Using Electronic Voting Systems Data outside Lectures to Support Learning

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Abstract

Many years of research into using Electronic Voting Systems (EVS) within lectures has so far led to the conclusion that EVS is of beneficial value to students' learning by involving students directly in conversation and deeper reflection. EVS researchers have proposed that using the voting data from EVS outside the lecture theatre may also benefit learning. They suggest that an Integrated Learning Environment (ILE) presenting this data would enable students to self-direct their learning and tutors to continue the dialogue from lectures.

This thesis describes the implementation of such an ILE used within an introductory programming course at the University of Glasgow, in order to investigate these proposed benefits. The results show that there are certain benefits to this approach but these are small compared to the benefits within lectures. Only some questions are likely to generate these benefits and only some students seem to have an attitude towards learning to appreciate this. The results also show that there may not be reason to build an ILE to provide these benefits.

This thesis discusses to what extent students use the questions in lectures as an instigator into deeper reflection and to what extent the EVS data can be used to provide an accurate assessment of students' attainment. This thesis also discusses what impact the instructional design of the course has on students' learning and uses this discussion to illuminate the findings. This reasoning leads to suggested changes to the instructional design to provide better opportunity for deeper reflection amongst the students. This suggestion is currently being trialled and judging from early observations seems prosperous.

Acknowledgements

I would like to thank the students and tutors of CS1P for their effort in helping me out by just agreeing to be my guinea pigs, unbeknown or not.

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My final thoughts go to my father, a man of integrity and decency, in spite of everything life offered. How I wish I had known him better.

Declaration

I hereby declare that this thesis is of my own composition, and that it contains no material previous submitted for the award of any other degree. The work reported in this thesis has been executed by myself, except where due acknowledgement is made in the text.

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1 Introduction

Electronic Voting Systems (EVS) have been used widely in large class lectures for many years at the University of Glasgow. By using similar technology as used in "*Who Wants to be a Millionaire*" for "*Ask the Audience*" a lecturer may ask one or more multiple choice questions in lectures and have the students answer anonymously.

By having students vote in lectures using an EVS the lecturer may effectively change the lecture format from one-way imparted information into a two-way communication system (Draper 2002, Draper 2004, Cutts 2004, Cutts 2005, Stuart 2004, Purchase 2004, Boyle 2003, Nicol 2003, Kennedy 2006, Beatty 2006, Bates 2006, Mitchell 2007).

The benefits reported include:

- **High engagement.** By having to vote the students become active for a short period of time, which breaks the didactic nature of lectures (Cutts 2006, Bligh 2000). Students are also more likely to produce an answer to a question when using EVS (Draper 2004).
- **Deep learning.** In order to produce a valid answer students must engage with the material at hand (Draper 2004, Stuart 2003).
- **Formative assessment.** The lecturer get instantaneous perception of students acquired skills and may provide immediate remediation or go into class-wide discussions (Cutts 2004, Nicol 2003)
- **Contingent teaching.** The lecturer can adjust the flow of the lecture from students understanding (Draper 2004).

General to all research is that dialogue, which is crucial to learning (Laurillard 1999, 2002), is enabled in a usually extremely dialogue poor environment. However, given the confinements of the lectures there is a limit to the number of questions than can be asked and to the remediation that can be provided.

Given these impediments it has been suggested that the data from EVS can be extracted and used outside the lectures to improve learning.

- As tutorials follow most lectures, tutors may have to continue dialogue from lectures and this continuing dialogue can be facilitated by the response data.
- Lecturers can reflect over a lecture and provide further remediation which was not possible within the lecture timeframe and may even adjust upcoming lectures

- Students can engage in active reflection and continue dialogue from the lecture in their own study time.

To meet these goals Cutts and Kennedy (Cutts 2005) have suggested building an Integrated Learning Environment (ILE) around the response data to continue dialogue outside lectures and provide further benefits from the EVS.

This thesis picks up where the suggestion stops and explores this assertion in practice. This research aims to build and deploy an ILE within the Introductory Programming course at the University of Glasgow and hereby provide lecturer, tutors and students with an environment to continue dialogue outside the lecture theatre using modern web technologies.

In order to test the hypothesis data will be collected from students' behaviour within the ILE. After collating and analysing this data, students will be approached through an extensive questionnaire. Furthermore, tutors and lecturer will be interviewed about their perception of the improved learning situation. This together with student's final grades will provide enough information to confirm or reject the hypothesis.

Chapter 2 introduces the background of the project from conversational dialogue to students learning. It provides further background on EVS and the impediments to overcome outside lectures.

Chapter 3 outlines the hypothesis and how lecturer, students and tutors may benefit from having EVS data available outside lectures.

Chapter 4 describes the ILE, its design and features, and how it provides a rationale for testing the hypothesis. The chapter also outlines all instruments used to collect data for this research.

Chapter 5 takes a meticulous tour into the findings from each instrument bringing forward the significant findings. Chapter 6 is devoted to the evaluation of the ILE and its ability to reach the intended goals.

Chapter 7 builds on the information from chapter 5 and provides a discussion on student reflection outside lectures, the value of the EVS data outside lectures before finally discussing possible improvements to the instructional design.

Finally, Chapter 8 will conclude on the hypothesis, the ILE and the lessons learned from this experiment.

2 Background Reading and Theory

This chapter will describe the use of Laurillard's conversational framework to enhance learning, and its applicability to large class lectures. It will describe how EVS can be used to support dialogue in lectures, as well as shortcomings hereof. Furthermore, this chapter will step outside lectures and introduce blended environments and their use as a dialogue enabler before describing a proposal for an integrated learning environment using EVS. Finally this chapter addresses student engagement in learning inside and outside of lectures.

2.1 Lectures, dialogue and electronic voting systems

> **Conversation**: oral exchange of sentiments, observations, opinions, or ideas
> **Dialogue**: a conversation between two or more persons. from *dia-* + *legein* to speak
>
> Merriam-Webster OnLine (http://www.m-w.com)

2.1.1 Learning as conversational dialogue

The starting point is the conversation as a conveyer of knowledge and skills from the institution to the student. In order to construct reasonable skills and understanding the student must engage in this conversation with the institution. As students may have different prior knowledge and learning topics are highly advanced, it would be appropriate to build on conversational techniques as a system to mediate learning (Pask 1976, Atherton 2005, Pask 1976-2). In Laurillard's Conversational Framework (Laurillard 2002, Laurillard 1999), depicted below, the learning process is driven by conversation.

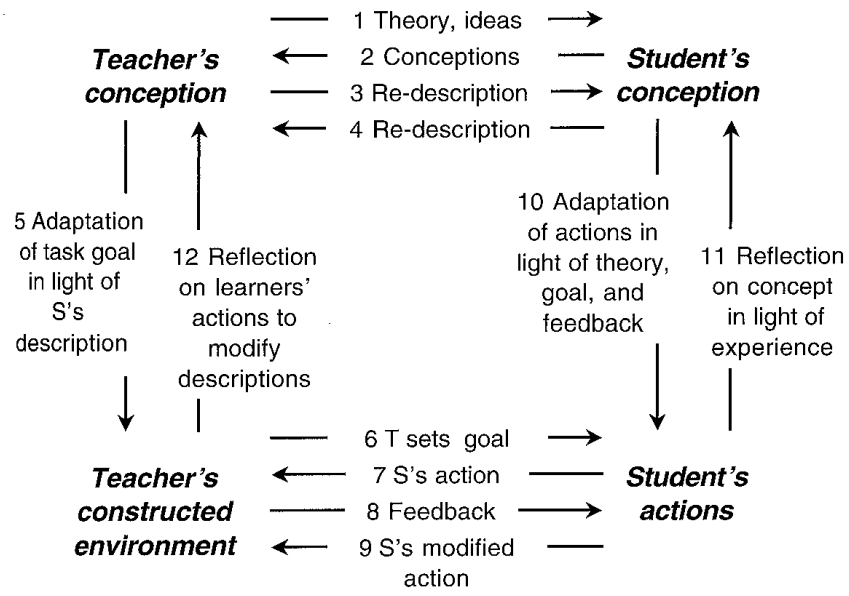

Figure 1 - Laurillard's Conversational Framework

The teacher can initiate a conceptual understanding in the student and, by further setting the goals in a constructed environment, allow the student to train and adapt to this understanding. This is then followed by feedback on these goals by both parties. This allows modification and rearrangement to occur at the conceptual level if necessary for both teacher and student. Example given:

> *A teacher introduces theoretical aspects of a topic, using the teacher's view and student's own knowledge as foundation for understanding. The teacher then sets one or more tasks or assignments to be solved by the student. The student must respond to these actions in light of the theory and prior understanding. By the student's actions and responses, the teacher can provide valuable feedback and if necessary re-assign or re-frame certain tasks. Students must eventually reflect on actions and feedback at conceptual level. This process iterates until conclusion.*

The teacher negotiates the initial conceptualisation and assumes the role of task provider but also monitors and supports feedback.

The conversational cycle is similar to the experiential learning cycles of Kolb (Kolb 1984) in that learning occurs through an iterative cycle of experience followed by feedback. Laurillard make a distinction between the conceptual process and the situated process of Student/Teacher interaction and this would match the distinction by Kolb (Kolb 1984, Atherton 2005-2) between comprehension using abstraction and apprehension using direct experience. Vygotsky (Vygotsky 1986) (based on Piaget) divides conceptualisation of knowledge into two categories, spontaneous concept building and non-spontaneous concept building. Spontaneous concepts are usually constructed using personal experiences and focussed on a specific task.

It would usually be the case that spontaneous concepts are well understood without necessarily being formulated in any way. For non-spontaneous – in particular scientific – concepts, systematic knowledge must be imparted and "instruction and learning play a leading role in their acquisition". "[A scientific concept] starts its life in the mind at the level where spontaneous concepts reach only later" (Vygotsky 1986). This means that non-spontaneous conceptualization starts in generalized or abstract forms and may not necessarily be put into action immediately, whereas spontaneous conceptualization starts in a non-abstracted form and is generalized and reflected upon later. Vygotsky argues that usage of these two systems of concept building develop towards each other as we mature.

Higher Education places emphasis on scientific conceptual understanding and it is therefore vital for the institution to initiate and support a conversation at a conceptual level whenever possible, while still recognizing practical experience. While still endorsing personal experience and action tasks learning in Higher Education, in light of Laurillard's conversational framework, begin and conclude at conceptual level.

2.1.2 Dialogue in lectures

Higher Education today often still uses 50 minutes lectures as a medium for delivering theory to students. Many introductory classes in universities may have lectures with up to 500 students. Lecturing to 500 students is not an obviously conversational task as "there is little opportunity for the teacher to do anything other than deliver the theory" (Laurillard 2002). Most often such a lecture consists of only the lecturer talking and no interaction from the student. To put it in a humorous way: "Lecture: The process by which the notes of the lecturer becomes the notes of the students without passing through the minds of either" (Atherton 2005-3, Gibbs 1992).

Lectures which only imparts knowledge upon students seems at first to have no obvious place in a conversational framework, however Laurillard points out that "the dialogue must take place somewhere, the actions must happen somewhere, even if it is all carried out by the student" (Laurillard 2002). Laurillard place an additional conversational cycle occurring within the student, engaging in a reflective process.

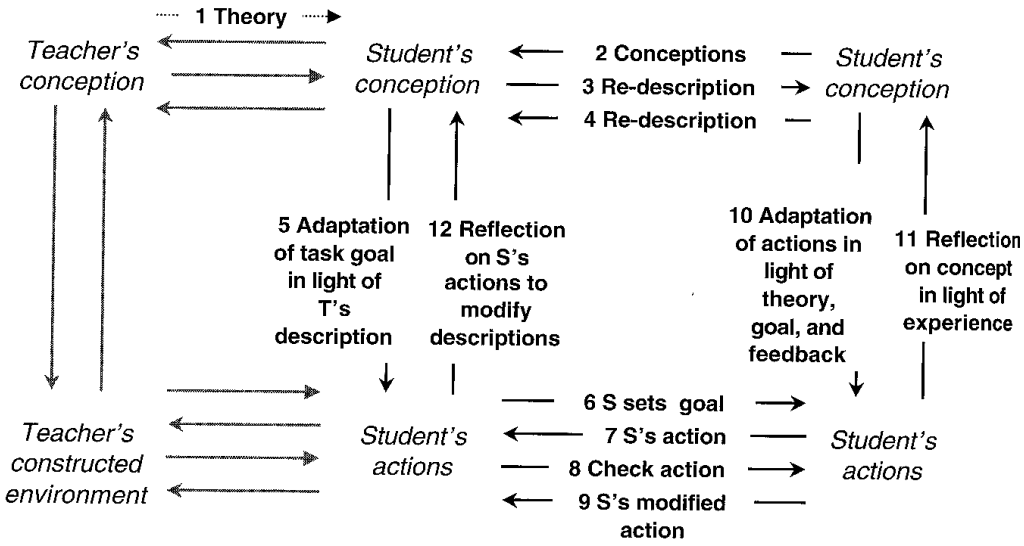

Figure 2 - Laurillard's Conversational Framework with Internal Dialogue

For learning to take place in a traditional lecture, it is the responsibility of the student to engage in an inner conversational dialogue (Laurillard 2002), the teacher does not construct an environment in which to set tasks. Some students may find the topic or lecture interesting and engage mentally and reflect on the information and provide tasks for himself or herself, whereas others will simply take notes (at least, hopefully) without any intellectual commitment. Marton and Saljö (Marton 1976, Marton 1976-2) describes this as "deep" and "surface" approach to learning, and the student applies these approaches differently depending on the situation. However, Marton and Saljö also found that the choice of approach is not fixed, but can be influenced by the lecturer i.e. by upholding a conversational dialogue in the lecture. Cutts, Kennedy, Mitchell and Draper (Cutts 2004-2) identify three main categories where classic lectures fail to uphold a dialogue:

- **Didactic mindset**. Most lectures are planned in advance and the lecturer follows a highly narrative path from which he/she may be unwilling to deviate. Students may struggle just to transcribe vital information and since there may not be time allocated for dialogue they use most of their time just paying attention without reflecting on the material presented.
- **One Lecturer/Many Learners**. In order to engage in a conversational dialogue, the lecturer must get an understanding of the fundamental understanding of the individual in a lecture. Students are often reluctant to speak out in lectures, afraid of being wrong or looking stupid. The lecturer can probe the students for responses, but these may not be very representative of the entire class and may not even be relevant for them. There seems to be no

way for the lecturer to effectively gauge the consensus and understanding of all students.

- **Student initiated dialogue**. The lecturer may invite questions during the lecture, to which perhaps only the bravest dares to answer. As contradictory as it should perhaps be, only a few students actually ask questions for further clarification or reflection during a lecture. Students seem to give silent consent to the didactic mindset.

Research on lectures has been extensive, and as such it is possible to apply different methods and techniques, like buzz groups or questioning, in order to promote a more active learning (Gibbs 1992, Bligh 2000) and increase feedback (Laurillard2002). Within the last decade however, use of technology in society has increased, and this is also true in class rooms. This may change the format of the lecture into a more dialogue-centred activity. Some research has used technology to alter the lecture format (Draper 2002, McCabe 2003, Boyle 2003, Nicol 2003, Dufresne 1996, Crouch 2001, Novak 1999), whereas others use technology to support or enhance the classic lecture (Draper 2002, Stuart 2004, Poulis 1998).

2.1.3 Electronic Voting Systems (EVS)

Electronic Voting Systems (EVS) also known as Audience Response System (ARS)/Group Response System (GRS)/Personal Response System (PRS) are a very simple technology enabling students to vote on multiple choice questions (MCQ) (Purchase 2004, Mitchell 2007). EVS have been used extensively at University of Glasgow in a diverse range of courses and modules (Cutts 2004, Stuart 2003-2004, Stuart 2004, Draper 2004). The hardware used in University of Glasgow is commercially available (http://www.gtcocalcomp.com/), but the precise software and hardware combination and capabilities are designed and implemented locally (Mitchell 2007).

EVS allows students to engage into dialogue by having 1) the lecturer ask a question to the audience, 2) students reflect on the question and conceive an answer; 3) submit this answer to the lecturer using the EVS. The lecturer can see the summary of responses and can 4) process this information to see if remediation is necessary. The technology in itself seems little different from a lecturer asking a question out loud and counting show-of-hands, except that students submit the answer electronically. However, the consequences of using an EVS to ask questions are:

- **Anonymity**. EVS allows the individual response of a student to stay anonymous, which increase the likelihood of students working out an answer (Draper 2004). This anonymity seems to break down the barriers of social de-motivation for answering. In fact students report they are twice as likely to

attempt to construct a valid answer when using EVS rather than show-of-hands (Draper 2004).

- **Interactivity**. Using EVS to answer a question tends to break-up the lecture at least for the duration of the voting. These small periods of interactivity may help students to sustain attention and engagement throughout an entire lecture (Cutts 2004, Draper 2004, Atherton 2005-3). In a survey through 6542 students test data in an introductory physics course, Hake found that any form of Interactive Engagement did increase the learning outcome of the student (Hake 1978).
- **Speed and accuracy**. If a lecturer was asking a question using show-of-hands in a lecture with 500 students, it would be impossible to get a precise count without spending too much time counting, and hence the perceived response is inaccurate and in the worst case wrong. The technological nature of an EVS makes it possible to gather results in a timely and accurate manner (Purchase 2004, Mitchell 2007).

EVS can be used by lecturers in many ways during lectures to engage the students. The following is a list of some example usages, but it is by no means exhaustive.

- After covering a topic, the lecturer may ask one or more questions of the students to gauge their understanding of this topic. Using the response, the lecturer can from the response decide to further elaborate/remediate, or continue to a new topic. This makes the lecture more contingent on student understanding.
- Practice a set of exam multiple choice questions with the students to revise topics and give the students an understanding of the exam. This is most often done in a specific lecture close to the end of term.
- When starting the lecture, the lecturer may present the students with a list of topics to cover and have the students select which one to approach first. This gives the students power to decide what is being lectured, which may increase their interest and hence their engagement.

Between 2001 and 2003 EVS have been used in eight different departments at the University of Glasgow with class size ranging from 18 to 500 students. The number of sessions in each module in which the EVS was used range between one (a one-off experiment) to 40 (every lecture) (Draper 2004). The conclusion of using EVS was that “this equipment does provide a modest but worthwhile augmentation in the quality of the learning and teaching in lectures in the opinion of both learners and teachers” (Draper 2004). The most elaborate use of EVS at the University of Glasgow has been within

Computing Science department where an EVS has been used in every lecture of a large class since 2001.

2.1.4 The Introductory Programming Course at University of Glasgow

The Introductory Programming (CS1P) course at University of Glasgow has had a high number of students each year ranging from approximately 450 in 2001 to 185 in 2005. Introductory Programming is the first module that students encounter in any of the Computer Science related degree courses at University of Glasgow. Most students have at least some prior knowledge of programming, but some have never programmed before (Cutts 2001). Introductory Programming requires a conceptual understanding of programming as well as actual programming skills. The skills must be practiced and the concepts must be understood so the module requires an equal share of “hands-on” (active) and “heads-on” (conceptual/reflective) (Hake 1978).

The module consists of 24 lectures, six one-hour tutorials and six two-hour lab sessions. The tutorial groups consist of around 15 students working on concepts, tasks and assignments. The tutorial groups extend to the lab sessions, in which time is usually spent in front of the computer. The module has one lecturer and a staff of tutors supervising both tutorials and lab sessions.

In order to pass the module, the student must be able to program a computer reasonably well, but often more import the student must demonstrate problem solving skills. Even though students may have had prior programming experience, “the university course is ultimately aimed at problems of a larger magnitude and so [the student must be] willing to learn the new techniques on offer” (Cutts 2001).

For some students, programming is a new skill to acquire whereas for others, programming is a further scientific conceptualization of previously adapted skills. Some students must work hard with the basic skills whereas others can transcend into further conceptualization. This can tend to split the students into groups and influences the students’ perception of the benefits of any lecture. To some a lecture may seem repetitive and boring whereas to others the topic may be too difficult or over their head.

2.1.5 Dialogue in CS1P

Lectures in CS1P have most often been used to introduce new concepts and to try out new skills. These concepts and skills have then been taken into tutorials and lab sessions where assignments and questions have been worked out by students individually and in dialogue with their tutor. Tutorials often continue the dialogue from lectures, this time

between tutor and students. Tutors become aware of lecture content from the lecturer as well as from the students. Tutors have the responsibility of marking the student's progress and report this back to the lecturer. This allows the lecturer to revisit areas for further conceptualization and clarification.

The split between lectures at a higher (conceptual) level and tutorials and lab sessions at a lower (practical) level resembles Laurillard's model as the conceptual dialogue and the situated learning. However, there is no real dialogue in the lecture and hence lecturer cannot get feedback in a timely manner. This makes it hard for the lecturer to adjust the conceptual learning.

2.1.6 Use of EVS in CS1P to support dialogue in lectures

For lectures to become other than factual regurgitation and actually engage the students in deep understanding from which the lecturer can get valuable feedback the lecturer must endorse and most often initiate a conversation. The articulation/re-articulation between lecturer and student can be viewed using the model below, a simplification of Laurillard's conversational model as used by Cutts et al. (Cutts 2004, Cutts 2004-2, Cutts 2005, Cutts 2005-2)

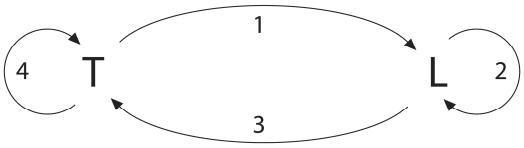

Figure 3 - Simplified Laurillard's model

Within the learning situation the teacher (T) imparts knowledge and skills to the learner (L), and asks engaging questions (1). The learner reflects upon this and formulates a proper response (2). The response to the lecturer (3) gives the lecturer the ability to perceive current understanding and he can reflect upon their current understanding in relation to the intended learning outcome (4). For as far as the lecturer find this appropriate, the lecturer may engage in further questioning or remediation, thereby starting a new cycle (1) again. EVS have been used extensively in CS1P in the last few years to facilitate this dialogue. The lecturer asks a question using the EVS (1). The students formulate and contribute an answer (2+3). The lecturer can then see the distribution of answers as a histogram and he can reflect upon it (4) and choose to continue the dialogue as appropriate.

The format of the lecture in CS1P has not been changed radically after introducing EVS. The lecturer covers a topic by presentation first, and then asks a question using EVS and remediate over this, before going on with the next topic. The lecture is structured

so that three to four prepared questions are asked within each lecture. One of these questions is usually at the very beginning of the lecture with the intention of engaging the students early on. This format was chosen because the lecture did not have to be radically redesigned to incorporate EVS questions and the lecture would not be completely dependent on the technology either.

