

Facilitating collaboration in lecture-based learning through shared notes using wireless technologies

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Abstract

This paper reports a case study for developing lecture teaching in higher education by connecting simultaneously the benefits of face-to-face teaching and social software for capturing and sharing students' lecture notes. The study was conducted with 12 university students taking a degree course on pre-primary education. Data were collected on (1) the nature of the shared lecture notes produced by the students; and (2) their experiences in creating and sharing lecture notes. Students wrote 367 notes in eight lecture sessions. Discourse analysis revealed five types of notes: reproducing lecture content; summarizing lecture content; connecting key concepts; developing lecture content; questions arising from lecture content. Content analysis revealed those aspects of the lectures developed through the shared notes. Discussions with four students at the end of the course explored their experiences of using the shared notes. The results are discussed in the context of changes to the cultural ecology of learning.

Keywords

collaborative learning, cultural ecology, improvisation, net generation, note taking.

Introduction

It is said that we live in a knowledge society (Hargreaves 2003; Sahlberg 2010) and information age (Scardamalia 2001). Both assertions refer to the rapid development of information and communication technology (ICT) and associated practices. Students in the knowledge society are said to be members of a net generation (Tapscott 2008). These students have lived their whole lives with ICTs and the Internet. ICT has become a part of their cultural ecology (Dillon 2008); the technology is integral to the norms and patterns of behaviour in society (Halldén 1999). These developments pose challenges for educational institutions, first in keeping track of the changes, and second in providing students with necessary skills.

According to Scardamalia (2001), the rate at which educational institutions adopt new technologies and change their practices to incorporate them is slow. There is a related problem with skills. According to Hargreaves (2003), today's students must learn deep cognitive skills to foster their creativity, ingenuity and problem-solving abilities, and skills of cooperation and collaboration to cope with changing and new situations. Scardamalia (2001) stresses the importance of providing students with skills for knowledge creation, cooperation, and lifelong learning to prepare them for information age society. Both Hargreaves and Scardamalia are calling for emphasis on the changing dynamic between the construction of knowledge, the development and application of skills, and social contexts. Despite this, the lecture is still a commonly used way for teaching in higher education, typically based on 'transmission' from lecturer to students (Young *et al.* 2010). The relatively passive role of students is problematic in terms of arguments about a knowledge society and a net generation.

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Social constructivism (Shay 2008) sees knowledge construction as a social process in which learners share their perceptions and conceptions in the collaborative production of new understanding. Emphasis is placed both on the value of the unique interpretations and comprehensions held by individual students and their contribution to collaborative learning practices. Students' unique interpretations may offer new and creative ways of conceptualizing content and relating it to established knowledge.

In this paper we present a case study of an application of ICT in lecture teaching in higher education to better meet the challenges described previously. The case study utilizes a cultural ecological framework (Dillon 2008) to investigate the potential of shared lecture notes to capture university students' different interpretations of a lecture. A cultural ecological framework is compatible with theories of both social constructivism and collaborative learning, but places particular emphasis on the dynamic between learners and their environment. In the case study, the lecture situation constitutes a 'cultural ecology' which includes the participants (students and lecturer), the learning resources, and the interactions and transactions between them. Mobile technologies and social software are used during lectures for capturing and sharing students' unique lecture notes. The creation and sharing of lecture notes may be characterized as student 'improvisations' within the cultural ecology. By improvisation we mean 're-originating meaning' without leaving behind the original meaning (Peters 2009). Students' improvisations with the lecture content are shared and become a resource for further learning and discussion. This study concentrates especially on the nature of the lecture notes created by students and the students' impressions and experiences of sharing their notes using social software. It is the first part of a research and development programme concerned with how creating and sharing notes may be used for supporting teaching and learning.

Theoretical framework

Social dimensions of learning

According to Dillenbourg (1999), collaborative learning is a 'situation in which particular forms of interaction among people are expected to occur, which would trigger learning mechanisms'. Collaborative learning emphasizes the role of students' unique knowledge

structures in directing attentions and actions and in the process of learning. Central processes in learning are the so-called cognitive conflicts, situations where a new experience does not correspond with earlier knowledge structures. Cognitive conflict can be seen as a triggering event for restructuring knowledge during learning (Dillenbourg 1999; Limón 2001; Weinberger 2003). Collaborative learning situations, incorporating students' personal interpretations about content, provide good possibilities for addressing cognitive conflicts and for negotiating different ways of solving the conflicts (Derry 1996). According to Vygotsky, learning is seen first as an external process in which existing and new knowledge are discussed in social settings, and through this collaboration new schemas are better understood and internalized (Vygotsky 1978; Smitdt 2009). This is learning in the zone of proximal development (ZPD); students learn more effectively when they have others to support them. 'Scaffolding' is an assisted learning process that supports the ZPD; it utilizes the resources of the cultural ecology, human and technological, in enhancing understanding.

