InterLect - Lecture Content Interface

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Abstract: Large audiences complicate interactions between lecturer and individual students. Because students differ in their individual qualities, all of them have their own individual needs and challenges - at different topics and at different points in time. We reviewed current academic teaching processes in their way of presenting and consuming lecture material. Based on our findings, we implemented InterLect to observe students' perception of lecture material and to examine their conflicts and needs during the lecture. These needs help us to improve the awareness on comprehension and determination of appropriate learning activities, so students are able to increase their benefit from the teaching content.

1 INTRODUCTION: ENCOURAGING THE "DEEP APPROACH" ON LEARNING

As the educational researcher John Biggs suggests, passing through academic studies is a way to alter an individuals interactions with the world. Biggs states (Biggs, 1999, p. 60), "as we learn, our conceptions of phenomena change, and we see the world differently." Thus, learning should not be dominantly about the quantity of information a learner is able to store and recall. It is about whether a learner is able to "structure that information and think with it [...]." This level of information processing may only be attained by a "deep approach on learning", where learners need to go beyond "memorizing" and "note taking". (Biggs, 1999, p. 59f) They will have to expand their engagement in information processing to the description, explanation and interrelation of phenomena. They will have to apply and theorize problem solutions.

Consequences on the design of teaching are far reaching. It will not be sufficient to anticipate the degree of knowledge and ability on the students side in order to adjust the extent and vividness of information which is supplied in a lecture lesson. Teaching should rather encourage and develop the students' strategies to combine, link, reduce and enhance information within the backdrop of their individual epistemic processes. Furthermore, teaching should help to reveal and change the implications that conduct such processes (Biggs, 1999, p. 63).

Consequently, encouraging the deep approach on learning will change the way lectures work. They will cease to be just successions of propositions and illustrations but instead help to establish spaces of action, where students are challenged to progressively build up, evaluate and develop conceptual frameworks enabling them to acquire epistemic objects. Section 2 discusses identified issues and possible enhancements in the process of content delivery and information processing.

Current Classroom Response systems provide environmental and mobile tools to reform the level of interaction between lecturer and audience. These systems focus on improving the process of teaching by encouraging interaction between lecturer and audience. Besides improvements of Classroom Response Systems as described in section 3, we have to consider the fast evolution of mobile phones as well as an increasing availability on mobile devices among students (Hanley, 2013). This development enables a use of private devices to interact with delivered information in lecture scenarios. Used as an interactive visual channel, private devices support a high level of individuality in ways of processing information as well as expressing requirements. Improvements in comparison to the current state of the art in Classroom Response Systems are discussed in section 3.

Since the delivered information correlates with the

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presented slides, we conclude, students' conflicts in comprehension of lecture information should be semantically attached to slide material itself.

Therefore, we aim to identify and resolve students' conflicts in processing information induced by lecture material such as misconceptions (Lucariello, 2015) or further difficulties in comprehension, during and after a lecture. Section 4 introduces InterLect as a new evaluation prototype that connects students to the lecture material based on findings of section 2. The prototype is able to identify and evaluate students' conflicts based on lecture information. Evaluated parameters and expected observations are discussed in 5. Summarizing, InterLect enables a collection of insights into student's reflection processes to determine ways in assisting conflict recognition and handling, for both the student and the lecturer side.

2 DIDACTICAL ISSUES

In this section we discuss a dynamic approach on lecture reception. It emphasizes learners' activities while attending lectures from a situated learning theory approach and shall outline basic principles for the design and evaluation of the learning processes induced by a lecture content interface.

2.1 'Doing' Lecture - A Generative Approach on Lecture Reception

Learning goes beyond transfer and documentation of content within a lesson. Learning concerns all processes a system works out to adopt to the affordances of any environment relevant to this system. In particular, academic learning has to establish learning environments where problem solving has to be rationalized and has to detect epistemic objects which are relevant against the background of scientific discourse. Lectures only play a decisive role within these processes, if they provide information or hints, which can be used to focus, improve or revise the adoption processes of a learning system to such environments (Biggs, 1999, p. 60) (Laurillard, 2008) (Laurillard, 2012, p. 54-56).