From the research of Kennedy, Cutts and Draper (Kennedy 2006), the benefits of using an EVS in this format fall into two predominant benefits on teaching and learning.

- The first is **provision of feedback**. The lecturer is able to get feedback about the students from the EVS responses, and can therefore support dialogue. Secondly the lecturer can interactively change the lecture based on the feedback and can by this provide a more contingent teaching. The student may also get formative feedback. The lecturer can choose to show the result of voting to the students (most often as a histogram), or provide oral feedback based on responses.
- The second benefit of using EVS is the **promotion of active learning**. Students move from being passive bystanders in lectures towards a more active role. EVS can be used as a starting point for peer-instructed learning or class-wide discussions (Nicol 2003), but even in its simplest form it activates and engages students in the lecture (Bligh 2000).

2.2 Outside lectures

Dialogue and EVS are not the topics of this research but the foundation on which it stands. Rather we must establish an understanding of the holistic learning possibilities outside of lectures using EVS technology. This chapter therefore describes some of the limitations of EVS inside lectures, and explains how EVS can be extended outside of lectures.

2.2.1 Improvements to dialogue in lectures using EVS

Even though EVS allow a certain amount of dialogue in lectures there are still areas in which the dialogue could easily be easily improved (Cutts 2004-2, Cutts 2005).

- **Time for response**. When the lecturer sees the result of the vote, he or she must immediately decide whether or not to remediate and how much remediation would be necessary, whether or not to provide remediation for all discriminators or just the popular options.
- **Time for re-questioning**. If the students did not respond as the lecturer expected the lecturer could choose to elaborate and perhaps ask additional

questions. These questions should preferably be prepared in advance, as improvised questions may not always be a good idea (Cutts 2006). However, due to the didactic nature of the lecture this is rarely the case, and hence the dialogue is not continued beyond the initial loop.

- **Active reflection for students**. The students should sometime use the questions as indication of their deeper understanding, and as such the student should sometimes ask additional questions to further probe understanding. Since the EVS can only collect votes they do not support these additional questions, and students will not engage in this dialogue for usual reasons.
- **Student presence**. Not all students in a course are necessarily in the lecture theatre when the lecturer asks a question. The results of any vote therefore do not reflect the understanding of all students on the course, only the students attending the lecture. The lecturer may falsely believe a general level of understanding may have been reached when in fact it may not be so for all.
- **Continuing dialogue**. Most often the content of a lecture is revisited in the tutorials and in the lab work later on. Therefore it would be best if the tutors had an understanding of what was covered in the lecture, and how well it is understood by the tutorial group. As correctly as the EVS reflects the understanding, this response stays in the lecture theatre and is only reflected upon by lecturer and students.

This has led Cutts et al (Cutts 2004, Cutts 2004-2, Cutts 2005) to describe some ideas for reusing response data from EVS, as discussed in the next section.

2.2.2 Integrated Learning Environments using EVS

In an article evaluating the usage of EVS, Cutts and Kennedy (Cutts 2005) pick up the idea from a previous article (Cutts 2004-2) in which the response data from EVS is extracted and used outside of lectures in order to maximize dialogue. Cutts and Kennedy go beyond the idea and describe an integrated learning environment, such as depicted below

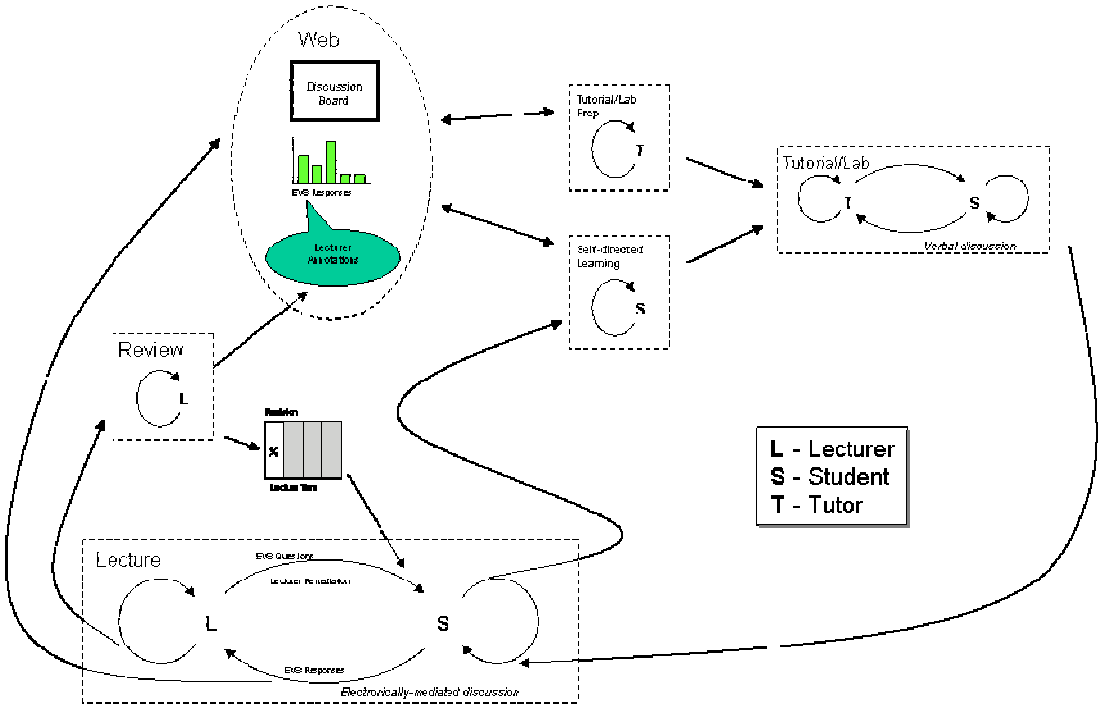

Figure 4 - The Integrated Learning Environment

The proposed Integrated Learning Environment (ILE) starts in the lecture by having electronically mediated discussion using EVS. After each lecture, the response graph is published on the web and linked with a forum for additional dialogue. The lecturer uses some time to review the questions and provides an annotation for the responses. Students who have answered the question can see the response graph and the lecturer's annotation, but only if the student have answered the question. If the student has not answered the question already (i.e. not present or no handset in lecture), the student must attempt an answer before given access to the record.

The students may leave the lecture and access the EVS record to determine to which areas of the material they should pay most attention. They should bring this into tutorials to get a deeper understanding of the topics. If a student has problems with understanding something from a question, he/she can ask a question on the related forum and get help from other users of the forum, including lecturer, tutors and other students. Even though it appears to work in a cycle between two lectures, the information is available throughout the course, and hence the students may revisit earlier lectures to assess, reflect or revise on the questions.

Tutors can see the EVS record for the class as well as for the students in the specified tutorial group. This makes it possible for the tutor to continue the discussion from the lecture in the tutorial. Furthermore, during the semester the tutor can gradually become aware of students struggling with answering, and approach these and offer pastoral care, even for students who do not speak up voluntarily. The lecturer allocates some time in the

upcoming lecture for revisiting the material, which together with students' attained learning should help clarification.

For the ILE to work it must be possible to link the response from an EVS vote with an individual student. In CS1P all students sign for a handset at the beginning of the semester, and this handset carries a unique identification.

2.2.3 Initial evaluation of ILE

In 2004 a first implementation of the ILE was carried out for the CS1P course. This implementation was later evaluated by McDermid (McDermid 2005), but the evaluation was mainly an evaluation of the usability of the computer system rather than an evaluation of the learning benefits. However, it did contain useful information as such. The interface was reported to be "bland and uninspiring" and there was a decrease in logins during the semester. Students used the ILE mostly for viewing lecture annotation rather than asking questions regarding learning, but also reported mostly that they had either benefited (2) or was neutral (3) from its use, with the median value equals 2. Correlating usage with the perceived difficulty of the course suggested that students who found the course tough were less likely to participate. When some students were presented with a prototype of a similar but further advanced system, 8 out of 10 students reported they were more or much more likely to use the system.

2.2.4 ILE as a blended learning environment

From the sparse results of the McDermid report (McDermid 2005), it seems likely that such a system could be beneficial. Using an ILE may surpass the time frame of the lecture, and provide a more persistent tool for students to use. Using web technology together with face-to-face lectures is often termed "a blended learning environment" (Novak 1999, Derntl 2005), and results in these areas are gradually emerging. Novak et al (Novak 1999) describe one way of using web resources interactively together with lectures, coining the phrase "Just-In-Time Teaching". Even without changing the lecture format too much, it is possible to benefit from blended environments, such as publication of lecture notes (Grabe 2005), but this seems mostly beneficial when students are not attending the lecture. Cutts et al (Cutts 2004-2) believe that "the combination of the response data and the lecturer's material constitute a record of the lecture as delivered to a particular class. This is a valuable and immediate resource".

2.3 Student learning

So far we have been looking at the conversation from the lecturer's viewpoint. This section describes issues related to the student in an EVS environment.

2.3.1 Student engagement in lectures

In a traditional lecture it is the student who "must do the work to render the implicit structure explicit to themselves" (Laurillard 2002). They must be able to focus on the material presented and reflect on this. However, some students do not engage much, but rather transcribe the lecture as notes. Marton and Säljö (Marton 1976) describes the differences in level of processing as surface-level and deep-level processing. Amount of workload, motivation and time pressure may be among the factors for choosing either approach, but more importantly "the students did adapt their way of learning [surface/deep] to the conception of what was required of them" (Marton 1976-2). When asking questions in lectures using EVS, most students think through and decide on an answer rather than wait to see consensus (Draper 2004). This would imply that using EVS changes the student conceptions enough to engage in a deeper level of processing. The student also reported an increased willingness to contribute since the individual responses were kept anonymous.

A benefit for the students from using EVS is the feedback of their own understanding (Draper 2004). According to Cutts and Kennedy (Cutts 2004-2), the students should also use this feedback to determine the areas to which they should pay most attention. By publishing individual and class votes on the ILE, students would be able to use this feedback to direct their own learning.

2.3.2 Student engagement in dialogue

When the lecturer asks an EVS question in lectures, it presents the student with a goal-action-feedback cycle (Laurillard 2002) insofar as the student is presented with an action task, which must meet some attainable goal, and the student will receive feedback after voting. This goal-action-feedback cycle is easily understood by the context of the EVS question.

The lectures usually engage students by imparting knowledge, examples and conceptual discussions but the lecturer does not engage students in any concrete tasks during the lecture. Concrete experiments are usually performed in lab sessions later on. Students are therefore only able to grasp by comprehension and intention in lectures (Kolb 1984). For students to get deeper understanding they must externalise actively in order to get concrete experience from which they can apprehend the topic.

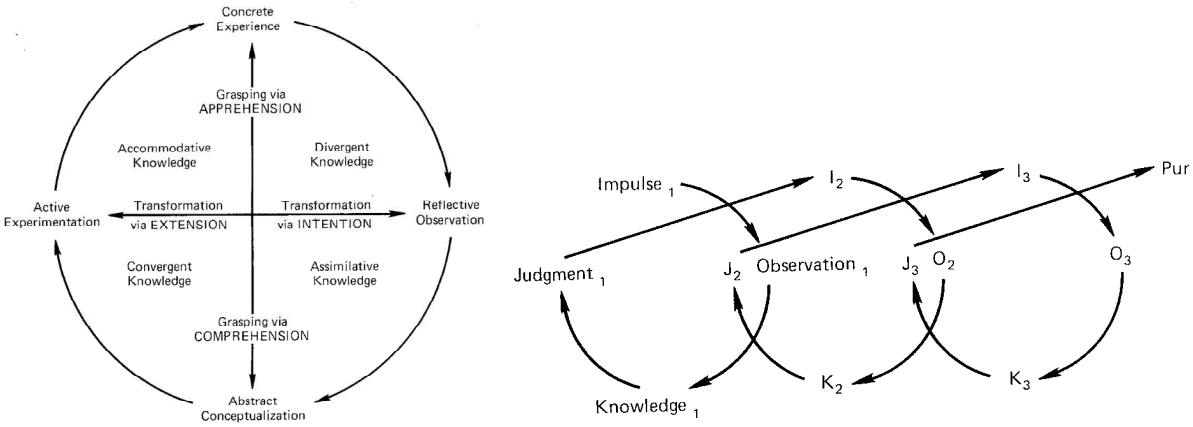

Figure 5 - Kolb's Learning Cycles (left) and Dewey's Model of learning (right)

Dewey's Model of Learning (Dewey 1938) and Kolb's Learning Cycles (Kolb 1984) both stress the continuation or re-iteration of the principles of activity and conceptualisation for deeper understanding. Students are provided with a conceptual understanding in lectures which later is turned into actions in tutorials and lab session. After actions have been carried out the student would have to reflect on the concrete experiments again to strengthen the conceptual understanding. This repeating reflection which exists internally in the students might be summarized with the tutor or by repetitive topics inside the lectures.

Students usually have a large curriculum to meet. The instructional design of lectures and tutorials usually disallow for additional iteration and conceptualisation and this reflective process is therefore often left for the students to carry out.

2.3.3 Student reflection outside lectures

Outside lectures, students must regulate their own learning. They must determine when they will study, where they will study, with whom they will study, what they will study, how they will study it and especially why they will study. These are all attributes of self-regulated learning (Winne 1998, Zimmermann 1997).

From seeing just the response to a question, it may no longer be obvious "what is required of the student", and outside the lecture there is no longer a dialogue between the student and lecturer. This seems even more apparent for the students who did not attend a lecture. In the context of an in-lecture EVS question the student often has an implicit understanding of the surrounding topic or learning goal. Lectures and tutorials work towards an understanding of these learning goals without necessarily making these

learning goals explicit. According to Chi et al (Chi 1989), student who can relate actions to principles are shown to perform better. Catrambone (Catrambone 1995) also found that when students were presented with sub goals during problem solving examples, they were better at transferring this knowledge to a new problem domain.

Other studies (Woulters 1996, Bouffard 1995, Morgan 1985) also found that student who were oriented towards learning goals and were able to self-monitor their progress towards the learning goals had a higher academic achievement. Since the conversational dialogue to a student is split between lectures and tutorials and self-regulated learning outside these, it seems imperative that the student have a familiarity with the learning goals. The learning goals are usually formulated in the form of learning objectives. These can be and are most often used for formal assessment of the student's skills, but they may also be provided to the students to direct his or her learning in multiple learning environments.

2.3.4 Student absence from lectures

Students are not enforced to be present in lectures. The participation in lectures is strongly recommended but not mandatory for students. Still not all students participate in every lecture. Some students may encounter illness, unavoidable conflicts etc. These students lose the potential learning from the lecture. EVS questions asked in lectures may constitute as a persistent record of what occurred in the lecture. Cutts et al (Cutts 2004-2) believe that "the combination of the response data and the lecturer's material constitute a record of the lecture as delivered to a particular class". For these reasons the EVS data may be beneficial for students not attending lectures.

2.4 Background summary

Conversational dialogue is the cornerstone for students to comprehend scientific concepts in Higher Education; however a conversational dialogue is not always possible in a lecture-based education with large class sizes, because of its didactic nature. At the University of Glasgow in CS1P conversational dialogue is traditionally supported outside lectures through the use of tutorial and lab sessions where tutors have closer interaction with the students.

Within lectures EVS has been introduced, which allows the lecturer to support a conversational dialogue in lectures, and thereby partly to overcome the impediments to dialogue. EVS helps lecturer and student to get an understanding of their current comprehension and learning in the lectures. However, the lectures are still limited in time, students may not be present at lectures, and students may have to engage further with

the material before fully comprehending this. It has been suggested to introduce a blended learning environment based on EVS data, where EVS questions ties lectures with tutorials and students' self-directed learning. For students to appreciate this they should be made aware of the learning goals and objectives of the lecture.

3 The hypothetic benefits

As chapter 2 has shown, existing research suggests that using response data from EVS outside lectures will be beneficial for learning. It may bring more coherence between lectures and tutorials and it can enhance reflection for student and lecturer alike. This means that response data from the EVS system would after lectures be distributed to lecturer, students and tutors. By giving response data to these audiences a set of benefits to learning are proposed as detailed below. The purpose of this thesis is to determine which of these proposed benefits are realised in an implementation of an out-of-lecture system.

3.1 Benefits of giving response data to lecturer

The lecturer would already have seen the response data in the lecture. However, providing the response data afterwards will enable the lecturer to provide additional feedback and improved contingency.

3.1.1 Provision of additional feedback

Even though the lecturer provides remediation on EVS questions in the lecture, there may not be enough time in the lecture to address all misunderstandings. This lack of sufficient feedback can be addressed outside lectures. After the lecture, the lecturer can analyze the response data without any time pressure overhanging and provide further remediation to the students if deemed necessary. Secondly, the lecturer can provide remediation for options that only few students chose and which probably would not have been covered in lectures. Even though this feedback is immediately directed towards the students, it may also be given to tutors, to support their upcoming tutorials.

3.1.2 Supporting contingent teaching

By answering EVS questions in lectures, the lecturer may get an indication of the conceptual understanding of the class immediately and not wait for responses later on by tutors. The lecturer may identify confusion about certain aspects and perhaps change upcoming lectures and tutorials accordingly. This clarification may come to the lecturer in a split second within the lecture, but a more thorough thought on this is possible when the lecturer revisits the response data outside lectures.

3.2 Benefits of giving response data to students

In most cases, the students would see the response graph of an EVS question before the end of the lecture. However, they could still receive this information afterwards and gain further benefits.

3.2.1 Provision of formative feedback

When students watch the distribution of answers in a response graph, they get valuable feedback from how others answer the same question. They assess themselves on their answer as well as the distributed of answers from others. This assessment gives the student an indication of how well they are doing right now and provides a formative feedback. From multiple questions, they should also be able to assess their own contribution to learning the course.

3.2.2 Absenteeism

Not all students participate in all lectures. Providing students with access to the response data afterwards would give them valuable insight into the content of the lecture just by viewing the questions afterwards. Furthermore, they could answer the question outside lectures and this answer could be included in the previous response set and provide feedback to lecturer and tutors as well.

3.2.3 Additional reflection

When students answer an EVS question, it is also with the intension of getting the students to reflect on the issues in question. By providing the students with the response data, they should reflect further on the issues addressed in the questions either passively or actively. Passive reflection means treating the question and the responses as a lecture note which may be reread outside the lecture and perhaps acted upon by further study. Active reflection means actively engaging in the material by asking additional questions. Active reflection can provide feedback to lecturer and tutors and increase the dialogue.

3.3 Benefits of giving response data to tutors

The tutors are the only persons not present in lectures, yet still they must continue the dialogue from the lecture. Apart from feedback from lecturer and student the tutor may also use information in the response data to continue the dialogue in tutorials.

3.3.1 Extending the lecture

The tutor may know the topics of a lecture before the tutorial. However the tutor can be given a copy of the questions the students have been asked in the lecture and the tutor can use this in his or her preparation. Furthermore, as well as the lecturer gain immediate feedback about the conceptual understanding of the students from the EVS so can the tutor. Tutors can be given a subset of the answers of the individual students of the tutorial group before the tutorial.

3.3.2 Pastoral care

As the tutor only addresses a smaller number of students in the tutorials than the lecturer addresses in the lecture, the tutor is better suited to help the individual student. By examining the responses of the individual student, the tutor may get an indication of the progress and may be able to help students struggling with the course.

3.4 Benefits of using EVS response data outside lectures

To summarise the descriptions from above it seems apparent that using the EVS response data outside of lectures may provide additional benefits to learning. There are a total of seven benefits from using the data outside lectures depending on the audience.

Audience	Benefit
Lecturer	Provision of additional feedback
Lecturer	Supporting contingent teaching
Student	Provision of formative feedback
Student	Absenteeism
Student	Additional reflection
Tutor	Extending the lecture
Tutor	Pastoral care

Table 1 - The seven benefits of using EVS response data outside lectures

By implementing an Integrated Learning Environment the response data could be made available to all audiences and make it possible to test this hypothesis.

4 The Research

In order to test the hypothesis, an ILE was built and used to publish information from the EVS. By analyzing the behaviour from this system, a clearer picture of the use and benefits from EVS should emerge. Secondly, quantitative and qualitative studies amongst the various users of the system would be used to collect additional data material. This chapter explains the structural composition of the ILE and how it relates to the hypothesis. The chapter then outlines how the hypothesis should be tested using the instruments available.

4.1 The Integrated Learning Environment (Nenya)

The integrated learning environment used for this experiment was based on the ideas in the original ILE. However, there were aspects of the original system which needed to be redesigned to support the hypothesis, and a new ILE named Nenya was therefore designed and implemented.

4.1.1 The initial Integrated Learning Environment

The initial system previously used had a simple interface. Indexed by lecture number, students were able to see the original EVS question together with the annotations which were made by the lecturer immediately after the lecture. Each question was followed by a forum thread for the students to ask additional questions related to the topic. The problems identified by the McDermid report were:

- **Usability.** The interface was reported to be “bland and uninspiring” and in need of colours and graphics. Functions such as user profiles, search facilities, chat and post identification was reported to be missing. Many students also complained that the system only worked in one specific kind of browser and was not cross-browser compatible.
- **Failure to engage.** McDermid suggested that those finding the course tough or very tough were less likely to use the ILE. These users claimed they were unable to see benefits from the system and only found it useful for remediation of specific problems.
- **Hindrance to dialogue.** Many users commented that they were too shy to ask basic questions in case they were ridiculed by more experienced students and therefore did not post.

- **Unrelated discussions.** Another problem with the more experienced students was that they used the forum to ask questions unrelated to the specific EVS question. Students reported they were being "put off" by this and reported a need for a more general forum for these issues.
- **Self-directed learning.** The students saw the ILE mostly as a forum, and not as a tool for self-directed learning. The only way to progress from not understanding something was to ask a question on the forum. Students could only view individual questions and not an overview of their results.
- **Many browsers.** The report also suggested a large number of students only browsing the system and reading the comments. This was seen as no participation and there were no mechanism to investigate these issues.

Based on these issues it was decided to redesign and implement an improved Integrated Learning Environment to test the hypothesis.

4.1.2 Nenya

In order to address previous issues, the ILE was designed differently. From a system which basically listed the questions and contained a forum, Nenya was a more versatile learning environment. It needed to engage students with the curriculum by making links between the questions and the objectives of the course. It would still present EVS questions, but rather as a mean for self-directed learning. There was a need for removing entry barriers for students participating and leave enough room to discuss other matters as well. Issues related to usability would also be addressed. Finally to address the many students just browsing, it would need additional functionality to monitor students' behaviour while online.

4.1.2.1 Underlying model

Instead of just presenting questions, the model behind Nenya comprised of three central artefacts, *questions*, *sessions* and *objectives*. The question artefact would represent an EVS question or any other question asked online. The session artefact would represent lectures and tutorials and constitute a permanent record of this session. The objective artefact would represent learning objectives from the curriculum.