Typically, in lectures, lecturers work according to their plans and students listen, take notes, and learn. This is a highly structured process. However, even though individuals seem to be passively sitting and listening, lectures still stimulate all sorts of thought patterns, new ideas and also conflicting ideas (Murphy & Sharma 2010), which could loosely be called improvisations. But the structure and 'authority' of the conventional way of doing things mean improvised constructs are often lost. Students may have very interesting opinions and ways of looking at things, but often these ideas are written only in their notes and very seldom do they speak out about them, especially if the ideas are far removed from the norm. Improvisations represent a largely unused resource for discussion and further learning. Constructive use of mobile technologies and social software during lectures offers the possibility of utilizing improvisation within the formal structures of the lecture.

Collaborative learning can be seen to have similarities to improvisation in music. According to King (1997), when jazz musicians improvise, they mess with the harmonies and slip in and out of the melody, but the song provides the essential form and structure that organises what they play. The underlying tune inspires the whole improvised performance. Improvisation is a

collaborative process: musicians support each other, providing resources and new elements for each to build their improvisation. For jazz musicians, improvisation is a means through which they communicate with each other. The same elements can be seen in learning. The learning context, in our case the lecturers' presentation, builds the 'underlying tune' around which students use prior knowledge for creating their subjective interpretations. Typically, during lecture-based teaching and learning, these unique interpretations remain the property of individual students; the collaborative element, in the sense in which it applies to improvisation in jazz, is missing. With mobile technology linked to social software, students' thinking and learning may be captured and shared *as it happens*, thus making it available as a resource for further thinking, discussion, and learning within the wider group of students.

Improvisation has the potential to change the cultural ecology of a learning situation (Dillon 2008). A cultural ecological frame takes a holistic and inclusive view of the learning environment, recognizing the *collaborative potential* of the prior experiences and knowledge that the students bring with them and the interactions of this collective experience and knowledge with the material infrastructure and social relations within the environment. Realizing the collaborative potential requires fluidity in the learning environment to enable freedom of educational transaction. The role of ICT in facilitating collaborative potential in learning environments is developed further in Vesisenaho and Dillon (2009).

Lectures and note taking

Despite what we know about social constructivism and collaborative learning, taking account of students' unique experiences and knowledge to support interaction and collaboration during lecture-based teaching is challenging. Phillips (2005) sees this as a problem of distinguishing between espoused theory and theory-in-use. Phillips (2005) argues that even though research about learning stresses student-centred and collaborative learning, the reality is different. Lectures are typically based on teacher-centred and instructive learning activities. Oblinger and Oblinger (2005) refer to a study by Fletcher which estimates that the level of interactivity in a traditional lecture is low: each student asks 0.1 questions per hour and the lecturer asks 0.3 questions

per hour. Young *et al.* (2010) also highlight the passivity of students during lectures and the associated surface learning.

Young *et al.* (2010) suggest that lectures should contain elements that better engage students with the learning process at cognitive and affective levels. Murphy and Sharma (2010) describe several ways to get students more actively and collaboratively participating in the learning process during lectures. They suggest, for example, interactive voting systems, posing questions to the audience and for the lecturer, using audience responses as sources for learning, using clinical cases, and organising debates.

