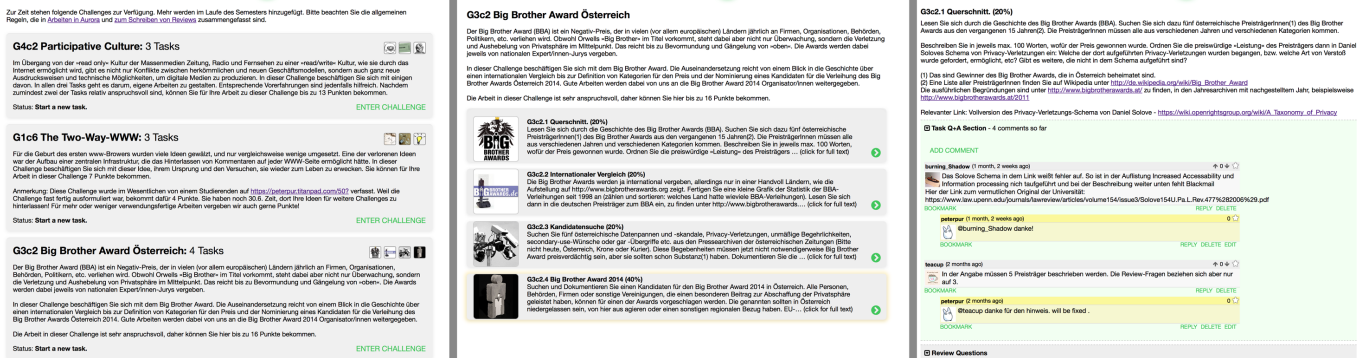


Fig. 11. The three views needed to navigate challenges: [left] Catalog of all challenges (three shown), sorted with latest additions on top; [middle] All tasks in a challenge; [right] A single task view, with the associated Q&A area

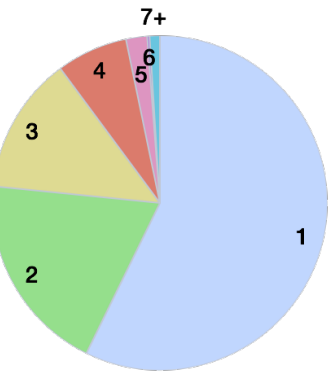


Fig. 12. Time it took to grade an exercise in Challenges, calculated in weeks

diversify so much that they did not receive these minimal two reviews. Of course, the last students to start each task at the end of the semester also had to rely on tutor substitute reviews. In other words, peer reviewing worked very well, and thus most feedback from the students about the peer reviewing mechanism was very positive.

One problem that stood out was the quality of some of the reviews. Some students saw reviewing as an annoying appendage to the core task of working through the challenge, so they wrote predominantly short reviews free of any substantial feedback. We plan to tackle this problem by placing more importance on good reviewing, e.g., by introducing a review reputation value and incorporating this value into the final grade, or by designing an introductory 'meta'-challenge that explains and focuses on the reviewing process.

On the other hand, we received feedback from students who pointed out reviewing as an essential component of the overall experience. The combination of first working through a task, and then reviewing the work of others for that same task was described as very interesting experience, central to what they learned in this course. They also rather liked the reviews they received for their own work, as long as they were substantial enough. Overall, we have the impression that the system leads to a higher involvement in the course, at least for those students who want to get involved.

B. Scope of Challenges

The specific structure of a challenge, being comprised of multiple preparatory tasks escalating into the final task, made it very hard and sometimes impossible to translate a number of the more exotic activities from the Portfolio into the new structure. Especially activities best described as meta-activities like finding new sources, suggesting new content, detecting and correcting mistakes on the slides, or suggesting new activities were hard to incorporate into a challenge. That way, the organisational structure was a step back into more conventional exercise territory. For us, this drawback is more than compensated by the fact that the tasks in the challenge build on each other offer a way to lead students deep into a subject matter, offering guidance and focus.

C. Conclusions

With the structure and organisation of the Challenges module, we believe to have solved a number of our core problems. The delay between hand-in and feedback was down across the board, from the very quick peer reviewing process to the overall evaluation of the whole challenge. As a result, we were able to send students their certificates significantly faster than in any prior year. While quality problems with the double blind peer reviewing were observed as anticipated, we are confident that we can develop concepts to counter those problems.

VIII. FUTURE PLANS

As described in Section VII, we consider the Challenges module a huge step in the right direction, and plan to enhance and strengthen it in the suggested ways. We think that we 'cracked' double blind peer reviewing in the context of large university classes.

Slides will probably undergo a major revision for next year. While we consider the general concept to offer a conversational structure following the course content as viable, doubts are mounting whether the slides are in fact the best scaffold for such a structure.

We are already thinking about a better Newsfeed structure, to alleviate the problems observed this year. Due to a much higher conversational 'background noise' in the Newsfeed this

year, many students complained that vital information went under their radar.

The value of having a single channel of communication for a course, without the need to hunt around and look through several modules to find all relevant information and answers cannot be overstated. So far, we have failed in finding a suitable structure, not only but also due to the fact that students never use the offered structures in the way we intend them to. We understand this as a design challenge for the coming years.

Another step in Aurora's development will be to include our discussion component Discourse into the system. The gains from using Discourse to facilitate discussions around the course content were substantial.

Handling more than 500 students in university courses is a rare situation. Often, such a challenge is tackled by introducing distance between teachers and learners, and by relying on examination and tests. This removes autonomy from the learning process, which we see as a central property.

Thus, we tried to go the opposite way, and designed Aurora with the explicit goal to give students as much autonomy as possible in such a setting. In our experience, such a challenge requires explorative approaches, learning not only from evaluation, but also from the design process itself.

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