The session artefact was added for students to remember what was happening in the lecture. This would facilitate students not attending, but also for later revision. The initial specification of the ILE suggested that students should use it for self-directed learning. For students to understand the purpose of their actions it seemed necessary to add the objective artefact.

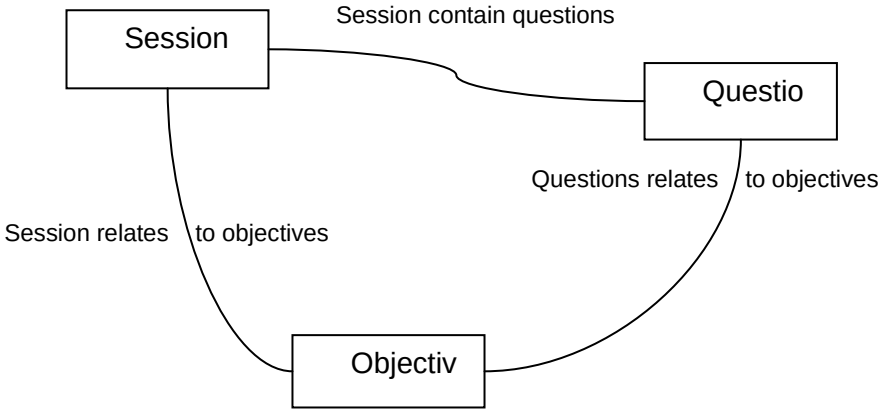

Figure 6 - Underlying model of Nenya

The three artefacts were linked, so it was possible from a particular lecture to identify the objectives used in the lecture, and the questions used in the lecture. Equally it was possible from a question to identify the lecture in which it was used as well as the objectives, which covered it. From the objectives, it was possible to identify the lectures in which it was covered as well as questions on this objective.

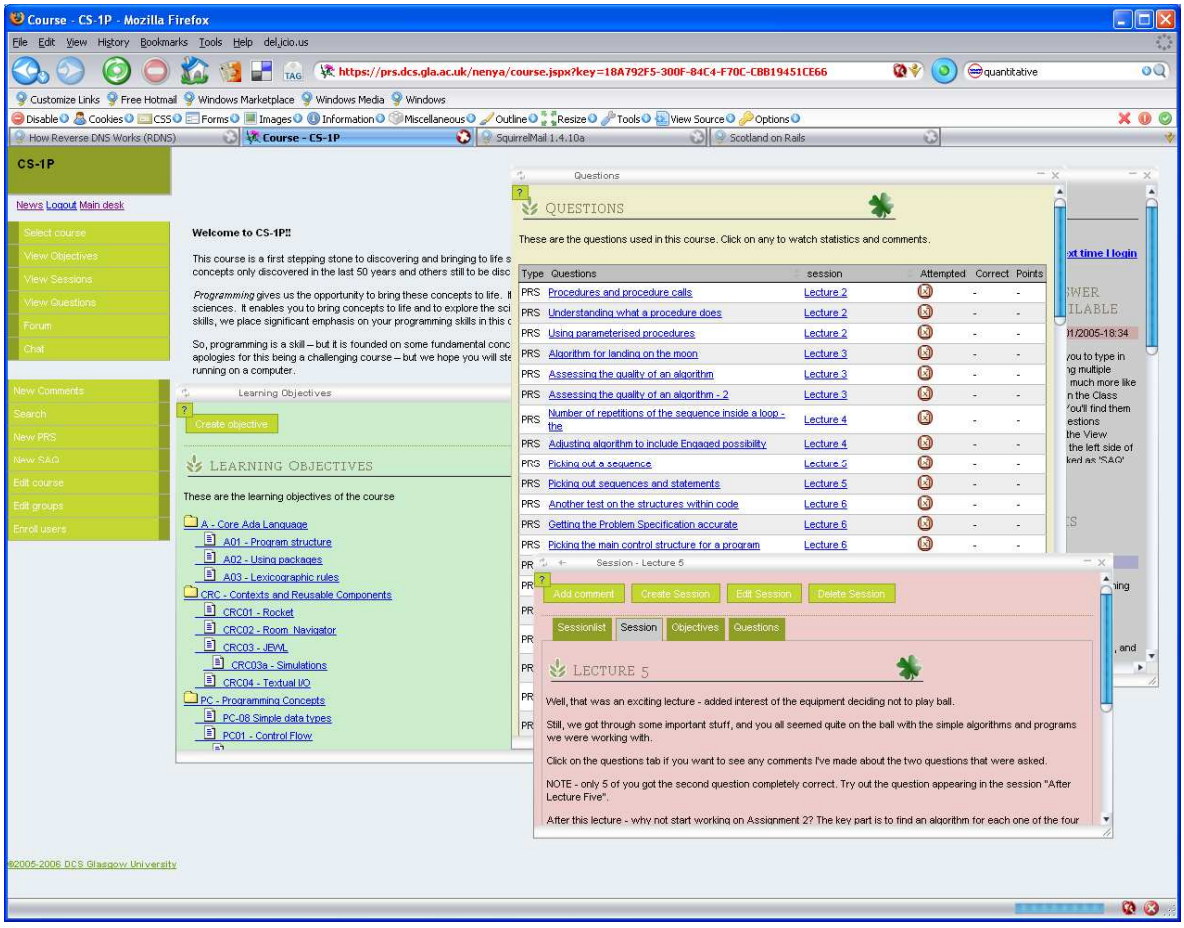

Figure 7 - Screen dump of Nenya

It was possible to get a list of all questions or all session in the specified course. Objectives were organized in a hierarchical structure and presented as a tree. The screen dump above shows a window explaining lecture 5, as well as the tree of objectives and a list of questions in the course.

4.1.2.2 Viewing questions

One important aspect of Nenya was to present the questions to the audience. This was little different from the initial implementation. When a particular question was selected, all information regarding the question was presented to the user. This information was:

- **Question Preamble.** Initial text to put the question into context (similar to lecturer's introduction in lecture) together with links to the particular lecture and the related learning objectives.
- **EVS artefacts.** This was the information provided from the EVS, including question text and the individual options. All the current answers was displayed in a matrix as well as presented as a graph
- **Right/Wrong indicators.** If any option was marked as the correct option, this would be highlighted. If the user was a student his or her answer was highlighted as well.
- **Lecture annotations.** The lecture would have had time to look over the response data after a lecture and could provide additional remediation on the website, including remediation for those options not addressed in lectures.

An example of how a question would look to a student is presented in the figure below.

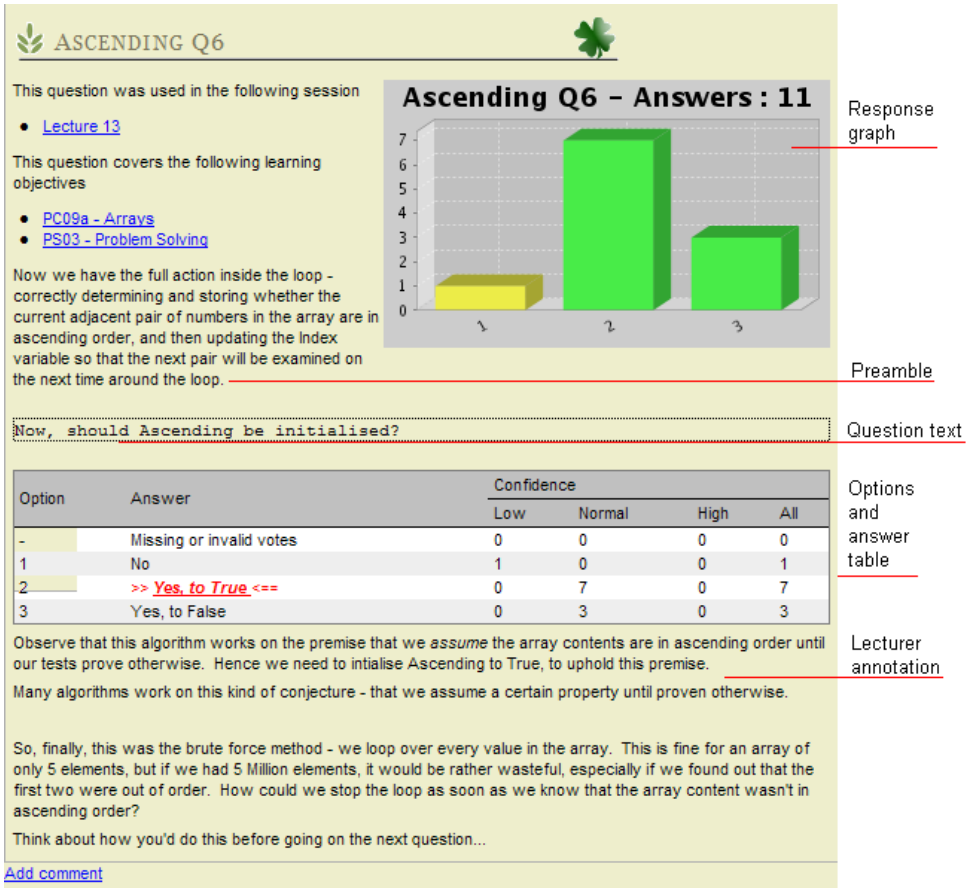

Figure 8 - How a question was presented in Nenya

If a student wished to view a question he or she did not answer in lecture, they were asked to vote before presenting this.

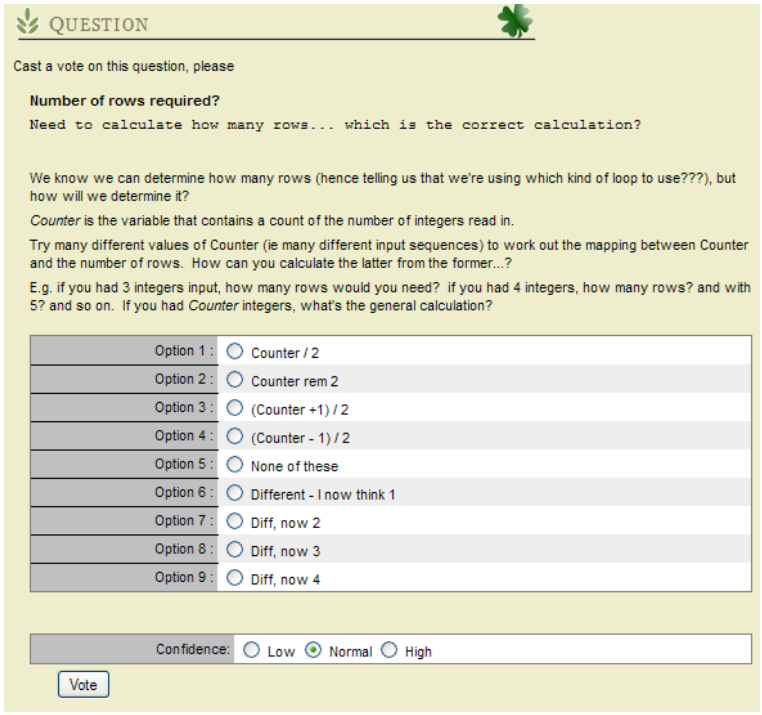

Figure 9 - Answering a question in Nenya

Tutors and lecturer were able to see all questions as well, however, they were not asked to vote and there would be no indication of their vote. Instead tutors and lecturer had an additional tab pane to view. If the user was a tutor, it would present votes from the individual tutorial group, and if it was the lecturer, it would present votes from all tutorial groups.

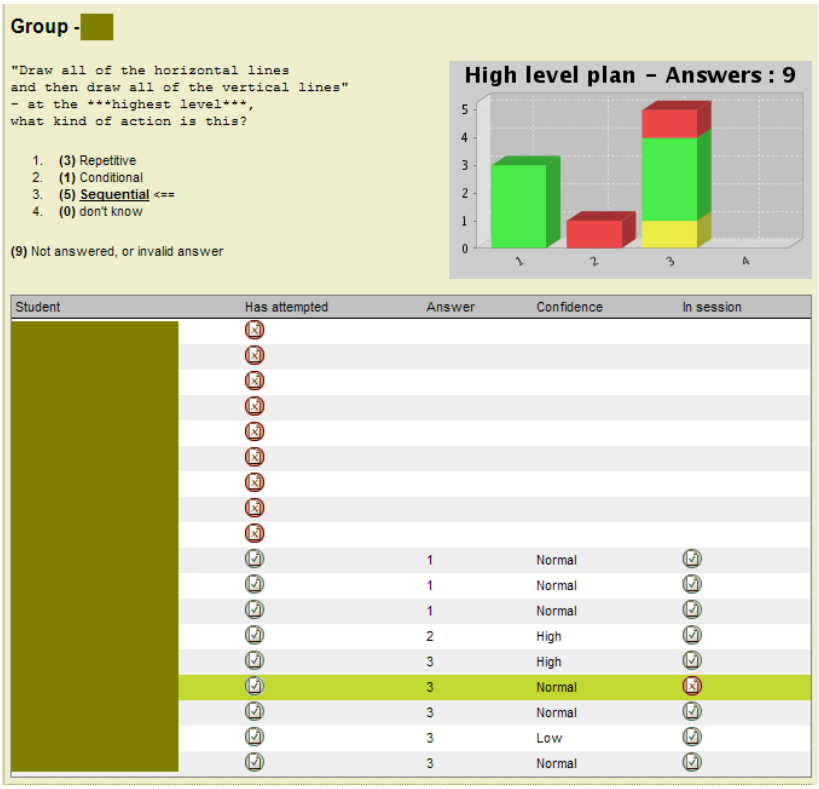

Figure 10 - Additional information for one tutorial group in Nenya

In the figure above, the individual student names have been carefully edited out. Half of the students have answered the question and one of the students has answered using Nenya. However, the tutor can see a list of students and their answers, their confidence levels and whether or not they answered in session or on the web. The tutor can also see the distribution of the answers, including those students in this tutor group who did not answer. The graph presents the information for the selected students only.

4.1.2.3 Adding artefacts to Nenya

The objective artefacts were created and added to Nenya before the beginning of the semester by the lecturer. However, questions and session artefacts were added dynamically throughout the year.

Tutors and the lecturer could create a page for any session held with students. Sessions could be shown to entire class or individual tutorial groups. These session

artefacts contained free-text accounts of what was covered in the session, and could be linked to learning objectives and questions. Even though the initial intent was to represent real lectures and tutorials, it was possible to design “virtual” lectures where students would be introduced to a topic and a set of related questions.

Questions could be added by the tutors and lecturer. The lecturer would usually upload the EVS questions into a central database, and they could then be imported into Nenya. However, questions could also be created manually by specifying the question, the discriminators and the correct option. The difference would be that when importing from EVS the response graph would be visible for the lecturer to see and data was filled into the form automatically. When adding EVS questions into Nenya the lecturer would usually provide a preamble to put the question in context as well as add remediation to the question. These would normally not be necessary if it was a manual question. Finally questions could be related to a session and linked to one or more objectives.

4.1.2.4 Forum and comments

In the initial ILE, the students used the forum for other matters than necessarily related to the question, and so it was not clear if questions were related to this particular question or in general. In Nenya a specific section was allocated for general discussions (forum), which allowed the students to differentiate between the two situations. Since Nenya comprised of more artefacts than questions only, it could be possible for the student to have questions regarding a question, a session and/or an objective, and hence a mechanism was designed for *commenting* on all these artefacts. This commenting mechanism also changed the design of the forum into becoming a topic artefact to comment upon.

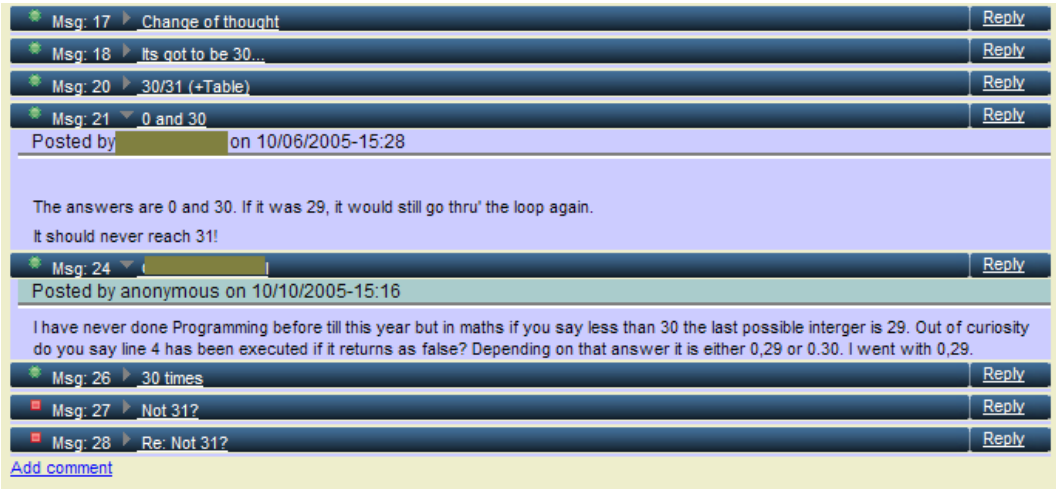

Figure 11 - Comments to a question in Nenya

In order to promote active discussions, two features were added to the commenting mechanism: the ability to comment anonymously and the ability to comment to a limited audience. When students commented anonymously, their identity would not be revealed, and hence they would be more willing to speak out. Their identity was preserved in the system and could be made known to staff if necessary. Secondly, the students could limit their comment to only be shown to their own tutorial group, and hence just to a familiar set of students. The figure above shows part of such a comment list from one of the questions. One of the unfolded comments is posted anonymously (However, the student wrote his own name as title...). Note how the last two comments are private for one particular tutorial group, as indicated by a red square.

4.1.2.5 Usability

The most reported arguments against the original ILE were related to the usability of the system, and hence this was a major issue. The website was designed more dynamically using styles, colours and advanced behaviour. When working with questions, a yellow colour was used. When working with objectives a green colour was used, and when working with lectures a red colour was used. All other aspects used a grey background. Comments from lecturer, tutors and students had different colour and different icons for immediate recognition.

The system comprised of individual windows within the website, allowing the student to arrange these for maximum usage, i.e. it was possible to look at individual questions and information about the lecture at the same time, see Figure 7 - Screen dump of Nenya. When the student provided input, he/she was presented with a rich editor allowing him/her to create a richer response using bold, italic, font sizes and much more.

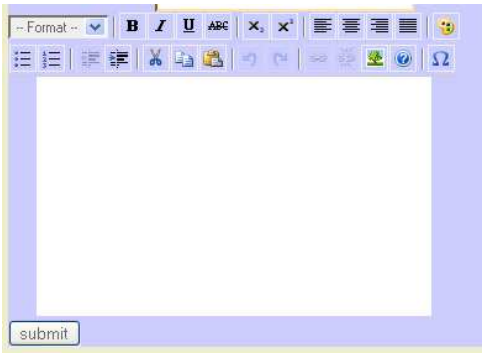

Figure 12 – A ”rich” editor for submitting a comment in Nenya

Finally, all input was indexed, allowing everything to be easily searched and referenced.

4.1.2.6 Tracing

In order to identify the behaviour of students on Nenya, a tracing mechanism was designed and built-in. The tracing registered any action performed by any user at a specific time. The actions included login, looking at questions overview, looking at particular question, answering a particular question etc. and described in the table below.

Artefact	Action	Description
	Login	Recorded when users performed a successful login, indicating their presence in the ILE
Question	Lists all questions	User requested an overview of all questions which for students also meant a matrix of attempts, rights and wrongs on the questions
	View question	User requested an individual question, reading all information including the remediation by lecturer
	View question comment	The user expanded a comment for a particular question allowing the user to read the comment.
	Create question comment	The user posted a comment to a particular question
	Answer question	User was prompted to provide an answer to a question. This indicates a student who has not answered previously
Objective	View objectives	User reads the full description of a particular objective.
	View objective comment	The user expanded a comment for a particular question allowing the user to read the comment
	Create objective comment	The user created a comment about a particular objective
Session	View session	User reads the full description of a particular lecture or tutorial.
	View session comment	The user expanded a comment for a particular session allowing the user to read the comment.
	Create session comment	The user created a comment about a particular lecture or tutorial
Topic	View topic	User read the full description of a particular topic post
	View topic comment	User expands the reply on a topic allowing the user to read the comment
	Create topic comment	The user created a reply to a previously posted topic
	Create topic	The user creates a new topic, asking a new question

Table 2 - Actions traced in Nenya

The actions above were recorded in a central database. Each user could also retrieve a list of the actions he or she had performed in Nenya but could not change anything.

4.1.2.7 Security and stability

As the site included personal and confidential material for the individual, the system was also designed with an advanced security system. It was therefore possible to designate specific behaviour to specific users and groups if necessary. Secondly, the system was built using enterprise architecture, which includes a scalable and transactional architecture to provide a stable system. The system could be easily monitored and configured in real time and the system even logged and reported bugs automagically.

4.2 Educational rationale of Nenya

The overall purpose of Nenya is to provide a virtual environment for all audiences - lecturer, tutors and students - outside the lectures by using the EVS response data as glue. By providing this environment all aspects of the hypothesis can be integrated.

4.2.1 Nenya for the lecturer

The lecturer uses Nenya to provide additional feedback. Immediately after a lecture the lecturer creates the lecture artefact, adding an overall description and linking the lecture with the objectives covered. Secondly the lecturer uploads all EVS questions from the lecture, creating links to objectives and providing additional annotations to the question. The response graph is presented to the lecturer during upload, and the lecturer can therefore use this information to further remediate and add explanation to the options only few students chose. As all this information is published on the site, it becomes available for all students and tutors to see using Nenya as the communication tool.

Nenya does not provide contingency to the teaching directly. However, the time used by the lecturer to upload and annotate the lecture content allows the lecturer reflection and the lecturer may choose to add additional manual questions to seek further clarification amongst the students. The lecturer can comment and post just like any other user, and the lecturer can therefore help students' active reflection by replying to posts.

4.2.2 Nenya for the tutors

Tutors can login to Nenya and get access to the additional feedback from the lecturer regarding previous lectures and EVS questions. Tutors can participate by commenting and posting just like any other user and help active reflection. As all posts can optionally be targeted a specific tutorial group, the tutor can only see posts related to his or her particular tutorial group or global comments. For each question, the tutor can get additional access to the individual results of student votes as well as the group

distribution. This provides the tutor with response data before a tutorial to help prepare or adjust the upcoming tutorial. The votes of individual students are visible to the tutor to allow for any pastoral care.