An important part of lectures is the note taking. Piolat *et al.* (2005) define notes as external memories demanding students' activity in comprehending and selecting information for the notes and producing a new written product. Kiewra (1989) defines two functions for taking notes: (1) the storage function refers to storing lecture content for reviewing and thus facilitating retention; and (2) encoding, which refers to the process of taking notes. In encoding, students gain benefit from taking notes because of increased attention, more elaborative processing of ideas and content, and building connections between the content of the lectures and their own ideas (Einstein *et al.* 1985; Kiewra 1989). Peper and Mayer (1986) describe the generative effect that note taking has on learning which has strong similarities to encoding. The generative effect is based on the idea that taking notes activates cognitive processes especially fostering connections between content and students' existing knowledge. The generative effect and encoding functions align with improvisation in the sense that the interpretation of lecture content through prior knowledge structures creates the possibility of unique new entities. These entities may be similar to constructs held by lecturers and other students, they may offer interesting new perspectives on content, or there may be dissonance with lecture content arising from misunderstandings and misconceptions. In investigating the nature of the lecture notes created by students, this study explores some relationships between encoding and improvisation.

ICT for lectures and Internet generation

Murphy and Sharma's (2010) suggestions for novel uses of ICT in lectures utilize remote control devices

where comments are instantly presented and used as sources for discussion during the lecture (Van Dijk *et al.* 2001; Beatty *et al.* 2006). Students' mobile phones can be used in a similar way, for posing questions and offering comments to the lecturer (Cruz e Costa *et al.* 2008; Puranen *et al.* 2009). Taken together, mobile technology using wireless networks consolidates and extends the possibilities for interaction and collaboration during lectures.

Even though some of the assumptions about the Internet generation have been challenged (Bennett *et al.* 2008; Bullen *et al.* 2009), today's students are generally comfortable with using the Internet and mobile technologies. Mobile technologies allow each student to access the Internet, to use different resources for learning, and to use social software during lectures. The popularity of social software with young people makes it a potentially powerful tool for learning (Oblinger & Oblinger 2005; Tapscott 2008). Social software sets students in a more active role, offering tools for communicating, creating, and 'publishing' content online (Alexander 2006). Publishing materials online allows many-to-many communication, making working and learning an open process (Owen *et al.* 2006). Internet generation students are open to writing content to different online environments, including personal and private things (Tapscott 2001).

Stahl *et al.* (2006) describe software that is suitable for collaborative learning as software that is fundamentally social, mediating and encouraging of social acts. To be compatible with collaborative approaches to learning, technology should record learning activities and provide possibilities for creating, reviewing, and modifying materials produced through transactions between students. Technology should provide possibilities to take advantage of students' unique experiences and knowledge and the content of the lecture, and show how different perceptions and conceptions provide possibilities for both contesting knowledge and resolving cognitive conflict. In cultural ecological terms, such use of technology would help make the environment *adaptive* to the learning needs of the students (Loi & Dillon 2006; Dillon 2008; Dillon & Loi 2008). As Ferdig (2007) suggests, social software should be used as a tool for collaborative and co-operative learning, providing students with possibilities to actively participate in shared endeavours, to publish their artefacts of learning, and to get feedback and reflection.

Research objectives, context, and analysis

The aim of this case study was to introduce a new way to develop lecture teaching and learning, to capture students' improvised lecture notes as a means of accessing and sharing their unique interpretations and ideas. Mobile technologies and social software enabled students' thinking and learning to be captured and shared *as it happened*, thus making it available as a resource for further thinking, discussion, and learning within the wider group of students.

Improvising ideas and writing shared lecture notes with mini-laptop computers change the cultural ecology of the learning environment during lectures. Within a cultural ecological perspective, the research questions investigated in this study were: (1) what is the nature of the shared lecture notes produced by the students (i.e. types of lecture notes and their contents); and (2) what were the experiences of the students in creating and sharing lecture notes. The first question offers an insight into the relationship between storage, encoding, and improvisation. The second question aligns with the Internet generation discussion, providing an insight about Internet generation students and their use of social software in higher education.

Research context

Each student was provided with a mini-laptop computer. The computers had access to the Internet and QAIKU software so that students and lecturer could see each other's contributions. In the first session, the idea of the shared notes was introduced to the students. They were briefed on the use of mini-laptop computers and QAIKU software as a shared environment. It was explained that students' notes were potentially a resource for further discussion and learning during the course and afterwards. Along with shared notes, students were also permitted to ask questions and pose their ideas aloud.

The social software used to create the shared online environment, QAIKU (<http://www.qaiku.com>), is a so-called micro-blog (cf. *Twitter*). QAIKU provides possibilities for making notes with an individual maximum of 140 characters per note. There is no limit to the number of notes an individual student can write. All students can see each others' notes through the online environment screened on their mini-laptop computers.