More precisely, lectures perform this function as part of a sense-making process (Lee et al., 2008) (Tobias, 2010), which has to be considered as the core process of knowledge communication. It deliberates and - if required - evaluates and develops the conditions and prerequisites a learner needs in order to accomplish affordances in learning environments, i.e. writing a paper, preparing talks and exams, carrying out exercises and so forth. From this point of view, lectures are no means just to transmit abstract information. In fact lectures are part of a dynamic interplay that coordinates affordances of situated learning with processes that externalize, order and revise the conditions of accomplishment within learning environments (Laurillard, 2012, p. 116-121) (van Merriënboer and Kester, 2014).

This interplay has to be conceived as an active and generative practice of searching for inter-relations between situated constraints on the learners side and external stimuli from a university course or other media of teaching. It is about building focus and emphasizing areas of interest within given lecture material. Through this interplay between accomplishing situated learning and following courses, the learner performs a rather praxeological 'doing' or constructing lectures as the medial and material backdrop (Latour and Woolgar, 1986) of his or her individual learning processes. That means, we question how lectures become part of a students' ecology of learning' (Mioduser, 2015) that provides external forms and structures of thinking and acting and how students acquire such structures by means of active intervention into lecture materials.

Research on generative learning, established by Merlin C. Wittrock (Wittrock, 1990) (Wittrock, 1992) and currently debated by (Lee et al., 2008)(Tobias, 2010)(Leutner and Schmeck, 2014), has found three different ways of so-called coding, i.e. actively intervening into given educational material, such as lecture slides, with different effects on learning outcome. Depending on their motivational state, memory and meta-cognitive skills, learners use simple and complex coding as well as higher integration strategies in order to search for inter-relationships between new information and previous knowledge and to derive conceptual or schematic "knowledge units" (Lee et al., 2008, p. 113) from new information.

In summary, "simple coding strategies", i.e. "underlining, note taking and adjunct or inserted questions" (Lee et al., 2008, p. 114) have strong effects on recall and comprehension of new information. Especially learners with "low prior knowledge" (Lee et al., 2008, p. 115,121) benefit from note-taking, which improves their performance in information recall (Lee et al., 2008, p. 115) as well as in coping with transfer tasks (Lee et al., 2008, p. 121). In comparison research on "complex coding strategies", i.e. "the creation of hierarchies, headings, summaries (etc.)" (Lee et al., 2008, p. 114) did not result in unambiguous effects yet (Lee et al., 2008, p. 114f). So-called "elaborative integration strategies", e.g. "imaging and creation of examples, interpretations or analogies" (Lee et al., 2008, p. 114) are associated with forms of "higher order thinking" like "problem solving, reasoning, inference and application" (Lee et al., 2008, p. 115). Research has shown that these strategies depend on exercise and time of experience. Especially, benefiting from concept maps seems to require a higher degree of prior knowledge within the respectively treated domain (Lee et al., 2008, p. 121).

The following section outlines our application of generative learning strategies for preparing their technical implementation within a lecture-content-interface.

2.2 Basic Principles of Generative Lecture Reception

Using generative strategies while attending lectures require active and productive reactions on input and stimulus from a lecture presentation. Those reactions select and elaborate given input in order to record it and to rearrange it beyond the sequential order of a slideshow or at least to produce initial hinds on contextual relations. Constrained by the affordances of specific learning environments, generative strategies will select a specifically rich content form a lecture presentation. This selection and partial enrichment of content serves to re-construct and re-structure lecture material in order to constitute conditions of accomplishment in learning environments. Generative strategies support individual consciousness and social interchange on utilizing lecture or other media material for learning processes (Hannafin et al., 2014).