4.2.3 Nenya for the students

The main focus of Nenya is to provide a Learning Environment for the student. The student can locate any additional feedback from the lecturer on each EVS question. The student can see his or her own vote and therefore assess themselves on each question. A list of all questions further provides a summary assessment of the students. Nenya also facilitates students not attending a lecture. Lecture artefacts describe the individual lectures and link to the questions used in the lecture. Before viewing the individual questions, the student is forced to answer these questions and hence provide additional responses to the existing data.

The major part of student interaction with Nenya is intended to support additional reflection. The student may reflect passively by browsing the site or actively by posting on the site. Since questions, objectives and lectures are related to each other, the student can link a question with the objectives covered and follow the objective onto further questions which may bring additional clarification. The objectives therefore allow students to work towards a goal-orientation. Browsing this information is a passive reflection. Students can actively reflect by commenting directly on an artefact or by using the separate forum. Entry barriers to participation have been reduced by allowing the student to post anonymously and to limit the visibility of a post to his or her own tutorial group. Student posts can be read by lecturer, tutors and peer students, and participate to further clarification and reflection.

4.3 Experimental design

In order to test the hypothesis the following design was put up.

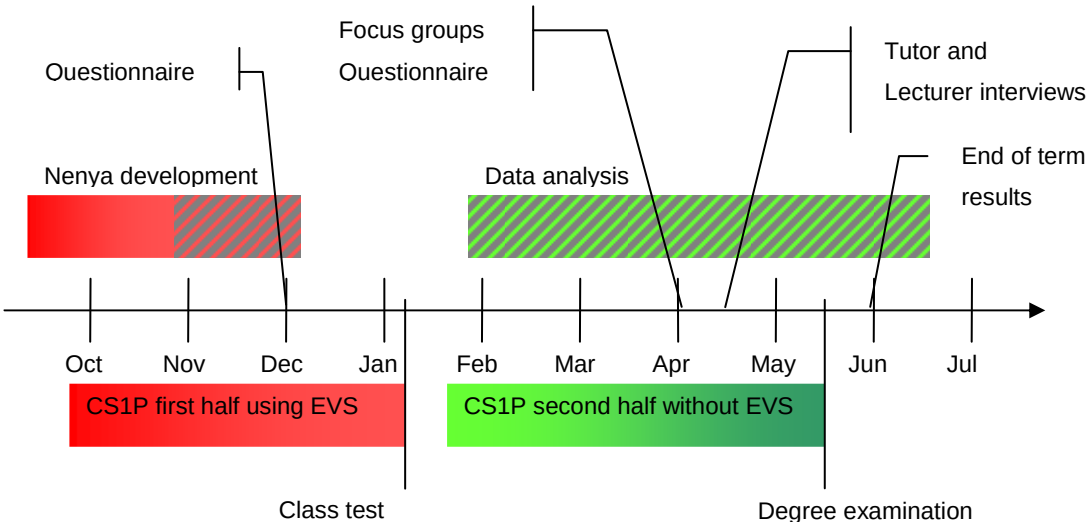

Figure 13 - Timeline of the project

Nenya was implemented to support CS1P, which was being held between October 2005 and May 2006. The course was divided into two parts with a class test in between in January 2006. EVS was only used to support the course in the first half. Before the class test a questionnaire would be issued to the students to verify the usability of the ILE and collect vital information about the generic use of it. After the class test the logs of the ILE would be analyzed for all aspects of student behaviour and to identify any conclusive evidence. After the log file had been analysed students, tutors and the lecturer were approached. Students were approached first with two focus groups and then a second questionnaire. After the second questionnaire tutors would be interviewed and lastly an interview with the lecturer was scheduled. After the course had ended final marks for the students were collected for correlation analysis.

4.3.1 Nenya

A large part of the initial work was building the new ILE, Nenya. It was built using state-of-the-art enterprise application technology and state-of-the-art user interface technology to become attractive to the students. The original plan was to deploy Nenya end of September (Just before first week of CS1P) and have a month of adjustment until finalization end of October (week 4). This plan however was readjusted due to the ambitious nature of the project, and so one version was deployed end of September, and then additional increments were made available during the semester, finishing end of week 8 instead.

Nenya was used mainly to post EVS questions. However, in week 3 a virtual tutorial was created to help the students engage in a particular topic. This tutorial consisted of 17

questions in relation to an exercise called the Hexagon exercise. The questions were available in Nenya only and were optional for the students to answer. All source code from building Nenya can be found on the enclosed CD attached as appendix F.

4.3.2 Questionnaire 1

In December, a two page double sided questionnaire was issued to the students. This questionnaire consisted of 19 questions split between six questions on study and 13 on website usage. The questionnaire included different types of questions, including multiple-select options, open-ended questions, etc. The questionnaire is attached as Appendix A.

Since Nenya was built to overcome impediments to the original ILE as reported by McDermid some of the questions in the questionnaire was an exact copy of questions from the McDermid report. Answers given to these questions would then be compatible with the McDermid findings. Besides duplicating some previous questions, the students were also asked to identify and prioritize resources they used during the learning process, as well as providing additional information. Since the questionnaire had already been in use it was not tested locally before issuing. The purpose of the questionnaire was to investigate the quality of the ILE compared to the previous one with regards to the impediments to dialogue and the usage. It was unclear as to when exactly McDermid had issued her original questionnaire but it seemed reasonable to think it was issued during the semester after week 5 but before week 10. The questionnaire was originally intended to be issued in week 8, however given the delay in finishing the ILE the questionnaire was postponed until week 10.

4.3.3 Data analysis

After the class test had been issued, the log files of Nenya were extracted and analysed. The log was then summarized using different views and analysed as to how students, users and tutors used the system. This analysis would be observational only and the purpose of the tracing was corroborating the hypothesis as best as possible.

4.3.4 Focus groups

After tracing the logs, the students would be questioned again to test the hypothesis again. At first two focus groups each consisting of five students would be held in order to find additional angles to place on the issues before a questionnaire would be issued to more students. The focus groups were held in April after the students were well into second half of CS1P. This decision was made so the students would have a clearer picture on the difference of EVS lectures (with an ILE) and non-EVS lectures. A fellow research student volunteered as a facilitator, and the entire session was recorded on

audio tapes. The content of the focus group was open-ended until results earlier on accumulated, but ended up covering these areas:

- **Learning objectives.** How students determined the extent of their effort.
- **Purpose and value of lectures/tutorials/labs.** In order to identify students expectancy regarding lectures and tutorials and especially their relationship. Lab sessions were included although not initially deemed very important.
- **Purpose and value of using EVS inside and outside of lectures.** Would the students be able to consider the response data useful outside lectures and how.

The result from the focus groups was used as input for the final questionnaire. The introduction used by the facilitator is attached as appendix B.

4.3.5 Questionnaire 2

As the first questionnaire was mostly regarding website usage, a second questionnaire focussing on deeper issues was designed. The questionnaire was published using the internet, which allowed the students to respond voluntarily. The questionnaire was issued after the focus groups in May. The questions were mostly statements to agree/disagree with on a 6 point Lickert scale. This format was chosen to have three positive and three negative correlations, forcing the students out of neutrality. 56 students agreed to answer the questionnaire. Questions in the questionnaire were based on findings from all previous work, and included questions in the following sections:

- **Self-regulation.** A set of questions was adopted for the student to describe his or her own study regulation mechanisms, and their willingness to participate in a dialogue.
- **Nenya.** Three questions from questionnaire 1 were repeated as well as additional questions on their reasoning for approaching the web site.
- **EVS value.** Additional questions were asked about student use of EVS inside and outside of lectures and their perception of this value.
- **Tutorials.** Seven statements were given on the value of tutorials and linking lecture and tutorials using EVS data.
- **Web systems in general.** A few questions attempted to place posting EVS data in contrast to other web mechanisms and web resources.

Student matriculation numbers were collected and consent was given to correlate findings here with student's results. The questions are attached as Appendix C.

4.3.6 Tutor interview

Tutors were given the ability to use EVS data in their tutorial and lab sessions, and an interview was scheduled with three of the tutors. The interview was carried out using email to get accurate quotation and understanding of the replies. The interview consisted of two major topics for the tutors to address. Each topic would start with one citation and then a set of engaging questions. The two topics and their citations were:

- Tutorials as extended lectures

  > *Tutors are supposed to help students reflect on topics from the lecture, however, tutors are not present at lectures. Tutors depend on the lecturer to provide information about the lecture or the students to raise any issues from the lecture.*

- Use of EVS data in lectures

  > *In lectures using handset the response data was published on a website. It was possible for a tutor to see the EVS questions asked, further comments and remediation from the lecturer, the distribution of answers in class as well as individual answers for the tutorial group. The system was created to maximize dialogue.*

The first topic addresses the synergy between lectures and tutorials and their composition of connectedness, whereas the second topic addresses the tutor options provided in Nenya. The questions are appended in Appendix D.

4.3.7 Lecturer interview

After the tutors had been interviewed a session was scheduled with the lecturer allowing him to explain his benefits in this context. The lecturer (Quintin Cutts) were one of the authors behind the original proposition of posting EVS using an ILE and, recognizing that he was already an authority in the subject area, were only asked about the specific benefits of the lecturer. More specifically the questions involved:

- **The benefits of lecturer feedback.** Would it be beneficial to provide additional feedback to students?
- **Contingency based on EVS data.** How was the EVS data to be used for lecture contingency?
- **The lecturer's usage of the ILE.** Which role would the lecturer have in an ILE?
- **The value of assessment using EVS data.** The qualities of EVS data for assessing a range of students.
- **The students' usage of the ILE.** Observations by the lecturer as to the nature of the students' actions in the ILE.

The format of the interview consisted of a set of questions which were sent to the lecturer in advance. The lecturer would provide a written response to the questions, and then the questions were discussed in a one-hour session. The initial questions are appended as Appendix E.

4.3.8 End of term analysis

Additional analysis was carried out when results from CS1P became available. In the second questionnaire the students gave consent to correlating answers with the final marks, which would hopefully add an additional dimension to the data. Students overall grades were determined as follows:

- A 70% contribution from a degree examination in May
- A 20% contribution from two laboratory examinations
- A 10% contribution from a class test in January

Both the degree examination and the class test included conceptual skills whereas the laboratory examinations were mainly focussed on the practical actions. The class test was held in January immediately after first half of the course, which was the part using EVS, whereas the degree examination held in May included material from both halves of CS1P. The analysis would be carried out using the results from the class test primarily and the degree examination secondary, but omitting the two laboratory examinations.

5 Analysis

This chapter contains all findings from the experiment. Each instrument will be thoroughly addressed and all significant observations will be included. All statistics have been performed using SPSS, and reporting is done using the guidelines of (Field 2005). When significance is not explicitly defined in the text it will be presented as * where $p < .05$ and ** where $p < .01$.

5.1 Questionnaire 1

5.1.1 Quantitative analysis

Data from McDermid's first experiment was partially reported using tables in the report. From these tables data has partially been reconstructed for correlation with this project.

5.1.1.1 Between group comparison

As four variables from the McDermid questionnaire were repeated in questionnaire 1, it was possible to see whether Nenya students differed from McDermid students. The four variables were:

- **Coping.** How well the students perceived they were doing in the course. (1=very well, 2=well, 3=ok, 4=tough, 5=very tough)
- **Usage.** How much they used the ILE. (1=daily, 2=2-3 times a week, 3=once a week, 4=once a month, 5=less than once a month)
- **Benefits.** How much they had benefited from using the ILE. (1=definitely have benefited, 2=have benefited, 3=neutral, 4=have not benefited, 5=definitely have not benefited)
- **Ease.** How easy the ILE was to use. (1=very easy, 2= easy, 3=neutral, 4=difficult, 5=very difficult)

Student coping was not expected to change between the two groups, however usage, benefit and ease was supposed to be improved with Nenya.

McDermid

	1	2	3	4	5
Coping	14	29	33	17	7
Usage	14	29	33	6	19
Benefit	6	45	39	10	1
Ease	12	43	35	11	0

Nenya

	1	2	3	4	5
Coping	15	37	32	14	2
Usage	8	14	40	22	17
Benefit	3	36	37	17	7
Ease	13	32	32	18	6

Table 3 - Frequency percentage of common variables

The tables above present the percentage of responses falling into each category. By running a Mann-Whitney test on the data if was not possible to find a significant change in Coping between groups. When analyzing Usage, the Nenya students (Mdn=3) had significantly higher rank than McDermid students (Mdn=2). U=4708, p<.05, r=-.18. This finding was consistent with reported Benefits (U=3958, p<.05, r=-.16) and reported Ease of use (U=3795, p=.05 (1-tailed), r=-.12). This means that contradictory to all predictions, Nenya was rated lower than the original implementation.

5.1.1.2 Correlation between coping and usage

McDermid suggested a correlation between student's perception of how well they coped and how much they used the system. By using Spearman's rho on the data a significant correlation was found (Rs=.275, p < .001). However, this accounts as a small effect, which could explain approximately 8% of the variance. For Nenya, it was hypothesised that there should be no such correlation as the ILE had changed. Running Spearman's rho on the data from Nenya did not yield any significant correlation between how well they coped and how much they used the ILE.

5.1.1.3 Correlation between usage and benefits

The ILE was designed to provide overall benefits for the students and so we needed to investigate if students using Nenya and reporting a higher usage also reported a higher benefit. When students reported a higher score on usage they equally reported a higher score on benefits (Rs=.38, p<.01). However this is a small effect explaining approximately 14% of the variance.

5.1.1.4 Nenya as an immediate resource

It was suggested that an ILE would be an immediate resource for students to use during study. The student was therefore asked to list the resources they used to understand a topic/objective and prioritise these. The result is shown in the table below, where percentage is the amount of students selecting this option and mean is calculated from the priority of the answers.

Resource	%	Mean	Std.dev.
Lecture	98.92	1.75	1.509
Tutorial	97.85	2.87	1.485
Lab	96.77	2.71	1.516
Course book	66.66	6.60	2.743
Other book	31.18	10.72	2.068
Library book	33.33	10.68	3.458
Internet articles	44.09	8.76	3.426
Internet discussions	37.63	10.17	3.034
PRS website (ILE)	73.11	6.96	2.995
Fellow known student	51.61	6.31	3.574
Fellow new student	79.57	5.28	2.064
Tutor in tutorials	81.72	5.16	2.027
Tutor outside tutorials	47.31	8.02	3.467
Lecturer in lectures	37.63	10.54	3.518
Lecturer outside lectures	38.71	10.53	3.821

Table 4 - Student use of resources

From the table above it seems that almost all students use lectures, tutorials and labs as a source of information. More than half of the students would ask their tutor or fellow students to explain matters but also use the ILE and appointed books. Less than half of the students would seek secondary sources (library, internet), but also less than half of the students would ask questions to the lecturer.

When plotting the means it gives a sense of the direction a student takes to learn matters.

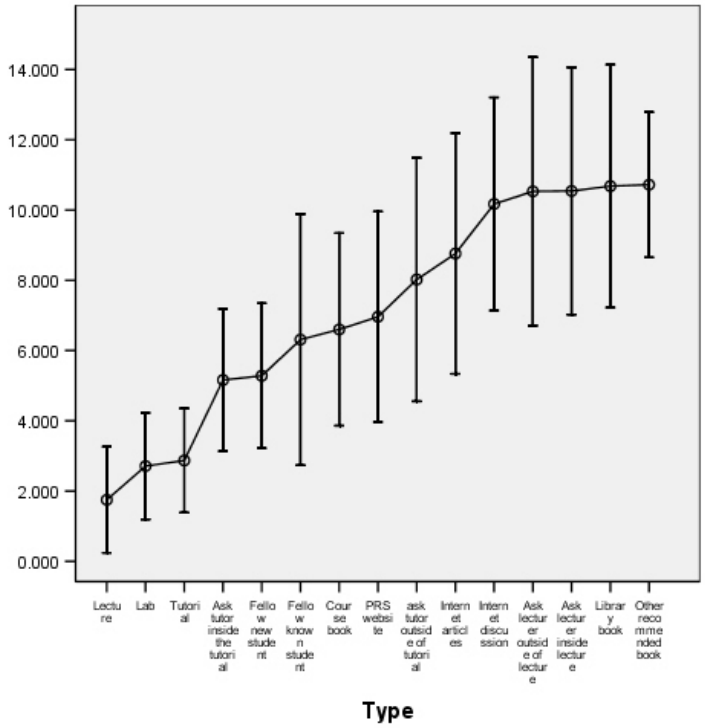

Figure 14 - Prioritised use of resources

Looking at this graph reveals little difference from the percentages, but gives an impression of the variance of the distribution. Lectures, labs and tutorials have the smallest deviation, meaning that they would always be prioritised as one of the first. Note that the course book is favoured a better resource than the ILE, even though more people used the ILE. There are other small differences as well, yet nothing important.

5.1.2 Qualitative analysis

Many questions in the questionnaire were free-form, in order to collect additional information from the students. The coming sections will elaborate the most important findings amongst this. Numbers in parentheses represent the sum of answers supporting the opinion

5.1.2.1 Reasons for using Nenya

When looking for why students used the website, it appeared to be same reasons as expected. Below are some extracts of the reasons for using Nenya.

They seemed to review questions and assess their understanding (21):

> *"To remember how to do some procedures when doing a lab". "For reviewing PRS questions from lectures". "Answer to questions I didn't understand". "I just generally had a browse and checked my PRS score".*

The students also came to find additional questions, either when missing class or some of the additional exercises (27):

> *"Attempted the non-lecture specific questions to improve my knowledge". "Answer questions couldn't answer in lecture". "I used it for the short-answer-questions and to finish PRS Q's"*

They came out of curiosity (12):

> *"To find what books are needed for the course". "Lecturer asked". "To see what it was like".*

They came to use the forum (23):

> *"I used it when I had a problem with a program so I posted my problem on the forum". "Used to read discussions on the forum". "As a forum". "I never do the exercises".*

There appeared to be an over-emphasis in using Nenya for the forum and the additional questions.

5.1.2.2 Reasons for not using Nenya

The students were also asked why they did not use it more or at all if they did not use it at all. Some students reported that the site was still not easy to use (2):

> *"Found it hard to navigate". "Didn't like the style of the interface"*

But they also reported that they did not necessarily need it (7):

> *"Coping well, so no need". "Not as helpful as other methods of remission [sic]". "Very little interest in computer science". "Busy with other university activities".*

5.1.2.3 Reasons for using Nenya more

When asked for things that would encourage them to use it, the students mostly reported a wish for a better interface (23), but also having additional material (lecture notes, examples, additional questions, programming tasks) (19).

5.1.2.4 Ease of use

When asked for their score on ease of use, most students reported finding the interface too complicated and difficult to navigate(38), but on the other hand other students reported it simple, set up easy and good navigation too(13).

5.1.2.5 Beneficial value

When asked why it had benefited or had not benefited them, students reported benefits (33):

> *"Help to practice and revise". "Could see how I was getting on with the course". "Helped go over things I wasn't sure of".*

However, students also reported less beneficial (9):

> *"Didn't find I learned much". "Didn't find any worthwhile material". "Forum proved useful once or twice as well as the questions, but I considered them a duty, nothing deadly stimulatory"*

5.1.3 Summary questionnaire 1

From the analysis of questionnaire 1, it became apparent that Nenya was rated lower than the initial implementation. One explanation given by the students was that they found the interface too complex as opposed to the previous report of a too simple interface. The main topic of dislike seemed to be the multiple windows for arranging information, which must be considered a wrong decision to have implemented in Nenya. Two additional reasons could be contributed to the students' perception of a complex interface:

- Development of Nenya was not finished until well within the course, and the students would also be partly prototyping the system.
- Some strongly negative posts were written by a student on the forum about the site, which required further discussion and justification in lectures, which may have created unnecessary attention towards the system, which again may have caused an overall negative effect on measurements.

It was hoped to increase students' engagement, but engagement would have suffered from the usability issues above. Some students reported there were not enough immediate benefits to use it. However, it appears that when students accepted the interface and actually used the system, they were likely to engage and some found it beneficial. When using the system for self-directed learning most students still reported a need for further material. Additional material could perhaps have provided students with more immediate benefits and increased the student engagement. Students did not report any unwillingness to participate in dialogue and so anonymous posts and a separate forum seemed beneficial.

5.2 Trace file

The data from the first questionnaire indicated that the students failed to engage with the ILE; however 64% of the students reported to have used it once a week or more and 39% of the students found the ILE beneficial, and so the trace files would be analysed to find the beneficial effects.

The logs consisted of a total of 34043 actions by the users and the actions were extracted and summarized in three different ways: by month, by semester week and by username. The by-month and by-semester-week summaries were grouped into students, tutors and lecturer as well. In week 3 a virtual tutorial was created to engage deeper into

a specific concept, and with this 17 questions which did not originate from the EVS. This hexagon exercise is separated from the other EVS questions because of their different nature.

5.2.1 Overall usage

Nenya had 200 registered users during the course, 187 students, 12 tutors and one lecturer. 91 questions were posted in total, 74 exported from EVS and the last 17 were part of the hexagon exercise. Of all the students 179 had answered at least one EVS question, whereas 61 students answered at least one question in the hexagon exercise. There were 35 learning objectives in total, divided into four major categories. In the forum 30 topics were created with additional 97 comments. As opposed to this 21 comments were made on the questions and four comments were made on the sessions. No comments were made on the objectives.

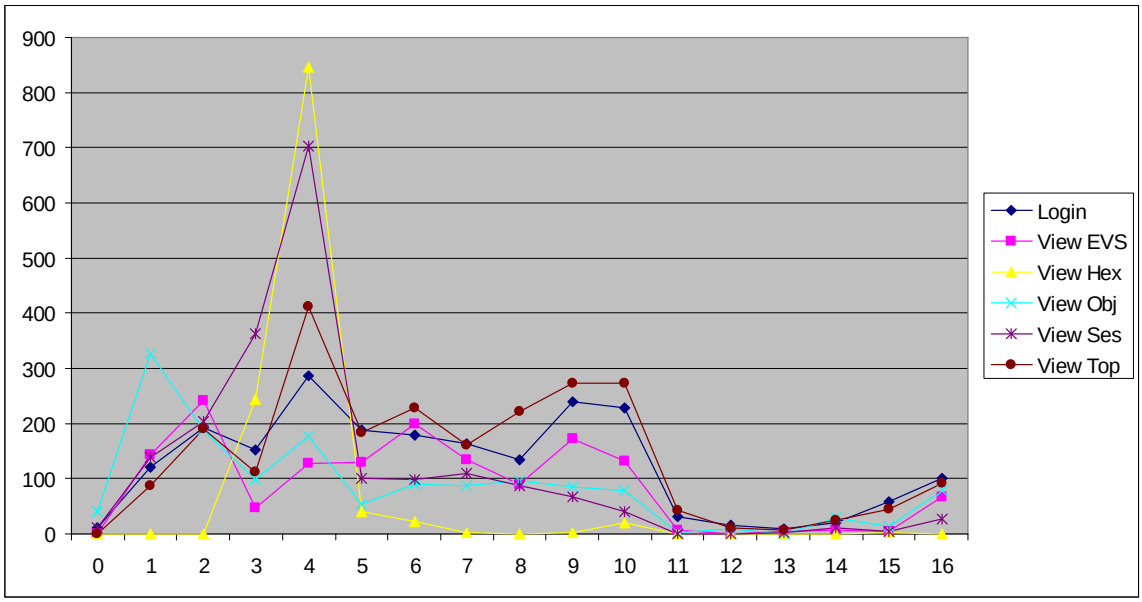

Figure 15 - Viewing artefacts in Nenya sorted by week

The graph above shows the usage pattern of Nenya throughout the experiment. Weeks 11, 12, 13 were the three weeks of Christmas where there was hardly any activity at all. In January the students rehearsed for the final class test in week 16. The scenario above includes actions from students, tutors and lecturer all together. The blue line marked with diamonds represents the number of logins. Many of the other markers lie under this line indicating an average viewing of less than once per login, which consolidates the low usage pattern already established. The highest number of logins was recorded in week 4, which was the same week as the hexagon exercise. Otherwise login appears to follow the amount of topics views.