Notes come as a list, updating when a student posts a note or clicks the refresh button. QAIKU provides also a facility for students to save their own and/or the group's notes. The lecturer has access to QAIKU during and after the lectures, offering the possibility to see students' anonymous notes. Shared notes were captured as the main data source for this study. The students gave their permission for the notes to be used in research.

To support students' encoding and improvisation with the lecture content, the lecturer provided ready-made paper handouts for them. The idea was that with handouts, students could concentrate on the lecture and write their own unique notes online and in so doing, the encoding function was supported over the storage function (Kiewra 1989).

The study was conducted during eight contact sessions with 12 3rd and 4th year university students taking a course on pre-primary (age 5–7) education as a minor component of their degree at the University of Joensuu (now the University of Eastern Finland). The course focused on child development and education. Details of the course sessions are given in Table 1. These students can be counted as part of the Internet generation by their age. The number of participants in the eight sessions varied between 7 and 12, i.e. this was a pilot study testing the possibility of creating shared lecture notes. The intention is to continue this research and development work with larger groups, building on the results from this study.

Shared notes were produced voluntarily in six different sessions as a part of a lecture series. After each session, the students' notes were saved as text and loaded into ATLAS-TI software. ATLAS-TI was used as a categorizing tool through which codes and quotations from the text material were regrouped for investigating the research questions. Students wrote a total of 367 notes, which they produced for themselves or for sharing with other students.

In addition to shared lecture notes, data were collected from discussions with selected students at the end of the course. Four students were asked to discuss their experiences about the course. Students were selected such that two of them had produced and actively shared many notes, and two of them had produced only a few shared notes. The aim of this discussion was to find out students' ideas about benefits and drawbacks of shared lecture notes. The discussions were audio recorded.

Analysis

Shared lecture notes were analysed qualitatively using both discourse and content analyses. Discourse analysis is concerned with language used in a social context; how we use language in different ways to express ourselves. Discourse analysis is concerned with the ways in which meaning is reproduced and transformed in the text (Roth 2005.) In content analysis, the central focus is on what is being written or said about the matter under consideration.

The discourse analysis focused on types of notes, the kind of notes students produced and their intentions for the notes linguistically and cognitively, for example, to make a question or to establish an interpretation. In the analysis, the categorizations were made by the lecturer, utilizing her knowledge of cognitive sciences, and the content of her lectures and the students' responses to it, i.e. how the quotations express the level of students' learning.

The content analysis was used to capture the kind of information students wrote down. The focus was on the content of the notes and how they related to the content of lessons. The quotations were categorized around core matters, for example, 'child development', 'educational actions'.

Audio-recorded discussion was analysed using an open coding approach picking up students' experiences about the course and the use of shared lecture notes. The aim of the open coding was to analyse students' speech without ready-made categories or concepts, and to analyse discussion directed by students bringing up their own experiences and ideas (Gibbs & Flick 2007).

Results

Different types of lecture notes

Altogether, 367 notes were produced during this study. The distribution of notes between the students indicates three groups based on their activity in producing notes for the shared environment. The first group consists of the most productive two students who produced 253 notes, writing many notes in each lecture. The second group consists of six students who together produced 104 notes, each student writing only a few notes in each lecture. Finally, there were four students who produced only a few notes in total.

Table 1. Schedule of the lectures in which shared lecture notes were used.

Session	Content	Aim
1st session 10 September 2009 8 AM–11 AM	Introduction Theory of development and theory of growing	To achieve a general view of child development and learn to know how the concepts growing and development differ from each other
2nd session 14 September 2009 10 AM–1 PM	Physical and motor development of the child	To learn the main phases of physical and motor developments in the child To learn to take account of the developmental aspects in teaching
3rd session 15 September 2009 10 AM–1 PM	Psychological development of the child	To learn to recognize the areas of psychological and emotional developments To understand the main phenomena in the early phases of school and to find ways to support children
4th session 17 September 2009 8 AM–11 AM	Social and emotional development of the child	To learn to recognize the areas of social and emotional developments To understand the main phenomena in the early phases of school and to find ways to support children
5th session 21 September 2009 9 AM–12 AM	Cognitive development of the child	To know the areas of cognitive development and the links between them To understand the phases of cognitive development
6th session 22 September 2009 9 AM–12 AM	Metacognition	To strengthen understanding of meta-cognition and how to support it in learning contexts
7th session 28 September 2009 8 AM–11 AM	Teacherhood in the pre-school and in the 1st and 2nd grades	To consider the teacher's role with young children and to learn the pedagogical methods to support children in their early years in school
8th session 29 September 2009 8 AM–11 AM	Family support and social relationships in childhood	To consider the families' role in children's lives and how family relationships affect children's lives and school work