Our efforts on technical implementation of generative strategies in lecture reception currently concentrate on simple strategies, as introduced above. That means, enabling information enhancement at local data points of lecture presentation. In particular, we distinguish three basic principles of generative lecture reception: The first principle is marking. It covers forms of highlighting content with respect to further processing. It is a simple activity of content selection, which is part of any other generative Strategy.

Secondly, we propose linking as generative principle. It involves forms of creating inter-relations between different data points within given stimuli. The angles of linkage could be semantically qualified or not. Linking allows to create data knots as inductively constituted scopes of relevance as well as sequences of coherence between data points independent from succession of slides or presentational concept.

Finally, we assume that identification and labeling of epistemic conflicts are as important as generative principles of lecture reception. Conflicting interventions are non affirmative reactions on lecture input. According to our theoretical assumptions on learning, they occur when situated learning processes and lecture stimuli do not interlock. The process of sense-making from a lecture is disturbed. The inter-relation between learning environment and lecture has to be readjusted.

3 CLASSROOM RESPONSE SYSTEMS

Digital tools are been used in classrooms more and more over the last years. Although there are several different categories of them, the approach described in this publication are mainly covered by Classroom Repsonse Systems (CRS), which focuses on learning-tools that are used during a lesson.

Traditional Classroom Response Systems have in the past been known as clickers (Kay and LeSage, 2009). They are utilized to ask multiple choice questions in lessons with large audiences and therefore require a device for every participant. Since these devices have to be purchased, handed out, collected after a lesson, and maintained, they are not widely used. In the last years several studies have been shown that the CRS functionality can be perfectly implemented on mobile devices. Whereas there are applications that rely on a phone-call ((Dunn et al., 2013)), where every question gets its own telephone number, Modern Classroom Response Systems communicate over an internet connection (Feiten et al., 2012) (Jenkins, 2007) (Kundisch et al., 2012) (Vetterick et al., 2013). On the one hand there are implementations that provide native apps for iOS and Android. On the other hand there are Modern CRS that are accessible through a responsive web site (scales for any kind of device). Most Modern CRS enhance their functionality with more ways to provide feedback. For example some allow students to ask questions in a facebook-like Chatwall.

CRS in general implement a tool for students, so that they can be able to provide feedback to their teachers in real-time during a lecture. Furthermore modern CRS do the same, but on the devices the students already have. Moreover, modern CRS allow access to the feedback given in past lessons. Students use this to prepare for their exams, whereas teachers use it to improve their teaching stuff or style of teaching. But even with all the feedback-mechanism, modern CRS lack of a direct link between students feedback and teachers teaching content and further, are only able to bring up audience-wide problems. In some functionalities, as the Quiz for example, the teachers only see issues if they arise in groups if most students answer a question correctly, teachers are not able to focus on the ones who gave the wrong answer.

The solution presented in the following chapter overcomes this lack of individual awareness by bridging the teaching content with conflicts arising in students' leaning process. This allows a private learning assistance that enables students to discover their individual weakness, while teachers are able to get informed about these conflicts.

Due to the challenging task for a lecturer to interact with individuals in large audiences, bridging the gap between lecturers and their audience strongly depends on the lecturers capabilities. However, our approach focuses on supporting the individual requirements. Therefore, we cannot rely on interaction with the lecturer, but focus on bridging the gap between audience and content.

4 THE InterLect SYSTEM

To connect students to a lecture and evaluate ways of didactic assistance described in 2, we implement a web based application named "InterLect". In its' current phase, InterLect serves as a tool to evaluate students' reflection processes. While InterLect is still a prototype, it supports a quantitative evaluation of performed reflection interactions such as marking, linking and conflicting. Additionally, it supports a qualitative evaluation of performed interactions by automatically generated and distributed questionnaires after a talk.

The InterLect-Software consists of three parts. The first part is a python webserver (tornado[1]) for client hosting and data distribution via web sockets using SockJS[2]. For storing and maintaining collected data described below, the server uses a Mongo Database[3]. Second part is a web client for slide presentation named "InterLect-Presentation". The third part is a mobile web client serving as lecture content interface named "InterLect-Audience". All web clients of InterLect use the Twitter Bootstrap framework (Otto, 2011) to support a responsive layout of content for desktop systems as well as different types of mobile devices.