5.2.1.1 Questions

Semester week	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Login	12	122	192	152	286	187	178	164	134	240	228	31	15	8	21	59	101
List questions	4	124	206	94	438	130	206	124	99	326	336	12	2	7	13	38	110
view_EVS	0	144	242	48	127	129	200	135	90	172	133	7	0	4	6	5	67
view_hexagon	0	0	0	245	846	40	23	2	1	3	21	0	0	0	0	3	0
Answer EVS	0	17	26	7	26	31	70	63	22	76	88	0	0	2	0	2	28
Answer HEX	0	0	0	168	537	26	19	0	1	0	20	0	0	0	0	3	0
View comment	0	85	144	13	353	17	10	10	0	3	4	0	0	0	0	2	0
Create comm	0	5	5	1	10	0	0	0	0	0	0	0	0	0	0	0	0

Table 5 - Actions on the question artefact in Nenya sorted by weeks

The table above shows that the hexagon exercise peaks in weeks 3 and 4, but becomes less used later on with a small increase in week 10. During the hexagon exercise, fewer people worked with the EVS questions, but this increased over the weeks. A few questions were commented upon in the beginning. However, after the initial month, no further comments are created. Each comment is viewed on average 50 times.

Throughout the semester, there is a consistent usage of answering questions using Nenya. As this can only be done by student who had not already voted in the lecture, these students were either absent or did not vote in lecture for other reasons. There was a slight indication of higher interest in the EVS questions in weeks 9 and 10 and then later again in week 16, as students began to revise their learning towards the class test.

5.2.1.2 Objectives

Semester week	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Login	12	122	192	152	286	187	178	164	134	240	228	31	15	8	21	59	101
view Objective	40	327	188	98	176	54	89	88	97	84	79	3	9	0	29	13	78
View comment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Create comment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 6 - Actions on the objective artefact in Nenya sorted by weeks

The objectives were meant to improve passive reflection by providing near goals (Woulters 1996) available from questions or sessions. The objectives seemed particularly viewed in the first few weeks, but after that the usage wanes to an apparently steady figure. The amount of views as opposed to logins indicates a low usage of the objectives amongst the users. No users found any interest in commenting on the objectives.

5.2.1.3 Sessions

Semester week	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Login	12	122	192	152	286	187	178	164	134	240	228	31	15	8	21	59	101
View session	11	139	204	363	703	100	99	110	88	67	41	1	0	3	11	5	27
View comment	0	0	0	52	54	26	1	1	0	0	4	0	0	0	0	0	2
Create comment	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0

Table 7 - Actions on the session artefact in Nenya sorted by weeks

The sessions were a description of the lecture but could also be used as an entry into the specific questions of the session. There seems to be a high usage pattern following the hexagon exercise as the usage of the session artefacts seems to rise significantly during the exercise. Otherwise sessions were only lightly used. In weeks 3 and 4 a few comments were raised which were read in the same period. The implication would therefore be that the sessions were only used as entry points for questions and most significantly for the hexagon exercise.

5.2.1.4 Topics

semester week	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Login	12	122	192	152	286	187	178	164	134	240	228	31	15	8	21	59	101
View topic	0	88	190	113	412	184	228	161	222	274	274	43	12	7	25	45	92
View comment	0	69	205	195	1556	818	960	690	695	812	908	145	36	33	165	110	240
Create Topic	0	3	2	2	3	3	2	2	5	5	1	1	0	0	1	0	0
Create comment	0	3	3	2	18	4	14	7	12	14	12	4	0	0	3	0	1

Table 8 - Actions on the topic artefact in Nenya sorted by weeks

Topics appeared to be heavily used by the users of Nenya. A total of 30 topics were started with 97 comments upon these. Of the 30 topics, two were raised by the lecturer and 12 were raised anonymously. Of the 97 comments, nine comments were raised anonymously and 22 comments were made by the lecturer.

5.2.2 Nenya vs. lecturer

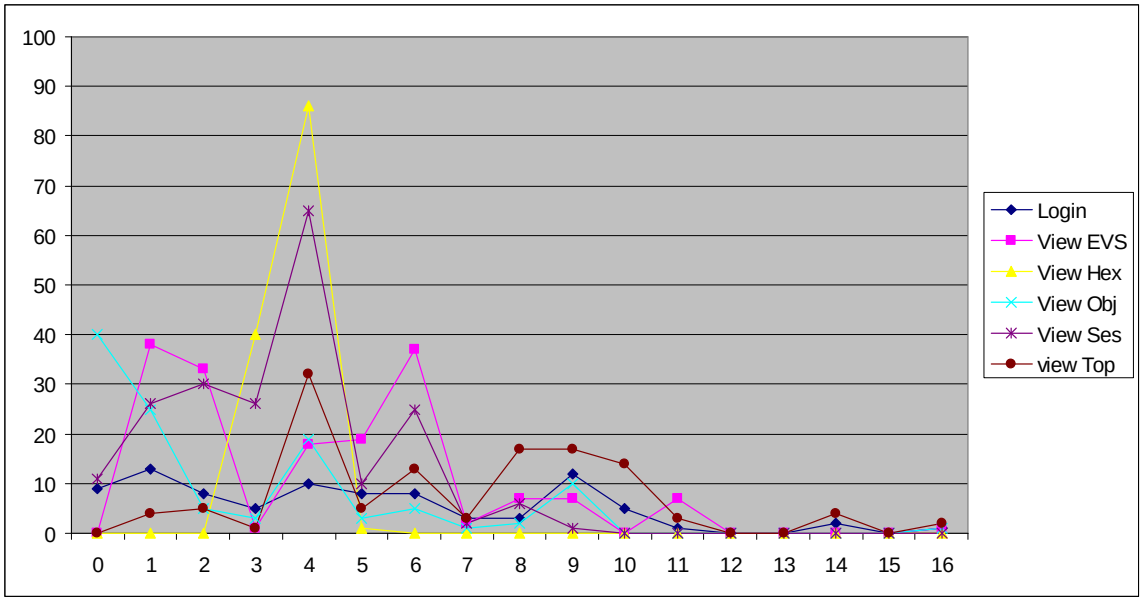

Figure 16 - Lecturer use of Nenya sorted by weeks

The lecturer had generally a higher usage of Nenya with approximately 7.6 logins per week during the semester, and could therefore be considered a regular user. The lecturer would export the EVS questions and also monitor Nenya for comments and respond to these if necessary. Once the lecturer had exported an EVS question, he would immediately be shown the specific question and so there would always be one view per EVS question. The lecturer did not appear to look any further on the questions at a later time from week 7 and onwards. In weeks 2, 3, 4 and 5, additional comments were made on the questions and the lecturer appears to browse additionally in these weeks or immediately after in the following weeks.

In weeks 3 and 4, the students attempted the hexagon exercise. The students could only answer via the web and hence the lecturer could only see the responses using Nenya. This explains the rather high peaks in these weeks. After week 5, the hexagon questions were no longer browsed for additional answers.

The lecturer created two topics and 24 comments in total. Of the 24 comments two were on EVS questions and the rest in the forum as response to topics. In Nenya the lecturer used the response data to add additional remediation necessary and to address additional discriminators which may not have been covered in the lecture. For the 74 EVS questions in total, the lecturer published on average 758 characters per question. The Hexagon questions had on average 497 characters per question. This indicates a thorough explanation given on all questions.

Observe that this algorithm works on the premise that we assume the array contents are in ascending order until our tests prove otherwise. Hence we need to intialise Ascending to True to uphold this premise.
Many algorithms work on this kind of conjecture - that we assume a certain property until proven otherwise .So finally this was the brute force method - we loop over every value in the array. This is fine for an array of only 5 elements but if we had 5 Million elements it would be rather wasteful especially if we found out that the first two were out of order. How could we stop the loop as soon as we know that the array content wasn't in ascending order? Think about how you'd do this before going on the next question...

Figure 17 - Example of average remediation by lecturer in Nenya (756 characters)

It was not possible to make any further conclusions concerning the benefits for the lecture using the trace data.

5.2.3 Nenya vs. tutors

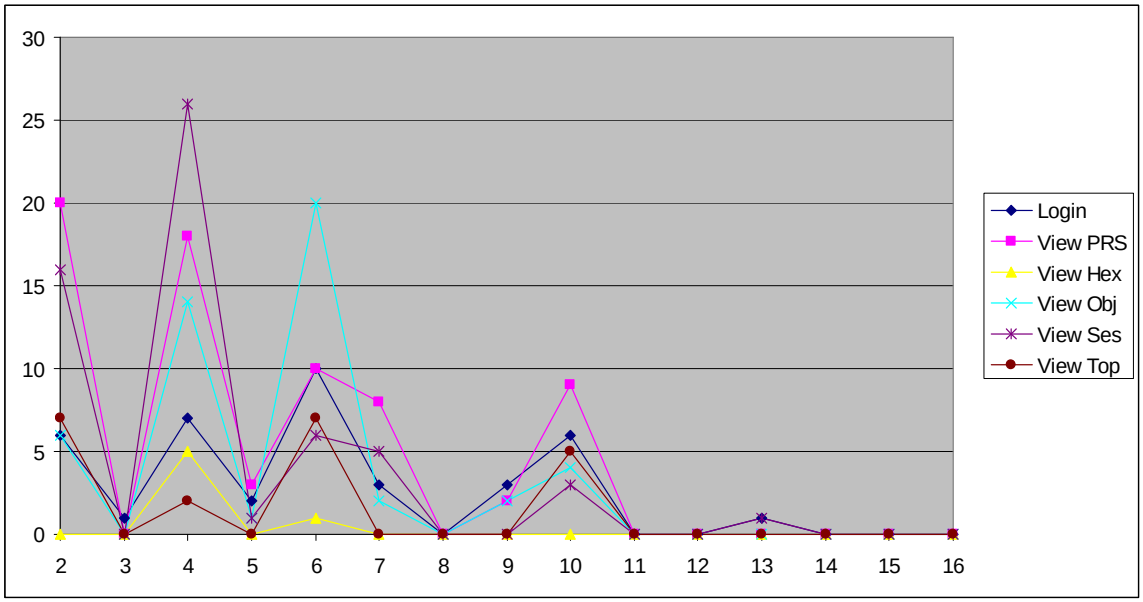

Figure 18 - Tutors use of Nenya sorted by week

The course had 12 tutors assigned. However, it did not appear that they used Nenya much. Of the 12 tutors only eight logged into Nenya. The highest number of login is ten in week 6 and lowest number is zero in week 8. After week 10 Nenya was used only once. The tutors appeared most interested in the questions. They viewed a question 70 times in total. Given that there were 74 EVS questions in total and 12 tutors, this was a surprisingly low number. There seemed a moderate interest in the sessions early on but also on objectives throughout the course.

The tutors did not read topics often and posted no comments at all. It would be unclear whether the tutors benefited from using Nenya given the low usage, and hence no conclusions towards the hypothesis will be drawn. One possible explanation could be that the environment did not achieve integration between lectures and tutorials as hoped, but this could not be concluded.

5.2.4 Nenya vs. students

Of the 187 students in the course in total, 158 logged into Nenya at least once. The last 29 (16%) never approached Nenya and therefore are not included in the trace files. Outlining the data by week produces the same chart as presented as Figure 15 - Viewing artefacts in Nenya sorted by week. Given the larger sample size it would be appropriate to go into further detail of the students' usage of Nenya and the data was summarized for each individual student. This data set is summarized in the statistics in the table below. The students had a higher variance in using the system than tutors and the lecturer as summarized in the statistics in the table below.

	Login	View EVS	View Hexagon	View either	View session	View objective	View topic
Minimum	1	0	0	0	0	0	0
25 percentile	3	0	0	1	1	1	1
50 percentile	7	3	0	5	4	5	6
75 percentile	13	10	17	24	14.25	12	16
Maximum	154	76	44	106	89	51	156
Sum	1953	1268	1051	2319	1712	1287	2213
Mean	12.36	8.03	6.65	14.68	10.84	8.15	14.01
Std Dev	18.37	12.33	10.84	20.40	16.35	9.56	23.53
Skewness	4.17	2.72	1.46	2.00	2.59	1.88	3.35
Kurtosis	24.41	8.90	1.07	4.65	4.58	3.97	13.40

Table 9- Frequencies for students using Nenya

The 158 students logged into Nenya 1953 times, which would average on 12.36 times. However given that it is positively skewed and positive kurtosis indicate a higher frequency of low users and a low frequency of high users. The standard deviation also explains the dispersion as extremely wide around this mean. Given that 75% of the students had 13 or less logins it is impossible to use the mean for anything. This is similar for all artefacts. The following box plot also highlights this trend

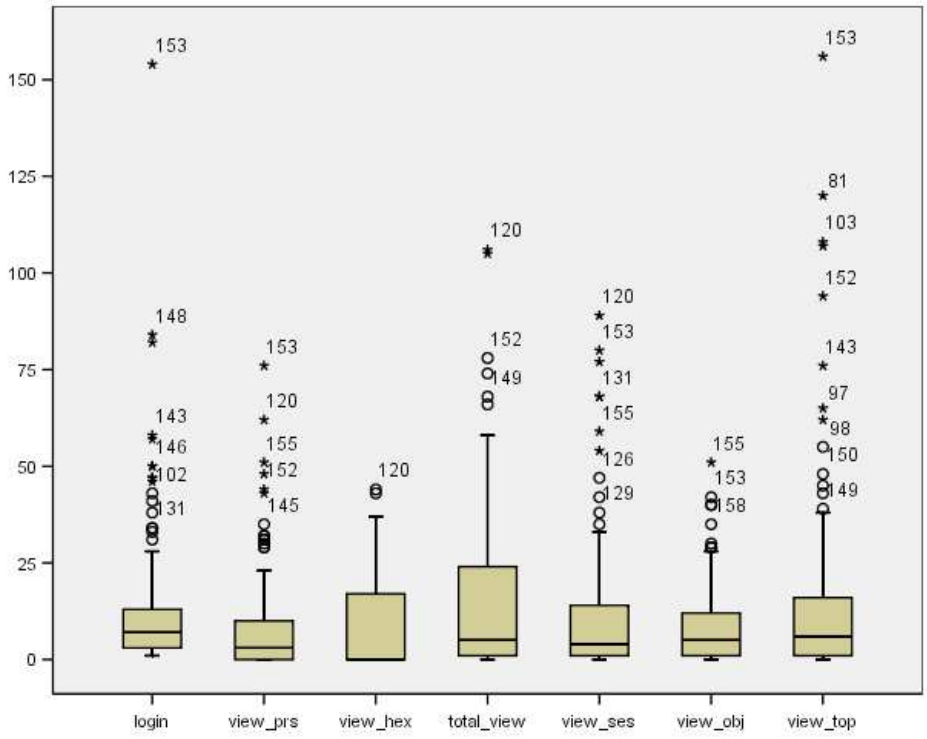

Figure 19 - Frequency distribution on student data in Nenya

The box plot above shows a box with the middle 50 percent of the cases with the median inside. The box is extended outside to show 95% confidence intervals before showing outliers (circles) and extreme cases (stars). Most of the cases fall in the lower end of the confidence interval and the mean is usually reported low as well. There are a high number of outliers and extreme cases. This all means rather high frequency of low usage and low frequency of high usages, and no normality can therefore be assumed.

5.2.4.1 Student categorization

In order to make sense of the data they needed to be broken down into different categories. However, it was not immediately possible to explicitly separate the students based on anything. From the data distribution, it seems that medians and quartiles as measure points were unsuitable, and there were also too many low measurements, and a factorial analysis was therefore conducted. A simple factorial exploratory analysis was conducted between the categories using the extraction method of Principal Component Analysis together with a Varimax rotation with Kaiser Normalization (Field 2005). This would attempt to establish a connection between the different elements and if possible extract underlying components of these connections.

The first extraction revealed that most components had a high communality between them except for viewing objectives (.340) and objectives were therefore subsequently

removed from the analysis. From the following analysis all items had a communality between 75% and 97% which allowed for the identification of two major components with an Eigenvalue higher than 1. These two components would cumulatively account for 88% of the variance between the initial factors. After three iterations of rotation, the components converged into the following rotated component matrix

	Component	
	1	2
Login	.369	.906
View EVS	.738	.479
View Hexagon	.899	.103
View either	.924	.345
View session	.883	.252
View topics	.156	.960

Table 10 - Rotated Component Matrix for Explanatory Factor Analysis

Component 1 (which we afterwards call Q) would explain approximately 52% of the variance found seemed focused on using the questions and most likely the hexagon exercise. Component 2 (which we afterwards call T) would explain approximately 36% of the variance found and were focused on login and viewing topics.

The students with a high score on component T would log into Nenya and read a few topics, occasionally browsing few questions but then leave. Students with a high score on component Q would also login but spent more time during each login to work with the questions. They would be most likely to work with the hexagon exercise but also interested in the EVS questions. Given the overlap in correlation it was rather likely to find presence of both components in some students.

This analysis was performed using the factors of viewing the individual artefacts as the correlation points. Additional factor analysis was performed using all actions on the artefacts, but due to rather large non-residuals they were unable to be any more conclusive than this simple analysis. However they still leant towards the same few underlying factors in the data and so the simple analysis was just as appropriate as anything else.

The component scores were calculated using regression and then stored in the data. Using these scores the students were divided into four groups based on a positive or negative correlation with either component. This resulted in the following grouping of students.

		Using topics	
		Low	High
Using questions	Low	78	27
	High	36	17

Table 11 - Student grouping based on extracted components

This grouping seemed an appropriate way of categorising the data. 78 students logged into Nenya but were not really interested in the topics or the questions. 44 students seemed to find interest in the forum and 53 students seemed to find interest in the questions. 17 students seemed to find interest in both using the questions and the forum.

	Low Q, Low T		Low Q, High T		High Q, Low T		High Q, High T	
	Sum	Mean	Sum	Mean	Sum	Mean	Sum	Mean
Login	293	3.76	556	20.59	381	10.58	723	42.53
List questions	250	3.21	269	9.96	722	20.06	854	50.24
View EVS	147	1.88	154	5.70	450	12.50	517	30.41
View hex	17	0.22	18	0.67	719	19.97	297	17.47
Answer EVS	43	0.55	32	1.19	203	5.65	180	1.59
Answer hex	14	0.18	17	0.63	530	14.72	213	12.53
View comment	14	0.18	60	2.22	212	5.89	284	16.71
Create comment	1	0.01	3	0.11	9	0.25	6	0.35
View objective	389	4.99	190	7.04	369	10.25	339	19.94
View session	227	2.91	121	4.48	844	23.44	520	30.59
View comment	8	0.10	18	0.67	41	1.14	58	3.41
Create comment	1	0.01	1	0.04	2	0.06	0	0.00
View topic	226	2.90	876	32.44	296	8.22	815	47.94
View comment	577	7.40	3011	111.52	847	23.53	2708	159.29
Create topic	2	0.03	18	0.67	2	0.06	5	0.29
Create comment	4	0.05	46	1.70	10	0.28	12	0.71

Table 12 - Sum and mean of actions by students categorized by factorial group

The table above seems to enhance the meaningfulness of the factors.

- **Group 1.**Students with Low Q and Low T logged in 3.76 times on average or approximately once a month viewing only two questions perhaps answering one of them. They may have created a few comments, but not many.
- **Group 2.** Students with Low Q and High T logged in 20.59 times on average or approximately twice a week. They did look at 6.37 questions and answered at

least one. Like the group above they did not really attempt the hexagon exercise. This group, however, created most of the topics and most of the replies on these, being responsible for approximately 40% of the traffic in the topic area.

- **Group 3.** Students with High Q and Low T logged in 10.58 times or approximately once a week. They would be browsing 32 questions each where most of this was spent in the hexagon exercise. They would be looking at 10 objectives, and they would also have a look into the forum while they were there.
- **Group 4.** Students with High Q and High T logged in between nine and 154 times, 42.53 times on average or more than twice a week. They would each look at 30.41 EVS questions and been through most of the hexagon exercise. They would also have been using the forum extensively even though they would not have commented as much as group 2.

The 53 students with High Q viewed the EVS questions 76% of the cases and the hexagon questions in 96% of the cases. They would have created 78% of all comments on the questions. Contrary to this the 44 students with High T were responsible for 80% of the posts in the forum.

5.2.4.2 Hypothetic benefits

Given that the purpose of Nenya was to support the hypothesis further analysis of the data was required.

Provision of formative feedback

Students would be getting formative feedback in two ways; by listing all questions, where there was an indicator for right or wrong or answered marks on each question, or by looking at the individual question. Students marked with Low Q looked on average at 2.86 EVS question whereas students marked with High Q looked at 18.24 EVS question on average. Given that there were 74 EVS questions in total would mean that students failed to look at information which could be important to them. However, students would still get formative feedback from the summary when listing all questions. High Q students would see this list 29.73 times or more than twice a week, whereas Low Q students would see this only 4.94 on average or approximately once a month.

Absenteeism

Students not present in lectures could gain valuable insight into the content of the lecture. Since students could not view an unanswered question without providing an

attempt it was easy to see that amongst the third of the students marked with High Q 7.23 EVS question were answered outside of lectures. For Low Q the same number was 0.71 Added to this was that students could view the session artefact to find additional information about the lecture. The High Q students looked at 25.74 sessions in average whereas Low Q students looked at only 3.31 sessions

Additional Reflection

Students could reflect passively by rereading questions and remediation after the lecture. This again was the same group as getting formative feedback. Apart from this they would also be able to link questions or sessions with the objectives and reflect using this as well. High Q students looked at 13.36 objectives on average while Low Q students looked at 5.51 objectives. Of the 35 posted objectives in total only 24 were viewed once or more. The last 31% of the objectives were never read by any student. Active reflection means actively engaging in the material by asking additional questions. All posts in the forum could be considered active reflection, but not necessarily because of having the response data available. Comments on particular questions were created 19 times in total and these were all within the first four weeks.