Students' notes were generally very short, often consisting of only a few words. Students often wrote key words for making a link with matters to be discussed with the lecturer. Discursively, students formed five types of notes: reproducing lecture content; summarizing lecture content; connecting key concepts; developing lecture content; questions arising from lecture content. In the examples that follow, students' notes are given *verbatim*.

Reproducing lecture content

The notes in this category reproduced core content from the lecture. There were 37 notes where students used the same words and sentence structure as used by the lecturer, typically key concepts from the lecture slides. There were also 11 descriptive notes, for example:

The parts of self-esteem are physical, social and mental.
Development of personality continues for whole lifetime.

These notes were repetitive. They were written by the students as *aide-memoires* about the lecture. The notes were seldom collaborative in their nature.

Summarizing lecture content

Although strictly linked to lecture content, the 94 notes in this category developed the content in the students' own words, often through a summary or concluding statement, indicating that the students understood the lecture content, for example:

The frames of municipality affect for co-operation between schools and homes – how school solve this!
In administrative level, the pre-schools are trying to link closer for the schools (knowledge transformation and co-operation are coming easier).
Learning environment is always planned.

Summaries were constructed around a larger discussion or theme from the lecture or from the PowerPoint slides. The summarized notes indicated the students' level of understanding and their personal views about the issues. These notes included some collaboration, typically involving questions or new arguments.

Connecting key concepts

The 15 notes in this category were mainly for defining and/or connecting key concepts using a combination of definitions taken directly from the lecture and the students' own words. Examples:

Awareness of own cognitive cognition = meta-cognition
Gross motor skills = big movements (running, jumping)
Fine motor skills = hands small movements (writing. . .)

In these notes, students qualified their understanding of some of the concepts introduced during the course. They helped the lecturer identify which key concepts were understood and which needed to be discussed further.

Developing lecture content

The 49 notes in this category combined detail from different parts of the lecture with students' own interpretations of this content. These notes were often applied to concrete educational contexts such as classrooms or interactional teaching situations. These notes included examples of where students had a clear understanding of content, but also where there were misunderstandings and ambiguous links. Examples:

If wrong models are drawn from home, it should be butt into at school. Parents can consciously or unconsciously limit pupils' life.
Planning is often mainly lecturer orientated and thus the evaluation become hard.

In these notes, the students developed new ideas for further discussion.

Questions arising from lecture content

There were 12 notes in this category. The students' questions were directed to themselves, often doubting or wondering about issues raised during the lectures. Examples:

How theory could be applied in concrete situations?
What is my conception about learning? What is learning, what children's learning means?

The notes were collaborative and some questions were discussed during the lecture. The students' questions were particularly useful for the lecturer, providing an insight into student thinking and reasoning, and providing material around which discussion could be structured. The questions also suggest a level of analytical engagement with content on the part of the students.

Content of the lecture notes

In terms of content, students' notes on child development focused on theoretical descriptions. These notes

were based largely on material presented by the lecturer and were mostly descriptive. For example:

Temperament is biological feature, which we cannot affect ourselves.
Motor skill development proceeds in four phases.

Some notes considered concrete everyday situations. These notes included educational actions which were justified or described based on child development matters. For example:

Literature support the development, e.g. in the latent phase.
The rules should be explained for the children -> development of cognitive development

In addition to developmental aspects, students made notes about children's learning. They widely wrote down aspects which are meaningful in 1st and 2nd grade (age 5–7) learning, especially those that are important for successful learning and good school work. For example:

Good social relationships affect for good school achievements.

The notes show evidence of students systematically thinking through content and relating it to what they knew to be meaningful in terms of teaching young children. These notes focus on their development as teachers, and their work in the classroom.

For example, their development as teachers:

I must be persistent.
Logicity in teaching is important because children learn logically. Argument ability.

Their work in the classroom:

It is important to develop the children's meta-cognition.
As a lecturer I need to know the different living contexts: micro- macro- and meso- levels.