To start a talk the lecturer opens the InterLect-Presentation web client on an environmental presentation screen. This client displays a connection URL and a lesson identifier, so that students are able to attach themselves to the lesson via InterLect-Audience client using their mobile phones. The following subsections introduce the application side, both the presentation and the audience client, in detail.

4.1 InterLect-Presentation

To support the process of presenting slides and introduce lecture material into our system, we implemented InterLect-Presentation. We aimed for a maximal usability and a minimal effort to lower the entry threshold of using the prototype.

InterLect-Presentation is implemented as a web application, shown in figure 1, and can be opened in any web browser on any device without installation. The slide viewer supports slide show material in PDF format to facilitate the use of already existing lecture materials. Therefore, PDF files can be opened directly from local file system. After closing the start dialog a slide is rendered on a full screen HTML5 Canvas using PDFjs (Gal, 2011). To minimize the impact on common presentation procedures, the handling of InterLect-Presentation is very similar to well-known presentation tools, such as PowerPoint (Microsoft, 2014) or Acrobat Reader (Adobe Systems, 2014).

During the presentation, the system transforms presented slides into a PNG Data-URL image (Hickson and WHATWG, 2014) and sends it to the audience's mobile phones. Hereby, the presenter has the option to decide whether a button has to be pressed to share a slide or slides are shared automatically. In case of automatic sharing, the presenter can set a minimum displaying time before a slide is shared. This delay prevents automatic slide sharing while scrolling through lecture material in situations, such as searching for specific slides or skipping parts of presentation material.

4.2 InterLect-Audience

To connect the audience with the currently presented lecture materials, we implemented InterLect-Audience. InterLect-Audience is implemented as responsive web client to support a multitude of different mobile devices and desktop systems. The audience connects InterLect-Audience to the current lecture using a lesson ID provided by InterLect-Presentation. To identify listeners, we use anonymously generated user IDs, which are stored locally on a user's device. To enable personalized user identification for a user on any device, a listener is further able to compile an anonymous user ID based on its own username and password. We use user IDs only to recognize individuals and is not in our intention to enable further student rating.

[1]http://www.tornadoweb.org/

[2]https://github.com/sockjs/sockjs-client

[3]http://www.mongodb.org

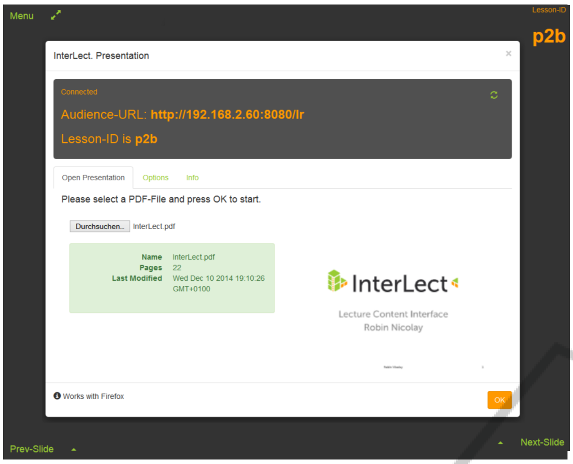

Figure 1: InterLect's starting screen, showed for teachers. PDF file can be selected from local file system. Both connection URL for the audience and lesson ID are displayed on top of the page.

A successfully connected listener receives all lesson slides, shared by the lecturer, in a scrollable list as shown in figure 2. Every slide can be selected to open a content dialog shown in figure 3. The dialog offers the student a set of interactions to process selected content. Performed interactions, discussed in the next section, are send to our server and stored in a database.