5.2.5 Nenya vs. questions

Another perspective of the trace file is the usage of the individual questions, as these constitute the response data from EVS and these are summarized in the following table.

Group	Lecturer	Students	Students	Tutors
Action	View	View	Answer	View
Unique questions	55	74	69	40
Total actions	170	1268	458	70
Highest action on any question	13	85	45	5
Avg per unique question	3.09	17.14	6.64	1.75
Percentage of group looking:				
Once	27.3	80.8	100.0	83.1
Twice	27.3	13.7	0.0	15.2
Thrice	20.0	3.7	0.0	1.7
More	25.4	1.8	0.0	0.0

Table 13 - Descriptives for response data in Nenya

Even though students viewed essentially all EVS questions each question was only viewed 17.14 on average or by approximately 10% of the class. The highest view any

question received was 85 views. This however was a question which was pretty unclear in formulation, which could be seen by the eight comments on this question.

81% of the students usually looked at any one question only once, 14% looked twice. This should be seen in contrast to the lecturer who actually on average looked at any particular question three times.

Students answered an EVS question 457 times in Nenya, or on average 6.64 per question. The highest numbers of answers on any particular question were 45 on the second question published and this score was almost double of the second highest score which was 23.

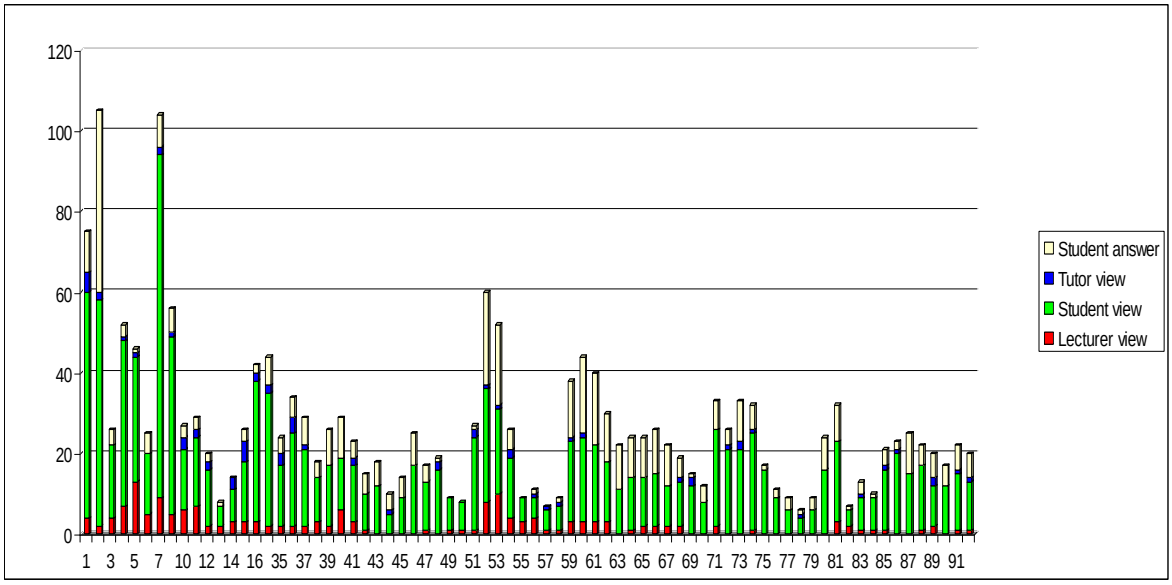

Figure 20- Actions per EVS question in Nenya

When looking at the graph above, the most interest seems to occur in the beginning of the course. However there seems to be some questions which stimulated more interest than others during the course. The numbers on the category axis is the question number, excluding the hexagon exercise which was numbered 17 through 33. The graph is cumulative, meaning that one lecturer (red, lowest) compares to 179 students (green) and eight tutors (blue), which seems to clearly highlight a lack of interest amongst the students and tutors. By comparison, the hexagon exercise attracted cumulative views between 54 and 116 times, with an average of 69.65 views. Only three EVS questions were viewed more than the least viewed hexagon question.

The database also contained records on student answers inside as well as outside lectures, and it was therefore possible to compare EVS usage inside and outside lectures, as presented in the table below.

	Inside	Outside
Minimum votes	0	0
Maximum votes	62	35
Sum of votes	6945	530
5% Trimmed mean	39.57	1.87
Skewness	-0.629	3.083
Kurtosis	-0.749	10.056

Table 14 - EVS votes inside and outside lectures

Students voted on 40 questions on average during the lectures out of 74 possible. The distribution of votes inside seems flat and top heavy while the distribution of the outside votes has extreme high frequency in low votes resulting in a mean around 1.87 votes outside lectures. If all students voted on all EVS questions, there should be a total of 13246 votes. Apparently 52% of the possible votes occurred inside the lectures whereas the votes outside lectures constitute 4% of the total votes only.

Of the 74 EVS questions, only 53 were marked as having a correct answer by the lecturer. For each student, a correctness factor was calculated as the number of correct answers divided by number of questions attempted having a correct answer. Students selected the correct option slightly less than half of the time (M=.44, s=.14). Students who attempted more questions seemed to be slightly less correct than students attempting only few questions (Rs=.27, p<.05, r=.07). However this constitutes only a small effect. This could probably be explained by the students answering fewer questions having chosen easier questions to engage in and therefore more likely to be correct whereas the students answering more questions would attempt harder questions as well and would therefore be less correct.

5.2.6 Summary of trace file analysis

Looking through the trace files seems to confirm the overall picture of low usage of Nenya, but it did also clarify some issues. Even though the ILE was designed to provide benefits to tutors, they seemed not to use it much and did not participate in discussions. This could indicate that the ILE did not provide an extension of the lecture for the tutor to continue but more of a lecturer/student tool. The lecturer did use the system regularly and did provide enough input to the system, however even the lecturer appeared to wane in usage during the semester.

There were large differences in how the students used the system. Most students only logged in a few times without any seemingly particular purpose. However two groups did seem to focus on using the topics and using the questions respectively. Most of the

students participating in the hexagon exercise were in the High Q group. Students using the EVS were also mostly found in this group, but also sporadically amongst the other students. One third of the students seemed to find the forum useful, but the forum was never directly related to any EVS questions. EVS questions were only viewed by relatively few students and only occasionally more than once. This could indicate that students did not find it interesting to review EVS questions after the lecture but it was unclear why this was so. Students did attempt to answer questions outside lectures but given the otherwise limited interest in EVS this purpose was unclear also. Nenya provided the students with study objectives but these were not used in particular and 30% of these were actually never viewed.

5.3 Focus groups

The purpose of the focus group was mainly to provide clarifications for the second and upcoming questionnaire but it did provide some qualitative data. The topics of the focus groups concerned three areas identified from previous analysis.

- **Learning objectives.** Having objectives in Nenya did not seem appreciated by students and so questions were derived for the students to discuss their learning styles and assessment skills.
- **Purpose and value of lectures/tutorials/labs.** Since tutors did not use Nenya much it may have indicated a larger gap between lectures and tutorials than initially anticipated and this would have to be investigated.
- **Purpose and value of using EVS inside and outside of lectures.** Since students did not view EVS results in Nenya as often as expected it could indicate a lack of interest in the questions outside lectures and the students would therefore be asked to describe their view on EVS and response data.

The result of the focus groups was compiled into the second questionnaire, but it also provided additional insight into the student conception, which leant itself towards a few major points.

5.3.1 Learning objectives

Learning objectives were published in Nenya to help students understand what they should be capable of and so these should be valuable with or without the EVS questions. When asking the students about how they would find out what they should understand in the course, they usually responded that CS1P was “all about doing, not knowing about”. They would usually prepare themselves by working through lecture notes and assignments to identify all areas.

"If you can do the assignments very well, then you are on the right track of knowing what you should do". "The theory and practical are so linked because the theory is the practical, but practical is just picking it up"

Students did not seem to work explicitly towards objectives but rather intuitively through action.

"As long as we work through the programmes you probably know most of the course."

5.3.2 The value of lectures and tutorials

Tutorials were mentioned as reinforcement of the lecture but also for practice.

"Tutorials is more doing lecture exercises"

The students did not appear to see tutorials being very different from lectures except tending towards being more hands-on. The students did not seem to be able to clearly differentiate between tutorials and labs in terms of learning except that lab sessions were purely hands-on. The impression from the students was that the steady flow of lectures, tutorials and lab sessions were a gradient shift towards being able to do practical programming.

"For programming [Lectures]'s like just to get the sort of basic concept of the greater details. These are just familiar signs with it, and then the tutorials and labs…you know…properly getting to grips with it, and then actually doing it in the lab"

Students also reported that it was clear what was covered in each individual session and that each element added up towards a cumulative understanding of the course. The students were also asked about their preparation before lectures to see whether new material was imparted or the lecturer would be more reflective in nature.

"…not actually read up on anything". "I usually see what the next lecture's on about 15 minutes before it". "No".

5.3.3 The value of EVS inside and outside of lectures

All the students reported that they liked EVS in lectures when they had a chance to reflect as well as the small break it would make in lectures.

"I didn't speak to one person on the course who didn't like using the handsets and getting the questions."

They felt that it did help them understand the topics and even highlight potential misunderstandings.

"Once or twice, he's went over something and I've thought I understood it, and then he's asked a question that I've got wrong, it turns out I haven't actually understood it, and I'd have went away quite happily thinking that and done it in my assignments and probably got it wrong in the exam"

When asked about their reflection on questions afterwards most students did not seem to worry too much.

> *"Normally you either have got the answer right in the lecture or you've got it wrong, but if they explain why you've got it wrong you understand." "…if you've consistently got them wrong, you think ah, I better look over that. Yet if you get them all right, you think ok, I understand that quite well"*

One student explained the lack of interest in the EVS questions was due to having a high workload

> *"There is so much material there is no point in going over the stuff at that time you understand. You can go over it again to study it before your exam, but if you understand it go on to the next thing that you maybe don't understand"*

While others students reported a lack of relevance outside lectures.

> *"Maybe if they were relevant to an assignment that we were doing at the time, yes, that can be helpful then". "I don't usually remember what the questions were in a lecture, so…". "Chances are you have to reinforce that work in an assignment, so…"*

Students did seem to care about a wrong answer as a way to find some kind of understanding if they got an answer wrong.

> *"It's helpful if the lecturer re-explains or you ask your friend" "If it's wrong I'll ask a couple of questions"*

Some students reported an interest in partly going over the EVS questions in tutorials

> *"There could be just a wee pre-thing at the start of the tutorial." "They'd know that they'd have people that didn't get such and such question right they could ask at the start if anybody wants help with that"*

But different opinions are raised on whether the tutor needed individual results or just group summaries, mainly on intrusion of privacy.

5.3.4 The value of Nenya

Within the focus groups questions were also asked on the use of Nenya. Most students reported same problems as in the first questionnaire, but they also explained some value to the concept.

> *"The time he (lecturer) doesn't (explain all discriminators) I would see the new website (Nenya)" "Because you can track your progress and see which questions you got right and which ones you got wrong and then there's extra wee ones and stuff so it's good."*
>
> *"I don't really see the point bringing up the question data that we've had in the lectures…Perhaps, If you missed the lecture I suppose."*

Some of the students had had other classes using EVS and could explain an added value from the website.

> *"My previous time I had [EVS], we didn't have anything like that and as soon as you walked out of the classroom that was it, you didn't really think about again whereas now I can go back and see what actions it comes from"*

5.3.5 Summary of focus groups

From the students, it appeared as if skills were the only identification of knowledge in CS1P, which could explain a light interest in learning objectives. Students did find lectures and tutorials to have a natural flow between them, and they even welcomed a stronger connection between EVS and tutorials. The students liked the EVS in lectures, but seemed unable to report much usage outside the lectures. The findings from the focus groups were accumulated into the second questionnaire in order to see if other students would be able to corroborate this.

5.4 Questionnaire 2

The second questionnaire was issued after the focus groups in order to collect supporting material from the students. 56 students chose to submit the questionnaire. For the 56 students, material from the trace file was collated and included in the analysis. The questionnaire further included questions from the first questionnaire on coping, usage and benefits, asking the students to replicate their answer from December. This allowed for a more thorough end-to-end analysis.

Most questions were statements given on a 6 point Lickert scale asking students to justify their relation to the statement. The scale went from absolutely not true (1) to very true (6). The scale only had six points to discourage a central tendency. Data in this section are provided with mean and median as the significant representation, while skewness and kurtosis are provided to indicate the precise shape of the distribution.

5.4.1 Correlation statistics

The first measure was made to check the relationship between the 56 students from questionnaire 2 with answers given in questionnaire 1 and findings from the trace file. Initially a Wilcoxon test was run on the three questions which were identical in questionnaire 1 and questionnaire 2. This comparison was not statistically significant, excluding a true relation between questionnaire 1 and questionnaire 2, and so there would be no correlation between them. Data from the trace files were merged with questionnaire 2 in order to see the categorization of the students.

		Using topics	
		Low	High
Using questions	Low	16	16
	High	12	9

Table 15 - Student categorization of second questionnaire

The largest group originally having Low Q and Low T were less represented in this second questionnaire. However, all groups were well represented indicating a representative answer. Three students had never used Nenya at all. The initial correlation between reported usage and number of logins from the trace files resulted in a significant medium effect (Rs=.588, p<.01, r=.34). As the initial question carried some ambiguity the medium effect was not surprising. However it did indicate a discrepancy between actual login and reported login.

Correlation between login and reported benefits did not reveal any significant relationship. This stood in contrast to the relationship between usage and benefits from questionnaire 1 (Rs=.38, p<.01, r=.14) and a similar but stronger reported correlation in questionnaire 2 (Rs=.446, p<.01, r=.20). A correlation was tested between reported benefits and students viewing EVS questions. This resulted in a significant but rather small effect (Rs=.259, p<.05, r=.06) which would be unlikely to replicate.

5.4.2 Reported use of Nenya

A set of statements were issued about why the students used Nenya.

Statement	Mean	Median	Skewness	Kurtosis
I used the website mainly because Quintin suggested it	4.17	4	-.116	-.683
I used the website because I learned something from it	4.07	4	-.458	-.348
I specifically allocated time for browsing the website regularly	1.89	2	1.165	.693
I used the website to monitor my progress in the course	2.65	3	.264	-.781
I used the website to compare myself to the rest	2.63	2	.504	-.789
I used the website as a kind of virtual classroom	2.70	3	.710	.146
I used the website to find things I could not find anywhere else	4.04	4	-.389	-.163
I used the website as a channel to ask anonymous questions	2.35	2	.723	-.835
I used the website to discuss with others	2.31	2	.891	-.192
I used the website to read other peoples comments	4.24	4	-.694	.447

Table 16 - Reported reasons for using Nenya

Students reported a high engagement because of the lecturer's (Quintin) encouragement. If this was so, it would appear as students would be even less likely to

engage on their own accord. Students came to read other people's comments. This would be consistent with the high usage of the forum. When asked about using the site for assessment such as to monitor progress or compare themselves to others they reported a negative tendency.

That students rarely seem to use Nenya for discussions but rather used it to read other people's comments seems ambiguous but probably emphasises the ratio between a high number of browsers and a low number of actual submitters. Students were also asked when they used Nenya. 57% students reported a useful value within the semester and 33% reported a useful value during revision. That revision was rated lower would be consistent with the trace file, however the usage in the trace file after semester was considerably lower, which would indicate that the reported value of benefits during revision was probably reported as a probable beneficial usage and not an actual usage.

5.4.3 Student reported engagement

A set of statements were issued about how willing the student would be to ask and answer questions under certain conditions.

Statement	Mean	Median	Skewness	Kurtosis
How likely would it be for you to ask a question in lecture publicly	2.15	2	1.129	.487
How likely would it be for you to answer a question from the lecturer publicly	3.00	3	.144	-1.338
How likely would it be for you to answer a question using EVS	5.54	6	-2.846	9.303
How likely would it be for you to ask a question in tutorials publicly	5.12	5	-.906	.232
How likely would it be for you to answer a question in tutorials publicly	5.13	5	-1.659	3.705
How likely would it be for you to ask a question on a course forum publicly	3.83	4	-.286	-1.027
How likely would it be for you to ask a question on a course forum anonymously	4.62	5	-1.162	.613
How likely would it be for you to answer a question on a course forum publicly	4.15	4.5	-.628	-.625
How likely would it be for you to answer a question on a course forum anonymously	4.65	5	-1.155	.841

Table 17 - Student engagement in dialogue

Students seem very reluctant to initiate dialogue in lecture, and are also partly reluctant to respond in public. However, the use of EVS by students seems to remove this barrier entirely. This supports previous studies on EVS usage. Students engage differently in tutorials. Even though the means are almost identical, the distribution on answering

questions in tutorials is more top heavy. The positive engagement seems to present tutorials as more appropriate for conversational dialogue, which could further encourage a stronger link between lectures and tutorials. When asked about using a forum, students seem again to favour answering as against asking questions and they favour anonymity most particularly when asking questions. This would indicate that students are somewhat reluctant to ask questions publicly, but don't mind replying publicly. Forums seem to be slightly less used than tutorials, which encourage a face-to-face approach to conversation.

5.4.4 Reported benefits of using an EVS

Students were given a set of statements on the beneficial value of using EVS in lectures.

Statement	Mean	Median	Skewness	Kurtosis
The EVS questions in lecture really tested that I understood a topic	4.00	4	-.424	.165
Getting a question wrong meant I did not understand the topic	3.06	3	.424	-.653
I might have gotten an EVS question wrong, but Quintin's comments afterwards usually corrected my mistakes [sic]	4.92	5	-1.198	1.552
The EVS questions were a good indicator of how well I was doing on the course	3.72	4	-.427	-.716
I hardly remembered the individual EVS questions after the lecture	3.51	3	.313	-.383
The EVS questions were mainly what I brought out from the lecture	3.15	3	.276	-.513
Getting an EVS questions wrong initiated me to do something extra afterwards	3.94	4	-.443	.644
The EVS questions showed me what I should read up upon afterwards	3.70	4	-.289	-.593

Table 18 - Reported benefits of using an EVS

Students seemed to favour EVS as a mean to test their understanding, and that it could provide a good indication on their progress. This was consistent with previous studies and not really surprising. Answering an EVS question wrongly did not necessarily mean a lack of understanding, which would partly contradict the above. Students reported a major agreement with the statement of getting a question wrong but learning straight from the lecturer's (Quintin's) remediation. This could indicate that the value of a question for assessment would decrease immediately after remediation. Students did report that they in fact did remember the EVS questions, and that the EVS questions did seem to initiate additional reflection afterwards.

5.4.5 Reported benefits of posting EVS data

Students were given two set of statements about the beneficial value of posting EVS data on the web after lectures. The first set of statements was titled “Posting the EVS data on the web helped me learn CS1P because:” and allowed the students to agree or disagree with the individual statements. The second set of statements carried the title “Posting the EVS data on the web would help me learn any course because:” and allowed the students to select which options they would favour. In the table below the metrics report the first set of statements and the last column indicates the percentage of students choosing this option in a generic course.

Statement	Mean	Median	Skewness	Kurtosis	Percentage
When I wasn’t attending I could still get a feel for the topic	3.10	3	.368	-.672	26.4
Quintin added more comments, which I found useful	4.47	5	-.395	-.498	83.0
Quintin commented on the incorrect options as well, which I found useful	4.71	5	-.838	.225	67.9
I could reflect on what the question was about at a later time	4.16	4	-.320	-.298	43.4
I could ask additional questions on the EVS problem even after the lecture was over	3.89	4	-.039	-1.156	45.3
I could compare myself to the other students and see how well I was doing on the course	3.6	4	-.202	-1.044	30.2
I could summarize how well I was doing just by seeing how many questions I had right or wrong	4.13	4	-.364	-.833	41.5
I could read over the questions again during revision	4.09	4	-.246	-.824	58.5
It basically helped me remember the lecture	3.89	4	-.300	-.685	24.5

Table 19 - Reported benefits of posting EVS data

Most of the results presented a positive response and, in particular, the two statements regarding the lecturer’s additional remediation were reported as a highly positive attribute. This was consistent with the high percentage choosing these features in any course. Using the response data when absent did not seem to be identified either in CS1P or in a generic context.

Students reported an interest in passive reflection using the EVS data. On the statement about being able to ask additional questions there was a bimodal tendency, which would indicate that the statement would be either very positive or negative depending on some other factor. This seems likely since only few students would actually ask questions rather than answer questions. Options for using EVS data for reflection were chosen by 43.4 and 45.3 percent respectively of the students.

The statement about comparing themselves to others had a bimodal peak as well indicating that even though approximately half of the students agreed, the other half seemed to strongly disagree. Less than a third of the students thought of this feature as helpful in any other course. Using the EVS data for assessment had a positive relationship and even had a positive bimodal peak, indicating there were both a positive and a strongly positive relationship to this statement. 41.5 percent of the students chose to include this option generically.

Students also reported a beneficial value to having the EVS questions available for revision in CS1P (M=4.09) as well as generically (58.5%). This however contradicts slightly their previous reported usage of Nenya during revision and the results from the trace files.

5.4.6 Using tutorials with EVS

Students were asked how much they would favour integration between lectures and tutorials using EVS questions.

Statement	Mean	Median	Skewness	Kurtosis
Would it be a good idea to use 5-10 min of each tutorial to go over the EVS questions from the lecture	3.15	3	.198	-.934
Would it be a good idea if the tutor was given a summary of how your tutorial group answered the EVS questions in the relevant lecture	3.81	4	-.304	-.871
Would it be a good idea if the tutor was given a list of each individual answer	2.72	2	.620	-.528

Table 20 - Students perception on integration tutorials with EVS

Students seem reluctant to allocate time in tutorials to go over the EVS questions once more, however they seem to agree with the idea of providing the tutors with a summary of the tutorial group answers. When asked about providing a named list students seems more reluctant. This seems to indicate that the students fear this would not be used properly.

5.4.7 Using EVS data for students benefits

It was hypothesised that posting EVS data would be beneficial to students with regards to assessment, absenteeism and reflection. These three identified benefits to students were asked throughout the questionnaire.

5.4.7.1 Using EVS data for formative assessment

One question students kept referring towards in the focus groups was the value of the data for formative assessment. Students reported that EVS questions were a good indicator of the progress on the course (M=3.72, Mdn=4), and that they could summarize how well they were doing by looking at which questions they had answered right or wrong (M=4.13, Mdn=4). 41.5% choose this option as a generic benefit. On a direct question on whether posting the EVS data would be a good way to get formative feedback on the course 85.7% of the students answered in favour of this method.