These notes were multidimensional in terms of content and thus had the potential to be used widely among the students.

Students' experiences

Discussion with four students provided an insight into their experiences of the course and of shared lecture notes relative to assumptions concerning the Internet generation, especially those concerned with students'

preferences for collaborative learning and using social software (Oblinger & Oblinger 2005; Hartman *et al.* 2007). All students explained that they were amenable to the idea of sharing their lecture notes. They also indicated that they had read other students' notes even between lectures or when preparing for tests. Altogether, the climate during the course and students' attitudes towards sharing lecture notes were positive. However, the practicalities of using QAIKU gave rise to some difficulties and restrictions.

At the beginning of the course, students could download and print the PowerPoint slides made by the lecturer. Students found it inconvenient to write their notes in separate places (i.e. in QAIKU) instead of on the paper next to the slide being dealt with. QAIKU software works like other micro-blogs showing the comments as a list so that the newest note comes first. Even though the target group students belong to the Internet generation, none of them had used the QAIKU software before. All the students perceived the software used as unsuitable for the task because of the way it separated notes from lecturers' slides. One student explained that after lectures, she copied the notes from QAIKU to the PowerPoint presentation provided by the lecturer. Students explained that as they improvise, that is, write notes based on their unique interests at their own paces, the 'list' of notes is sometimes confusing. The students' were unanimous in their view that the software used for making shared notes needs developing and refining so that it is fit for purpose. Students said that lecturers' PowerPoint presentations should be in the software so that notes could be linked directly with the slides, giving a consolidated document at the end of the course. Another problem with QAIKU is that it allows students to make their notes only by writing. Some students suggested that they would also need possibilities to draw lines and other clarifying markings. One student found writing notes with a mini-laptop computer challenging and preferred writing her notes with paper and pencil. There is also the possibility of enhancing the visual component of learning by adding facilities for integrating graphic and video material.

Discussion

This situation reported in this study was the first time that the students and the lecturer concerned had used

shared notes as part of teaching and learning during the lectures. Results align with assumptions about Internet generation students being amenable to expose their own ideas and opinions online (Tapscott 2001). At the same time, results indicate that the practicalities of sharing lecture notes are challenging: only 2 of the 12 students immersed themselves in the active production of notes. The main problem related to technical challenges, especially with the social software used for making shared notes. Even though students belong to the Internet generation, none of them had used QAIKU software before and the software was found unsuitable for the purpose of note taking. The next technical step is to modify existing or develop new software for creating and sharing lecture notes. Nevertheless, the study provides promising avenues for further development, especially given that students accepted the idea of sharing their lecture notes with peers and were willing to read other students notes. Software should allow students to write and draw their notes next to lecturers' slides so that at the end of the course there is a consolidated document containing lecturers' slides and students' ideas, interpretations, and comments.

Although technical difficulties were the main challenges raised by students in discussion, we are grateful to an anonymous reviewer for drawing our attention to the potentially challenging costs or overheads to students in dealing with (1) an additional activity and (2) the possibility of something 'going wrong'. In the first case, the additional activity may cause difficulties for students who are already struggling with the cognitive demands of note taking and/or with the pace at which they have to deal with information. Being unable to keep up during a lecture may also mean that the 'record' generated for review is likely to be inadequate (cf. Piolat *et al.* 2005). Here, some alleviation of the problem may arise from the benefit of the annotations generated by peers which may be reviewed at a later date when there is time to reflect and consolidate. In the second case, difficulties associated with cognitive overload and/or the logistics of note taking may in addition exacerbate already poor note-taking skills on the part of some students. The involvement of the lecturer in reviewing notes offers the possibility of remedial action, but this in turn requires a willingness on the part of the lecturer to address processes of learning as well as content.

Sharing notes in an online environment challenges the traditional way of teaching through lectures. Typically, lectures are based on lecturers' presentation with minimal interaction and collaboration (Oblinger & Oblinger 2005). This is what students expect, and in addition to technical problems, this may also be one reason for the small number of notes during this study, the first occasion they had encountered the process. Writing notes to an online environment and sharing ideas and interpretations in real time during a lecture are forms of collaboration which influence the cultural ecology of learning. Taken as a system, a learning environment is characterized by both stasis and change. Loi and Dillon (2006) have explained that day-to-day interventions in the learning environment cause perturbations that are accommodated through negative feedback. In the case study reported here, the technical constraints placed on the students through the software (and also the problems associated with cognitive overload and the logistics of note taking discussed previously) may be seen as forms of negative feedback, limiting the extent to which they could engage in shared note taking.