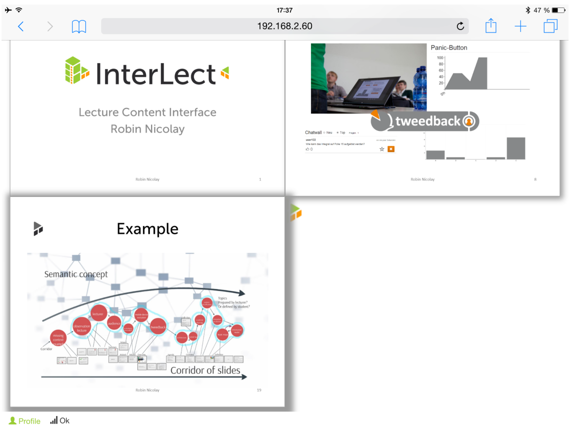

Figure 2: Interlect showing an overview of all slides.

5 InterLect's LECTURE MATERIAL INTERACTIONS

The content dialog of the audience client shown in 3 allows the audience to interact with the lecture content. It consists of three major interaction metaphors. First, marking lecture content with the use of buttons. Second, placing notes that can be enhanced by hashtags and references. And finally, defining bookmarks to highlight and quickly reference important slides at any point in the lecture. All three parts aim to support basal selection processes, such as marking, linking, and conflicting as described in 2. In this section we introduce these parts and describe their role in the evaluation of students' information reflection processes.

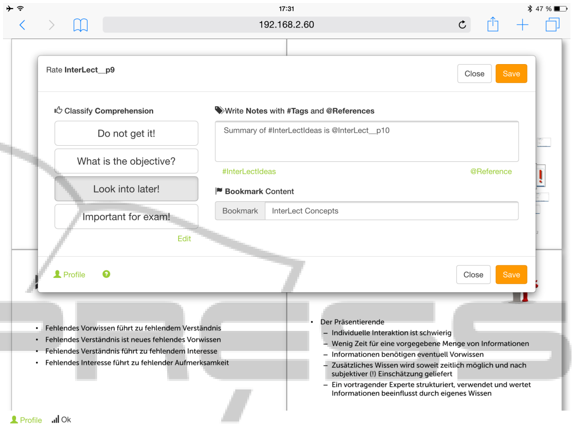

Figure 3: InterLect's content dialog, showed to students with editable buttons to mark content, a note field supporting hashtags, and references, and a bookmark input field.

As the first of three parts, we support a basal marking of lecture material by a set of configurable buttons. Buttons can be created and edited by the user themselves. Depending on the type of listener and presentation we expect to see different approaches of listeners creations and usage of these buttons.

Students will quickly mark current content for later processing. We aim to examine created and used buttons to explore desired classes of reprocessing, such as marking important content for later exams or the level of interest and comprehension for later repetition. These markings give us an insight into intuitive student post-processing techniques.

As another approach, listeners of a lecture might use these buttons to express conflicts as negational reactions to current content, such as "Where does this information belong to?", "What is the objective of this information?", "I need examples". The observation of expressed conflicts helps us to define appropriate ways to enhance lecture slides with semantic information, such as annotations and semantic linking between slides. These enhancements allow a conflict initiated content enrichment, based on an appropriately related content during and after a lecture.

Next to the marking of lecture material using buttons, the system supports the attachment of notes to a selected slide. Notes can be used to enrich a marking or as simple remarks. InterLect allows an extension of a note's text with references to other slides and tags.

References are represented as unique identifier of a slide with a leading "@". Hashtags are signed with a "#" symbol as used in systems such as Twitter (Wiliams et al., 2006).

The linking of content using references allows the listener to associate different slides in a non-typified way. As described in section 2, linking enables a consumer of information to relate different pieces of information. These relations depend on the listener's perception and are independent to the sequential structure of a lecture. The process of linking lecture slides builds an overall non-typified net of information and visualizes individual structures of relevance for a listener. Observing these structures of relevance enables us to examine if links, defined by listeners, can be used to enhance sequential lecture material to networks based on relevance.