When initially asked what they used Nenya for students did report they used it to monitor their progress (M=2.65, Mdn=3) indicating a looser coupling between this issue than perceived by the students. Some questions measured how students related to each other. Students did report an ambiguity about being able to use the data for comparison (M=3.60, Mdn=4) but reported that they had in fact not used Nenya for this purpose (M=2.63, Mdn=2).

5.4.7.2 Using EVS data for reflection

Students did seem to use the EVS questions as a stimulus to do something extra (M=3.94, Mdn=4) or read up (M=3.70, Mdn=4) afterwards. Whether posting the question would be beneficial was reported as beneficial for passive reflection (M=4.16, Mdn=4) and for active reflection (M=3.89, Mdn=4). However these statements caused some ambiguity and only approximately 45% of the students included these options as generic benefits of posting EVS data.

5.4.7.3 Using EVS data for absenteeism

Benefits for using EVS data as a persistent record of the lecture for students present as well as absent did not seem apparent. Students could use the questions to remember the lecture (M=3.89, Mdn=4) but not really when absent (M=3.10, Mdn=3), and they did not strongly request these features. 24.5% and 26.4% of the students respectively chose these for a generic purpose.

5.4.8 Summary of the questionnaire

Students participating in the second questionnaire were representative of the four groups from the trace file categorization, and could therefore provide a nuanced picture of using EVS data outside of lectures. Students did find EVS beneficial in lectures, but appeared not to relate directly to the individual question afterwards. Outside the lectures, the students would report a very beneficial value from the lecturer's comments. Students

did not find it useful to use the EVS data as a persistent record of a lecture for students present or absent. Students did report that EVS questions initiated them to further reflect afterwards, and they reported this as a valuable feature of posting EVS data. Students also valued EVS data for assessment on their progress. However this formative assessment was partly ambiguous in the responses.

5.5 Tutor interviews

In order to understand the tutorial aspect, a qualitative study was conducted with the tutors. Three tutors agreed to be interviewed. The interview was split into two parts regarding the tutorials as extensions of the lecture and the use of EVS data in tutorials. These two subchapters summarise the tutors' answers.

5.5.1 Tutorials as extension of lectures

The first part consisted only of questions on the relationship between lectures and tutorials.

5.5.1.1 Instructional design

Tutors would receive their instructional design from the lecturer explaining what was to be covered by the tutor. Apart from this, the lecturer doubled as tutor and always had the first tutorial. Immediately after this tutorial, the lecturer would email the additional tutors with issues raised. These two sources were regarded as the formal instructional design issued. One tutor was able to compare her tutorials to other tutorials she had had and could provide some additional detail. The tutor explained that she felt more confident in CS1P tutorials as opposed to this other tutorial (Also on a CS1P course, but different instructional design) because she had taken the course herself, and hence could "*place herself at their level by recollection my first year lecture*". This indicates that the tutors would often be predisposed to the content of the tutorial if they already had taken this course.

5.5.1.2 Coherence between lectures and tutorials

Tutors reported using between 15 to 30 minutes of the tutorial to topics directly related to the lecture. When not exactly deriving from the instructional design, issues were often raised from students or probed by the tutor depending on the actual students. One of the tutors reported less alignment between the lecture and the tutorials and encountered problems where topics had not been addressed yet or, on the contrary, had already been covered. Another tutor explained this as knowing where they were in the course, roughly

but not exactly. This indicates that even though a formal instructional design was in place, the lecturer's contingency could provide some misalignment in this system.

5.5.1.3 Feedback

Feedback from tutorials to lecturer was usually provided via student marks or through brief chats. One tutor explains the relations as this:

> *"We had to provide marks for assignments which I guess the lecturer would have seen, but the main feedback was via chats with the lecturer in the coffee room".*

From this it would be reasonable to deduce that formal feedback from tutorials to lecturer only existed as an option through marking, and informal feedback was the preferred mechanism for integration from tutorials to lectures.

5.5.1.4 Reflection and understanding

Tutors recognized tutorials as a place for students to ask additional questions about the curriculum. They could "*ask questions without having to do so in front of the whole class.*" Depending on the tutor's ability to "*connect*" with the students, "*certain students got more from the tutorials and lab sessions than from the lectures*". It therefore appears reasonable that tutorials are better at maintaining a conversational dialogue than the lecture. One tutor explained that he had used tutorials to additionally support students by "*advising students on university-related matters not directly pertaining to CS1P*". From this, tutorials seemed to be kept at more collegial level for the student and therefore a good interaction point between institution and student.

5.5.2 Use of EVS data in lectures

Tutors were presented with the rationale and the features of Nenya as initiation to discuss use of EVS data in lectures.

5.5.2.1 Tutor usage of Nenya

One tutor reported not to be aware of Nenya or its possibilities. One tutor was aware of Nenya, but did not use it. The last tutor used it initially for attendance check and to "*get a feel for the good/bad students*". He also reported "*being put off by the usability*" consistent with the students' experiences. The reason for not using it at all or not using it more was explained as having a high enough workload without using the EVS, whereas the tutor not being aware of the system did report she would definitely have used it.

5.5.2.2 Using EVS data to create synergy between lectures and tutorials

On questions related to using EVS data to create synergy between lectures and tutorials the tutorials provided three different answers The tutor who had in the first question reported a misalignment between lectures and tutorials, and who also reported unawareness of Nenya, believed that having the questions would provide the tutor with "*more to talk about in tutorials and would make the tutorials link better with the lectures*". Another tutor reported that she already had a "*group quite vocal about what they did and did not understand*", and would therefore not need the data. She also believed that had the student been less verbose, it was not necessarily a beneficial idea to use EVS data to identify topics of further clarification as "*the quiet ones would just 'smile and nod' regardless of whether it is a topic that they want to discuss*", indicating that it might just be a repeated effort and therefore wasted. The third tutor agreed in principle, however reporting that he "*knew his students well enough not to have to check up on them via the EVS system*". This tutor also reported that the laboratory-based exercises would show where people were having problems.

5.5.2.3 Using EVS data for student assessment and pastoral care

All three tutors seems to agree that one particular EVS answer may not necessarily reflect the students understanding, whereas consistently wrong answers might provide an indication that the student would be either struggling or not paying attention (which may or may not lead to a long term lack of understanding). Whether the tutor should use the information is a unanimous yes, but all three seem to stress that the tutor should handle the information carefully by not necessarily disclosing or discussing student answers but speaking in general terms of the question and the discriminators.

One tutor noted that, presuming the questions asked referred to what has just been taught, it may not make sense to rely on the answers as "*some students would need time to reflect and re-analyse the material*". Two tutors reflected that had the EVS data been used more extensively it could "*add a degree of 'need to perform'*" where as now it was considered "*stress-free*", and that this might discourage the students from answering EVS questions or in the worst case discourage them from attending lectures.

5.5.3 Summary tutor interviews

From the tutor interviews it became apparent that tutorials are equipped with an instructional design from the lecturer, but also from tutors' own experiences and students' engagement. Tutors had a high responsibility to engage the students in dialogue and

provide marks on the students' progress. Additional feedback to the lecturer was mostly informal. Tutorials were not always aligned with lectures leaving matters for tutors to identify or students to report even though tutors had access to some early feedback from the lecturer. The tutors who knew about Nenya did not use it as there were other means to understand student abilities and much to do. The tutor who did not know about Nenya would have appreciated this information.

Using student answers to discuss topics could be acceptable but caution should be used to avoid disclosing too much information and also not to discourage students from using EVS at all. Furthermore it would probably only provide an indication of additional action, not any certainties. However, tutors felt able to identify students' misunderstandings and shortcomings either from the students' own engagement or their actions, which could render the use of EVS data unnecessary.

5.6 Lecturer interviews

After having collected information from the students and the tutor the lecturer was interviewed about the benefits and values as seen from his point of view. The following sections are therefore the interpretation of this interview.

5.6.1 Reflections on the EVS format in lectures

The EVS questions in lectures were mostly used to engage students just after they had first heard about the concepts. This format was described as a "*reality check for the students because in the past these same concepts had seemed easy to the previous students, yet they failed to understand some aspects of these*".

When students were using the handsets the lecturer observed an emerging pattern of problems which he felt needed to be addressed.

- **Student need for reflection.** Many students usually got the questions wrong. By analysing the data afterwards the lecturer reported this trend to be "*often over 50% of the class*". Even after remediation it seemed as if many students still got related questions wrong.
- **Addressing all misunderstandings.** Usually the lecturer would remediate on all questions, sometimes instigating a class-wide discussion. However, when only a small proportion of the class picked a particular option the lecturer felt unable to justify using time towards all discriminators, but still felt the student were eligible for feedback, since they had taken the time to attempt the question.

5.6.2 Benefits of additional lecturer feedback

At the end of each lecture the lecturer would spend approximately 60 minutes or more going over the EVS data from the lecture, while uploading and annotating the questions. During this period the lecture could re-interpret the response graph and in particular note the number of students that got the answer wrong. In the annotation the lecturer could add additional remediation, some of this derived from the extra interpretation. While posting the question the lecturer could provide feedback to the particular students whose option were not covered in the lecture, and therefore prevent diminishing their motivation for responding. The lecturer reported that spending time reflecting and providing additional remediation was beneficial 80-90% of the time in that it enabled beneficial changes to be made to en ensuing material.

5.6.3 Contingency based on EVS data

The use of EVS inside lectures is predominantly used as a mean for conversational dialogue, which in itself would force the lecturer to be contingent at least to some extent. The lecturer reported in this course that using EVS in lectures often (40%) initiated additional discussion in class in order to address certain student perceptions. The combination of this discussion and the subsequent analysis of the EVS data would half of the time lead to either the lecturer having something to say at the start of the next lecture or small adjustments to the flow.

5.6.4 Lecturer usage of the ILE

The lecturer explained how else he had used Nenya. Apart from uploading and annotating the EVS questions, providing information for the environment, the lecturer assumed a more passive role of browsing only to search for additional comments and responding when necessary. The lecturer was issued with a list of all questions and their respective cumulative views. From this list the lecturer reflected how students *were making informed choices about which questions to follow up, rather than just looking at every question*, i.e. the students were selective in which questions to revisit. The lecturer furthermore reflected that "*the numbers represented the students who knew that their learning would be improved by following anything that they were still unsure about".*

5.6.5 The value of assessment using EVS data

The lecturer reported that EVS could provide a decent assessment of the class's level of understanding, although it was far from perfect. The lecturer also reported that some questions seemed to work better with the students than others, and that this recognition

often came immediately after asking the question in the lecture. However, the lecturer supported the connotation that many questions could in fact be seen as a decent enough assessment to act authoritatively on it. When addressing the assessment of the individual, the lecturer believed that "*gross attributes of a student's progress can be determined from collated responses over a period of time*". The lecturer finally believed that the response graph only accurately measured the students' overall perception in the instant when it was asked. The lecturer's remediation and students' own actions would mostly change this assessment.

5.6.6 Student usage of the EVS response data

The lecturer acknowledged that the amount of students looking at each individual EVS question was rather low compared to the hexagon exercise. When comparing each question with the amount of views it generated, the lecturer responded that it seemed as if "*the students were making informed choices about which questions to follow up*". Some questions would inherently be more interesting to view than others. The lecturer also suggested that the views represented those students "*who know that their learning will be improved by following anything that they are still unsure about*", and hence attributing the usage to students' approach towards learning.

5.6.7 Summary

From interviewing the lecturer, it became apparent that having the EVS data available for the lecturer afterwards was in fact beneficial to learning insofar as the lecturer could provide additional feedback to the students and provide more contingent teaching. The lecturer mostly used Nenya to browse for comments and reply to these to help individual students. The lecturer also believed that the response data from EVS provided a valid image of the students' understanding, however this image would change instantly by lecturer remediation and students' further action.

5.7 End of term results

After the end of term, all examination results were collected and analysed. Both class test and degree exam were represented as a score between zero and hundred for each student.

5.7.1 The relationship between class test and degree examination

Since the class test only counted towards 10% of the final mark and was held after half the course whereas the degree examination counted towards 70% of the final mark and

was held at end of term, the two results were not expected to be 100% correlated and a higher mean was expected for the degree examination. When analyzing the results the students scored between 7 and 95 in the class test with a mean of 57.432 (S.D. = 20.34, S.E. =1.64). In the degree examination scores fell between 3.8 and 92 providing a mean of 58.635(S.D. =19.14, S.E. =1.60). Correlating the two results provided a very significant result, showing that scoring high in the class test means a higher degree examination at a large effect (Rs=.786, $p < .01$, r= .62). This meant that correlating with either examination was likely to be consistent with a student's assessment, and that students participated just as seriously at the class test as at the degree examination.

5.7.2 Questionnaire 2 as a representative sample

When questionnaire 2 was issued, it was expected to be representative of the entire class as almost one third of the class participated in it (N=53). However analysis showed that the students participating in questionnaire 2 had a higher mean on both class test and degree examination (incorrectly labelled finalexam in the box plot below) than the respectively class means.

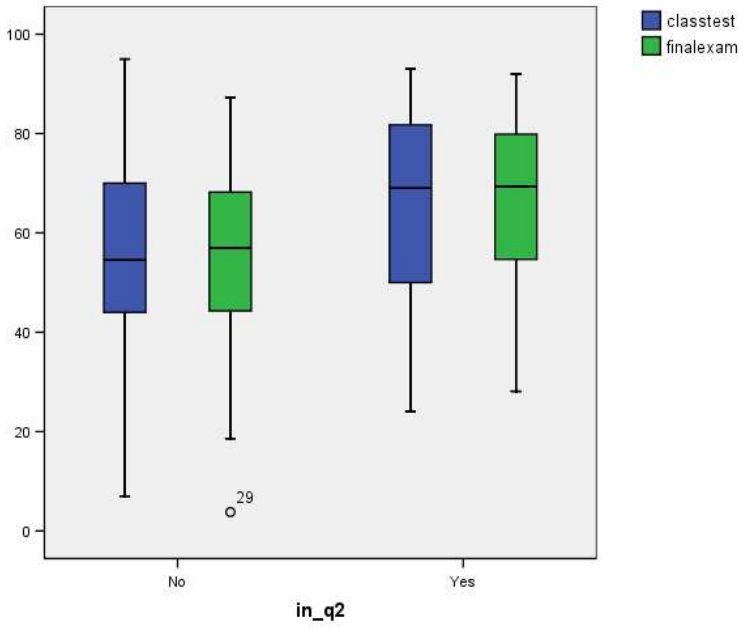

Figure 21 - Box plot of students marks grouped by questionnaire 2

The two plots on the left are students not participating in questionnaire 2, whereas the two plots on the right are students who did participate. The means are clearly higher on the right even though the interquartile ranges partially overlap. The whiskers in the bottom signifies the lowest scores (with one outlier), which indicate that the lowest scoring students did in fact not participate in questionnaire 2.

When testing for homogeneity of variance both groups are equal (F(1,135) =005, ns) which means that even though the mean is slightly higher, the spread in both groups are equal.

5.7.3 The relationship between end of term results and trace files

It was initially hypothesised that there would be a correlation between the class test and reports from the trace files for the students. However, after analysing the trace file this was no longer expected. All aspects of the trace file were in fact correlated but as predicted no significant correlation with the final results could be found. The correlation included all artefacts as well as the factorial components of Topic usage and Question usage.

5.7.4 The relationship between end of term results and EVS usage

For the students participating in questionnaire 2 all EVS results were collected and correlated. Analysis of the EVS results had previously found that overall, students attempting more questions were slightly less correct than students attempting fewer questions. As correctness could be a parameter for formative and summative assessment, the relationship with end of terms results was analysed. Correctness constituted a small effect in the class test (R_s=.418, $p < .01$, r=.17) and also in the degree examination (R_s=.440, $p < .01$, r=.19). This would indicate that these students' correctness was a small indicator (less than 20%) of how the student would score in class test and degree examination. However, since the trace analysis showed that those students answering more EVS questions usually was less correct than those students answering less EVS questions this would also point towards a fact of students answering fewer EVS questions would score higher in class test than students answering more EVS questions. Therefore using this result could be considered very ambiguous.

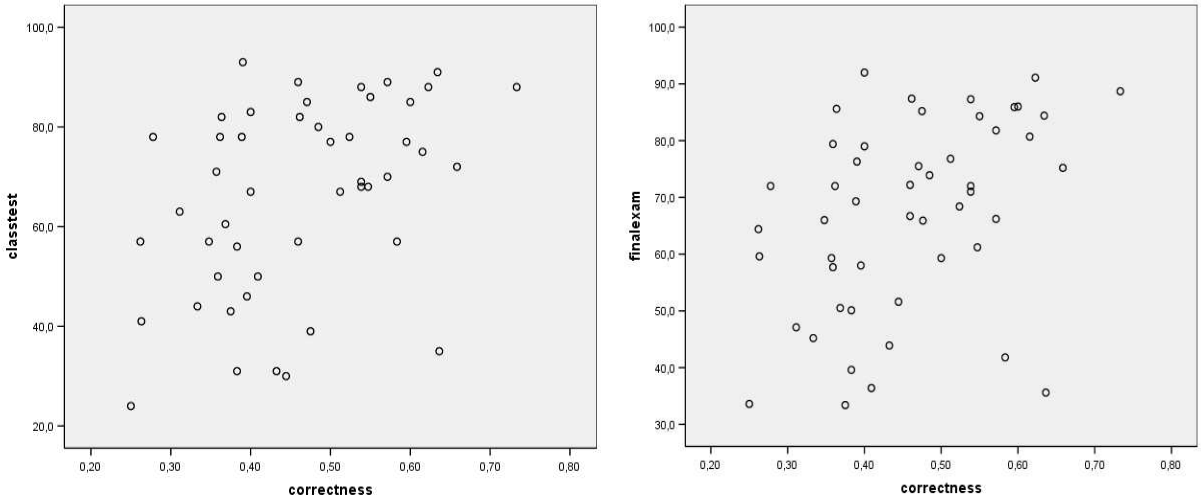

Figure 22 - Relationship between correctness and class test and degree examination

The scatter plots above outlines relationship between on the left correctness and class test and on the right correctness and final examination. For the axis to correlate 100% the points would indicate a straight line at 45 degrees. The linear model of 20% variance may not be a good fit. In the plots above three outliers scoring zero, zero and one in correctness has been removed. With the three outliers, the alleged relationship would seem even less likely.

5.7.5 Summary end of term results

From analysing the end of term results it became apparent that the class test provided a reasonable attempt from the student and the class test results could point towards the degree examination as a large effect. Students who participated in questionnaire 2 were representative of a class distribution but students scoring low were underrepresented in questionnaire 2 leading to a slightly biased answer. Correlating final results with the behaviour of Nenya provided no significant result. Correlating results versus correct answers in EVS questions showed an unexpected correlation with a minor effect. However, this result seemed ambiguous and its usage should be cautioned.

5.8 Summary analysis

This chapter contained a thorough analysis of the instruments of the research. All significant results from the analysis will be compared to the initial project proposition in the upcoming chapter, and therefore this summary is not conclusive. From the onset of this project and to final discussion this project has become gradually clearer and each instrument used has allowed to progress from a vague, distant observable idea towards a more precise understanding of the nature of using EVS data outside of lectures.

6 Evaluation of Nenya

When building an Integrated Learning Environment in order to test a hypothesis, it would be reasonable to assume that the system itself needs to be evaluated in recognition of the underlying Computing Science concepts. However, during the research, it became clear that the role of the ILE in the larger context would seem pointless as two consecutive systems had failed to engage students deeply. This led to a decision to downsize the effect of the ILE in this research and instead attempt to discover the underlying nature of the learning environment. Emphasis in this research was henceforth on the underlying paradigm in learning. However, it will still be reasonable to evaluate but to a lesser extent discuss the nature of the ILE, and this chapter therefore addresses this evaluation.

6.1 The underlying architecture

Nenya was build around a three-tier model using industry proven frameworks.

- **Data layer.** The data layer consisted of a single database and an overlying object relational framework to attach to the database and perform queries.
- **Business layer.** The business layer consisted of use-case driven actions which either query or perform modifications to the database. All modifications were encapsulated in database transactions, which ensured a consistent and reliable database.
- **Interface layer.** The interface layer consisted of a web application using common web technology to interact with the user.

This three-tier model provides a sufficient abstraction, and each layer can be modified or replaced individually without impacting the entire application. It would be possible to develop a new interface, both web and stand-alone application, which benefits from the existing code. Due to the architecture, there were neither explicit inconsistencies nor major downtimes in Nenya which in all provided a reliable and resilient solution.

6.2 Usability enhancements to the ILE

The original ILE was reported having several usability issues, which were highlighted by the first evaluation as a major reason for the ILE not being used. Nenya was designed to address most of these issues.

6.2.1 Cross-browser compatibility

The original ILE did only support one browser. Much effort was placed into using cross-browser functionality, and this issue was only raised once within Nenya.

6.2.2 Search facility

In the original ILE, there was little possibility of searching other than by navigating the structure. In order to support learning, all text available in Nenya was automatically indexed, this included EVS questions, forum posts, objectives. The underlying search engine supported free-text searches and wildcard searches. This was reported to be a positive feature by a few students.

6.2.3 Interface improvements

The evaluation of the original ILE produced reports that the interface was “bland” and uninspiring. It was therefore decided to introduce three improvements to correct these issues.

Layout

Web applications today use a richer layout in design and colours, mostly using techniques involving style-sheets. Text is initially marked with the name of a format, and then this format is taken from the style-sheet and applied to the context prior to presentation in the browser. In Nenya, a style-sheet was provided to enhance the layout. This style-sheet made use of section highlights and pleasing fonts to provide a decent layout. Additionally, it used separate colours to clearly express which area was being viewed. Questions would use a red colour, objectives would use a green colour, lectures would be use yellow colour and the rest would use a grey colour. The general section would use a light blue colour. The colours and styles were designed to be more pleasing to the eye. Since the technology used is style-sheets, it is possible to change the appearance of the system simply by replacing the style-sheet. In questionnaire 1 there were a few reports which disliked the use of the green colour, however there were not many negative comments to the layout, which therefore appears to be adequate.

Rich text

All submissions by users were through a rich text editor, which allowed users to write more appealing submissions. These included the abilities to represent text as bold, italic, larger and smaller font size, but also allowed certain input to be left unformatted, which is beneficial when displaying computer programs. There were no comments on this feature,

however it was widely used in most submissions as well as by the lecturer, and is therefore considered successful.