Fundamental change to the operation of a system usually requires deliberate and purposeful interventions. It is necessary to cause permanent (but not necessarily irreversible) perturbations that overcome negative feedback and, through positive feedback, move the system to a new mode of operation. At the simplest level, the technical constraints need to be addressed. Students need more time to get accustomed to the idea of sharing their personal notes, and to understand the value of shared notes. Beyond that, pedagogical strategies are required to enact positive feedback and change the cultural ecology of the learning environment. In particular, strategies are required to encourage improvisation and realize collaborative potential. In both cases, greater fluidity is required in transactions between the prior experiences and knowledge of the students, the content of the lecture, and the processes of learning. Shared lecture notes offer the possibility of lecturers aligning and adapting content to a cumulatively developing body of collective student knowledge and experience.

The content of the notes show some promising possibilities for improvisation in learning. In addition to just copying the lecturers' material, some students took a more active role by drawing conclusions, developing

implications, and explaining concepts. Also, students produced questions about difficult topics and questions where they 'continued the ideas of the lecturer'. According to socio-constructivist theories, sharing of ideas and interpretations are essential elements of learning, providing materials for cognitive conflicts, providing possibilities for learning from each other and possibilities for identifying gaps in students' understanding (Limo'n 2001). From this perspective, the notes made by students are an important source for learning. Shared notes contain unique interpretations, misunderstandings and students' personal opinions, evidence of cognitive conflicts and matters for further discussion.

Although students' notes were mainly short, in many cases they reflected the social nature of learning. Students used note taking as a storage function but, additionally, in many cases notes were based either on discussions with lecturer's or peers' notes. Here the notes had the encoding function (Kiewra 1989), building connections between the lecture and other dimensions of the content. Encoding was especially evident in the categories 'summarizing lecture content' and 'connecting key concepts', where in some notes students had picked up essential topics and made connections between concepts. Notes categorized as 'developing lecture content' and 'questions arising from lecture content' indicated students' active participation and understanding in connecting the content of the lecture with their own experiences and knowledge about the topic. These notes reflect students' encoding and improvisation with the content, i.e. working with and developing further the ideas provided by teachers, building new ideas and entities. The notes show evidence of Vygotsky's idea of shared learning and its role in knowledge construction. Through communication during lectures and in the QAIKU environment, students asked questions and produced notes addressing matters of cognitive conflict.

This study concentrated mainly on introducing to students the learning potential of capturing and sharing notes. There remain questions about costs associated with cognitive overload and logistics relative to the benefits of shared note taking. Moreover, the shortness of the notes raises questions about their longer-term utility. It would be interesting to know how useful the notes are at later stages of reviewing when the original context is no longer fresh. Also, the extent to which the collabora-

tive nature of note taking adds layers of context which are meaningful at the time of generation but less so in retrospect. Investigating the ways in which collaboratively generated notes are used by individuals may provide answers to these questions.

Related to these questions is the need to develop pedagogical interventions to support improvised shared notes as a resource for collaborative knowledge building similar to the way that jazz musicians rely on each other in order to make new arrangements in their music. An issue here is how to both encourage and manage fluidity. Initially, the lecture itself is the 'song', but as the students create and share notes (in the jazz analogy as they intervene with the harmonies and melodies), the collective interpretation becomes the 'song'. In this sense, it is also the vehicle for exploring different opinions, alternative interpretations, cognitive conflicts, etc.

Fluidity in the cultural ecology has some profound implications for the role of the lecturer. There are many opportunities, for example: seeing how their ideas are reflected in students' notes and using notes as a resource in subsequent lectures. There are also organizational challenges, for example: should the lecturer use the notes during lectures or after them, and what are the implications of each for the style of lecturing? Should writing notes be voluntary or obligatory, and what are the implications of this for tasks during and after lectures, individually and with peers.

Building on the work reported here, and picking up on some of the outstanding questions raised previously, the next phase in our research and development programme is concerned with a more nuanced look at how creating and sharing notes changes the cultural ecology of the learning environment. The longer term aim is to find strategies that enable lecturers and students to make better use of improvised and encoded notes to support collaborative learning.

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