Hashtags provide the ability to add a semantic keyword to a running text and performed interactions. Platforms like Twitter use these keywords to relate posts to a topic. In the context of our system, a straight forward use of keywords mark specific lecture content with a topic. In combination with a former defined non-typed reference a keyword may be interpreted as type of link between slides. Doing so, keywords enhance a non-typed link to a semantic association. Based on our didactic analysis described in 2 our system assists to examine if lecture material can be enhanced to semantic networks, such as topic maps (Marius et al., 2008). By observing interactions of students we identify ways to attach semantic structures to linear slide shows. These structures may enable an autonomous assistance in learning based on a listener's interactions. First ideas are described in (Nicolay, 2014).

InterLect proposes commonly used tags of other members in the audience. This mechanism supports a unification of used keywords for similar purposes. Together with the expressed conflicts described in figure 3, unified keywords in notes may be interpreted as topics for conflicts. Relating topics and conflicts enables an export of discussion bubbles as described in (Vetterick et al., 2014, p.159). A further aim of InterLect is to connect listeners after a lecture having the same type of conflict at the same specific lecture information.

The third functionality is bookmarking. Bookmarking supports individual revision of the sequential structure of a talk through punctuation. Bookmarks either are defined by the audience or the presenter. Defined by the presenter, they assist in anticipating the presenters intended structure similar to the process of priming described in (Popova et al., 2014). Defined by the audience, they serve as tool to highlight important anchors during a talk. Bookmarks are represented as a list of links and highlighted as the user scrolls through content elements. That way, listeners of a talk have a structural awareness and can easily jump to important lecture content.

Direct communication between individuals in the audience during the lecture is not in our focus. Furthermore we accept the distraction during a lecture for the use of InterLect to increase the benefit for students and teachers by interacting on the lecture content. Therefore we are keeping the distraction as minimal as possible. Based on our review of didactic issues in a lecture, we use our evaluation tool to get valuable insights in the students' reflection process as well as the overall perception of current lectures. Based on our findings we aim to enhance the prototype with assistance capabilities for lecturers and students such as methods of semantic enhancement of existing slide material, aggregated feedback of the audience's reflection process, and conflict driven content selection for a dedicated content enrichment.

6 RESULTS AND CONCLUSIONS

Processing the teaching content in lecture scenarios are not deeply covered yet. InterLect is a prototype build upon concepts of learning theory described in 2. It serves as analytic tool to examine the behavior of students during a lecture. We emphasize that InterLect aims not to stimulate the set of possible interactions performed by students during a lecture. Our main focus is to use InterLect to gain insight to actions requested by students during content processing and to find technical ways supporting these actions.

Therefore, InterLect comprises two main aspects. First, it helps to intervene in the process of content consumption. It extents known ways to process content based on concepts of marking, linking and conflicting. Second, it serves as analytic tool. It allows a free usage of all of these concepts. That way, it enables an empirical degree of freedom while using this tool, allowing an inductive analysis of generative activities arising during content cognition. These analyses are performed by evaluating studies based on user generated data as well as by attendant user surveys.

7 FUTURE WORK

Having an insight into individual needs and requirements during a lecture, we aim to build a tool to enhance current lecture slide material with semantic information, which will cover linking necessary previous knowledge, for example. Current approaches focus on using topic maps (Marius et al., 2008) and are described in (Nicolay, 2014). We plan to enhance lecture material either through manual preparation done by the presenter of a lecture or automatically through crowd sourced observations of performed students' interactions.

Further development goals to assist content processing during and after a lecture, using mentioned enhanced lecture material, are:

- Improve the awareness of the structural overview of a currently held talk
- Analysis of user needs for assistive content selection
- Provision of assistive content enrichment based on content selection and lecture material
- Improvement of content distribution on environmental and mobile visual channels based on aggregated content selection and requirement mapping in lecture rooms using mobile devices
- Aggregate feedback related to specific lecture material for the lecturer
- Analysis of user conflicts for dedicated post-processing assistance and to initiate study grouping

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