Information representation through multiple windows

In order to represent enough information in one webpage without providing unnecessary confusion, a multiple window solution was introduced. This allowed the user to open additional windows on specific issues and would make it possible for the user to arrange the information available as best as possible. It was thought the feature would make it possible for the student to work on one thing while being able to see another thing, and should prevent that any user should have to navigate continuously back and forth between the major artefacts. When Nenya was put into action this feature seemed to generate strong negative comments by most of the students.

From the comments it appeared that multiple windows, successful on a client computer, break with the normal conception of using an internet browser, which caused many problems for the regular user, e.g. using the browser back button would not browse back in the latest opened window, rather the browser would be directed to the previous site. All comments by the students were completely justified as the multiple windows did not provide many benefits and, in retrospect, it seems to be a bad design decision. However the users were also expected to use the system more intensively in which case the multiple windows may have provided some benefits. Some students did report that it served its intended purpose of helping representing multiple information sources simultaneously but they were few as opposed to the large majority.

6.2.4 Help windows

On each window there was a question mark in upper left corner which the students could use to get immediate online help. When clicking this question mark a new window would open with a description of the functionality presented, and how it would benefit the student. From the traces, it appeared that this particular function was rarely used.

6.3 Use of anonymity

One feature added to overcome low participation in Nenya, was providing the students with the ability to post anonymously. This should allow students to ask questions without having to reveal their identity. Within Nenya no posts were actually anonymous, they would only be presented without the user's name which made the post not exactly anonymous but with hidden identity, however the impression is the same. When analysing the trace files there were a 163 posts by students in total, 51 of these were anonymous.

This means that 31% of all student posts had an un-revealed identity. When the second questionnaire was issued, four questions were included to address this anonymity when posting on a forum.

Statement	Mean	Media	Skewness	Kurtosis
How likely would it be for you to ask a question on a course forum publicly	3.83	4	-.286	-1.027
How likely would it be for you to ask a question on a course forum anonymously	4.62	5	-1.162	.613
How likely would it be for you to answer a question on a course forum publicly	4.15	4.5	-.628	-.625
How likely would it be for you to answer a question on a course forum anonymously	4.65	5	-1.155	.841

Table 21- Students reports of using a forum anonymously (revisited)

In the table above it seems reasonable to say that having an anonymous feature can in fact be beneficial for student engagement. It seems that students are more likely to ask a question when they can ask it anonymously. However, more people would not mind revealing their true identity when answering a question. In Nenya, 28 topics were started by students, 12 were anonymous and 16 were not. Of the 78 answers to these topics nine were anonymous and 69 were not. This correlates well with the table since 43% asked a question anonymously, but only 11% answered anonymously. It seems therefore reasonable to conclude that having anonymity in Nenya did in fact help students overcome some impediments to participation.

6.4 Forum

When addressing the forum, students reported that many other software packages provide a better forum implementation than the one used in Nenya. This is quite a reasonable argument as there are many web forums available with many years of research behind them. The design criteria used when building the forum inside the ILE stemmed from the fact that the original ILE had many posts which seemed unrelated to the individual question. Within Nenya, the forum was separated to explicitly address this issue, yet keeping it within the ILE, so it appeared seamlessly integrated. Besides this, the forum needed to support anonymous posts to increase engagement and student behaviour needed to be monitored.

For these reasons, the forum was built and installed beside the EVS questions. Students never reported negatively on having a forum only that better implementation existed, an argument well understood. When analysing the students' actual behaviour in Nenya, it became apparent that there were users who had a greater interest in the forum

than others. These users had a significant approach to the forum which made them stand out in the analysis. It seems therefore reasonable to conclude that having a forum alongside CS1P will actually help students address many issues and that such a forum can benefit from the ability for students to post anonymously but simultaneously there is better software available to use.

6.5 Asking questions

One important aspect of Nenya was the ability to present multiple choice questions before and after answering. The intention was clearly to address the expected benefits of the hypothesis, yet Nenya was still usable to ask additional questions. One option of asking tutorial questions using Nenya was never introduced in the instructional design, even though this was possible. However, in week 3, a set of 17 questions were presented for the students to answer in a separate exercise called the hexagon exercise.

From the analysis, it became clear that students engaged more in the hexagon exercise than in using the EVS questions, as 61 students attempted and 39 succeeded in working through the entire exercise. Given the low usage on the EVS questions, there is no reason to suspect that using Nenya would be better than using any other software capable of asking questions. In the McDermid (McDermid 2005) report it was shown how EVS questions could be incorporated into other Virtual Learning Environment software, in particular Moodle, which is now extensively used throughout the University of Glasgow. As the underlying reason for implementing Nenya was more than just presenting and asking questions, it seemed reasonable to provide this implementation, yet other solutions seem just as good. Students did not report any difficulties in using Nenya to view and answer questions.

6.6 Testing the hypothesis using Nenya

As the research progressed it became increasingly obvious that most behaviour from students using Nenya were related to the issues which were secondary to the hypothesis, i.e. answering additional questions and having a forum available. However there was no reason initially to suspect that students would not use an ILE to receive the benefits hypothesised. After all, using EVS in lectures had consecutively been evaluated as a valuable tool inside lectures. However after evaluating the experiment it became obvious that all benefits would require the students and tutors to actively seek the benefits. They would have to pull information out of the ILE rather than having the information pushed onto them. This pull-model did not relate well to the hypothesis making it hard to really test the hypothesis.

Secondly, the ILE was a coherent web of functionality which made it difficult to express exactly why students acted as they did. It would therefore be reasonable to conclude that the ILE, independent of the value in itself, did not provide a good tool for testing the hypothesis.

6.7 Other ways to use EVS data outside lectures

In the original proposal the ILE acted as the mediator between the EVS data and its audiences. Other measures could easily have replaced the ILE in order to provide the EVS data to students, lecturer and tutors without jeopardising the hypothesis.

- **Using email.** Instead of the lecturer providing additional remediation through the ILE, the lecturer can equally choose to simply send an email to the students. Before this experiment this mechanism was used when certain questions raised enough ambiguity to be further reflected upon by the lecturer. This excludes the students' individual answer, but there is little to suggest that it is necessary.
- **Posting on web.** Another mechanism would merely be to create a simple webpage for each EVS question in which the response graph from the system could be posted. Again this excludes the students' individual answer.
- **Creating a report.** The EVS database can be queried in order to extract data targeting an individual tutorial group. This report could then be printed and delivered through standard communication, such as personal delivery or pigeon holes.

These measures are suggested as providers because there seems to be no apparent need for additional processing of the EVS data outside lectures. Two of these measures actively push information towards the intended users which would make it easier to test the implications of the information.

6.8 Summary

Building Nenya provided students with a better application than the original ILE by providing a richer interface, by providing more functionality and by overcoming some of the initial impediments as described in earlier reports. The main negative issue raised from the application was the use of multiple windows to represent much information, which must be considered a bad design decision. However, the interface can easily be redesigned as the underlying architectural model is strong enough to replace the entire interface layer without affecting the underlying layers. Building a new ILE seemed to make

no considerable change to students and tutors use of the ILE, even though it included more features.

The most prominent features of Nenya were the forum and the additional questions available and these features may equally be found in other software packages, software packages which may actually provide a better implementation of exactly these features. Nenya required that students and tutors should explicitly seek out the necessary information, and this pull-model made it difficult to test the hypothesis directly. With this said, there could also be other communication channels to push information to the intended users.

7 Discussion

This research has examined the use of EVS data outside of lectures from a rather broad perspective, in the way the experiment has been designed and executed. During the research however, it has become necessary to go further into details in order to understand the context of EVS data. During the research, it became clearer that defining the usefulness of EVS data was dependent on the context within which it was to be used. The first of these aspects concerned the usefulness of EVS questions as mediator in a continual dialogue, how it was used for reflection and what was the outcome of this. Another aspect of EVS questions regards assessment of students. Assessment based on EVS questions was conceived as valuable but the extent and applicability of this assessment could not be exactly specified. Orthogonal to these aspects were the persistence of EVS data and the role it played in the aspects above.

The following sections will address and highlight each aspect individually. From the findings, it became obvious that the learning design of CS1P and the students' approach to learning had a major impact on the usability of EVS data outside lectures which could ultimately lead to redesigning CS1P to improve students' deeper understanding. A suggestion for an alternative learning design is therefore finally discussed.

7.1 The value of EVS for continual dialogue

The EVS questions were meant to be used for student reflection and deeper engagement in the material. The students were expected to improve their conversational dialogue with the lecturer, the tutors and other students in order to continue the dialogue outside the lecture theatre.

In order to understand the value of EVS data for continual dialogue, one must attempt to understand the nature of dialogue through questioning. In the lecture, the lecturer would initially present a topic, ask an engaging question, retrieve votes from the students, and remediate over the distribution of votes. The question now becomes: From this moment on, what value does the question and the response data have for continual dialogue? How much from now on can the question still contribute to student reflection and further discussion?

7.1.1 Lack of retrospective interest towards questions

That EVS itself in lectures is valuable is best described from a quote by one of the students in one of the focus groups:

> *"I didn't speak to one person on the course who didn't like using the handsets and getting the questions."*

Another student was able to exemplify how using EVS actually rectified a misconception which could otherwise have had long-term effects.

> *"Once or twice, he's went over something and I've thought I understood it, and then he's asked a question that I've got wrong, it turns out I haven't actually understood it, and I'd have went away quite happily thinking that and done it in my assignments and probably got it wrong in the exam."*

Students did report in the second questionnaire that the EVS question did challenge their understanding (M=4.0 out of 6). They did in fact engage in the challenge. The trace files showed that 93% of all collected EVS votes were in fact collected in lectures, however these only represented 52% of all the possible votes.

Students also reported their likelihood of engaging in the EVS question in the lecture in the second questionnaire:

> *How likely would it be for you to answer a question using EVS (M=5.54 out of 6)*

Clearly all evidence pointed towards a high interest in EVS in lectures, even though not all students actually participated in the actual voting. However, the questions were posted in Nenya afterwards, and analysis showed that each question was only viewed by on average 11 students which would be less than 6% of the students. Furthermore, four out of five questions which the students looked at, they looked at only once. Since it was not directly possible to differentiate between the reasons for looking at any particular question afterwards (they could have been absent and therefore just investigating the topics), the usage for reflection and further understanding could be even less still. From this it appeared that the interest in the question inside lectures is very high, but afterwards the interest seemed drastically reduced. The most likely reason to explain this would be that **the individual question is largely interesting while being asked (a challenge to the student and therefore a motivator). Once the answer becomes known, the question itself becomes mostly uninteresting**.

A recent study on Question Driven Instruction (Beatty 2006) defines a question-cycle methodology in which after students have received remediation they reach a point termed closure, which could also mean that the learning cycle ended a this point. However, this research shows a clear sign of some, although more modest, activity of reflection afterwards.

7.1.2 The role of Nenya for reflection

Even though most students did not view many EVS questions in Nenya, there seemed to be three patterns around the use of the EVS questions in Nenya.

- **The interest of the individual question.** Some questions seemed to attract more views than others.
- **Students' attitude to learning.** Some students seemed to have an attitude towards learning that promotes the use of Nenya for this kind of exploration
- **The time for reflection.** Some students began to use Nenya for reflection as they came closer to the class test.

If referring back to the views each question received in previous Figure 20- Actions per EVS question in Nenya - there seemed to be certain questions or groups of questions, which attracted a slightly higher interest than others. The first question may have received additional viewing because of an initial general curiosity to Nenya. Yet according to Figure 15 - Viewing artefacts in Nenya sorted by week - consistent usage was built up during the course. That some questions therefore rated higher than others would have to be contributed to the nature of the question and the additional need for reflection.

The lecturer had reported that many students usually got the questions wrong and "*often over 50% of the class*". And so there certainly appeared to be a potential for the individual to use Nenya for reflection. Students who in the data analysis were categorized as High Q looked at 18.24 questions whereas students with Low Q looked at 2.86 questions. Students with High Q also had consistently higher scores in using the hexagon exercise and the objectives. From this it would seem that some students in general have a more positive attitude towards using available resources.

From the overall usage of question in Table 5 - Actions on the question artefact in Nenya sorted by weeks – there seemed to be a slightly higher interest as the students started to prepare for the upcoming class test. The reflection here would be classified as revisioning, and seems an inevitable pattern of students learning.

Even though some students have a positive attitude towards reflection on the EVS questions afterwards and some questions seemed to be more relevant for reflection than others, there was still a large group of students and questions upon which no actions could be monitored in the ILE. The conclusion from this seems to be that **most students, irrespective of whether they actually needed it, would not use the ILE.** Some students would use it to some extent, mostly depending on the nature of the question. Since only a few students actually used the ILE it could easily be assumed that this signifies that most students did not reflect upon their own votes. However, the next section

attempts to highlight exactly which actions the students did carry out upon the basis of the questions.

7.1.3 Students' immediate action based on questions

From the results of the focus groups it seemed that students answering the questions correctly usually did little afterwards related to this question. They felt no need to do so. However according to the second questionnaire, they related positively to a statement of

> *Getting an EVS question wrong initiated me to do something extra afterwards (M=3.94 out of 6)*

The formulation was exactly vague enough to catch the fact that they did recognize an incorrect answer as a prompt to do something. It seems therefore valid to conclude that **EVS questions may provide students with an indication of a need for further reflection or conversation.** However, on the formulation of immediate remediation, students very strongly concurred with the focus group.

> *I might have gotten [sic] an EVS question wrong, but Quintin's comments afterwards usually corrected my mistake (M=4.92 out of 6)*

There was a general tendency that even though the students in fact did answer incorrectly there was little reason to expect much additional behaviour from them after the lecture. From the lecturer interview, the lecturer observed that when asking questions related to a previous misconception there could still be a large group not being able to get the question correct. **Students did believe the lecturer's remediation to have been successful when in fact it might not have been.** Students reported that their reflective behaviour if any occurred mostly on an indicative level.

> *"…if you've consistently got them wrong, you think ah, I better look over that. Yet if you get them all right, you think ok, I understand that quite well"*

With this in mind it seems that most students would leave the lecture theatre without engaging in the particular question again. Still, a few chose to engage in the questions. Students had reported that there were cases when they felt initiated into doing something after the lecture because of the EVS questions. From the first questionnaire, students were asked to identify the sources for understanding a topic. Students primarily participated in lectures, labs and tutorials, the structural components of the instructional design, and only secondarily discussed issues with fellow students before turning to course books and Nenya. After this they would use the library and the internet before turning to the lecturer again. It seems as if **students primarily chose to follow the upcoming structural components of the instructional design, i.e. tutorials and lab sessions. After that they would approach sources from a sense of nearness**. This

would mean that if students found an indication in the questions they would at first wait and see if it would be reinforced, as these students pointed out in the focus groups:

> *"Chances are you have to reinforce that work in an assignment, so …". "I would accept that I was wrong and just wait and see."*

Students reported in the second questionnaire that they were more likely to ask questions in the tutorial (M=5.12 out of 6) as opposed to in the lecture (M=2.15 out of 6), and tutors also reported that the nature of the tutorial allowed for the students such that:

> *"Certain students got more from the tutorials and lab sessions than from the lectures"*

The students also confirmed this

> *"Most problems can be rectified by talking to someone and checking your notes"*

Students reported in the second questionnaire that in fact providing the tutor with the results from EVS might be a good idea:

> *Would it be a good idea if the tutor was given a summary of how your tutorial group answered the EVS questions in the relevant lecture (M=3.81 out of 6)*

After following the structural components of the instructional design and consulting immediate sources students could then approach Nenya. However, they seemed largely reluctant to use this resource. During questionnaire 2, students were asked to identify which would be good reasons to post EVS data on the web after lectures. Of these reasons, most students agreed with having additional lecturer comments (83.0%) and having additional comments on the question discriminators (67.9 %). This seems to imply that **the interest in Nenya as far as using it for reflection depended mostly on the additional comments**. One student explained such a circumstance in the focus groups.

> *"There was a couple of times where he didn't actually say what the right answer was. A few people put their hands up and then he explained it… The times he doesn't I would use the new website. It's quite good for that because he puts up a sort of description of what the answer was and why."*

From this it seems that the EVS questions may provide students with an indication of a need for further reflection. They would probably in most cases wait to see if it would be covered again or further in the instructional design rather than taking action themselves. Once the students do take action on any issue from an EVS question they would probably raise it with fellow students and the tutor. Eventually the student might approach Nenya. Having the EVS data posted on the web was beneficial for the students insofar as it provided the students with additional remediation from the lecturer.

7.1.4 Reinforcement of learning through goal-orientation

To facilitate self-directed learning from the EVS questions Nenya included the learning objectives of the course. They served two particular purposes for the students.

- **Provision of near goals.** The objectives would highlight skills the student needed to work with and allow the student to orientate their learning towards these goals. The students could use the objectives irrespectively of the EVS questions for self-directed learning.
- **Add motivation to EVS questions.** All EVS questions in Nenya would link into the objectives in order to establish a causal indication of the goal or reason behind any individual question. This was meant to enhance the reflection upon each EVS question.

The trace files of Nenya showed that of the 35 posted objectives only 24 were ever viewed by any person. 31% of the objectives were never shown to any single student. Objectives were mostly viewed in the beginning of the semester where most users of Nenya were mostly browsing the site out of curiosity. There was a slight increase during the hexagon exercise. This indicated a general lack of interest in using the learning objectives by the students. Even the students with the highest engagement (High Q and High T) looked at an objective only 19 times on average during the entire semester. The focus groups revealed that students were mostly focused towards the practical aspect of the course:

> *"The theory and practical are so linked because the theory is the practical, but practical is just picking it up".*

Students during CS1P did seem to be driven by practical goals such as finishing assignments in lab rather than working towards a deeper understanding of the underlying concepts. Since learning objectives does not seem to be used much by students in general, it seems that using **EVS questions as a deeper active reflection on the underlying topics does not match students perception of learning.**

7.1.5 Shaping conversational dialogue around questions

As the students mostly fail to use the individual EVS questions for reflection and conceptual understanding, it seems plausible that the EVS questions have little interest after the lecture. The most probable interest seems to be in having additional remediation published from the lecturer. Referring back to the simplified model of Laurillard's conversational framework (Figure 3 - Simplified Laurillard's model) it seems that the EVS conversation exists in one and a quarter loop with the remediation as the final action, be it inside or outside the lecture. However, this seems reasonable enough as the conversational framework describes the iteration of a conversational cycle by having additional dialogue.

> *[There must be] a continuing iterative dialogue between teacher and student, which reveals the participants' conceptions, and the variations between them, and these in turn will determine the focus for the further dialogue. (Laurillard 2002)*

The EVS questions usually work as an example of a particular implementation of the objectives of a given topic. They test only a few particulars in a topic. One application for additional dialogue around EVS questions could therefore be to ask additional questions within the topic. During CS1P one exercise was published on Nenya for the students to attempt. This exercise consisted of 17 additional questions which worked through a scenario of decisions to make during a course of action together with their possible argumentation. The exercise was orthogonal to a particular topic, and the students were encouraged to attempt it, but otherwise not forced to. 61 students chose to work through this exercise, or roughly one third of the class. Of these 39 students answered all 17 questions. This is still more than 20 % of the class who worked through the exercise. This seems to be a viable iteration of reflection which generated the proper effect in the students. From the focus groups the students also reported this exercise as useful.

> *"He put like other questions up that he wouldn't ask in lectures, but they'd be up in the website. There was a number that took you through step by step processes of solving a problem. I found that really helpful."*

Another aspect to support this would be the generic interest from the students in using this exercise. During the weeks of the exercise more people logged into Nenya and took part in the exercise than in reviewing the EVS questions. It is also obvious from the fact that only three EVS questions out of 74 in total were viewed more than the least viewed exercise question.

7.1.6 Summary

From these findings there seems to be a pattern emerging of the value of EVS data for continual dialogue. Once a question has been asked there seems to be very little interest in the question itself. If students feel from answering the questions that they do not understand the topic well some would probably at first wait and see if their understanding would improve as they progress with the course. Alternatively they would ask or otherwise engage in dialogue, mostly with fellow students or their tutor. Students defined their understanding through practical skills and probably reflected more in a practical context.

The benefits of posting the EVS data would only seem to be the additional remediation by the lecturer. In addition it would only prove valuable depending on the actual question or the student's attitude towards learning, and to some extent this reflection could in fact be revision for class test. The strongest indication of the value of conversational dialogue around the EVS questions after lectures would probably be to take one step back from the

questions and address the individual topics by giving the students additional questions to attempt. Conclusively, this could imply that deep reflection would be more appropriate after students had engaged in the practical aspect of the course.

7.2 The value of EVS for assessment

Another aspect of the usability of EVS data outside lectures is the value of EVS data for assessment. In order to understand this value this section outlines a definition of assessment as used within this research, how reliable this assessment might be and eventually how this assessment can be used by the students as well as the institution.

7.2.1 Definition of assessment

> **as·sess·ment:**
> Etymology: Middle English, probably from Medieval Latin *assessus,* past participle of *assidEre,* from Latin, to sit beside, assist in the office of a judge
> **1:** to make an official valuation of (property) for the purposes of taxation
> **2:** to determine the importance, size, or value of <*assess* a problem>
>
> Merriam-Webster OnLine (http://www.m-w.com)

Given the emotional charge of using a word such as assessment it might be important to define the meaning of assessment used in the following sections. The quote above from Meriam-Webster defines two usages and one etymology for the precise word. The usage implies that assessment today bears the meaning of placing a particular value onto an object or to perform an official valuation of it whereas the etymology seems to relate more towards assistance than valuation. In educational research the word assessment is often used in terms of either summative assessment or formative assessment.

- **Summative assessment.** Identified as *assessment of learning*. Summative assessment is the act of evaluating the individual student most often to grade students. Summative assessment is not regarded as having any intrinsic learning value, and it therefore matches the defined usages within Merriam-Webster.
- **Formative assessment.** Identified as *assessment for learning*. Assessment that is "*specifically intended to generate feedback on performance to improve and accelerate learning*" (Saddler 1998) and undertaking this assessment usually constitutes a learning experience in its own right. This seems to match the etymology of the word assessment.

EVS can be useful as a tool for summative assessment (Draper 2004), however all applications of EVS within the project was used as formative assessment. The lecturer reported the format of most questions being a "*reality check*", even though students also reported in one of the focus groups that:

> *"The questions checked that you understood the topic"*

Both formative assessment and summative assessment is centred on the assessment as an evaluation of the learner, but differentiates itself on its purpose and its outcome. Beatty et al describe the difference as being in terms of objectives only.

> *"The primary objective of formative assessment is learning; the primary objective of summative assessment is evaluation." (Beatty 2006)*

In the following context **assessment means any informal evaluation of the learner from using EVS where the purpose is considered feedback to the upcoming learning process**.

7.2.2 Using EVS for assessment

In formative assessment, the assessment acts as an instigator for a reaction back into the learning situation. The lecturer, the tutors and the students may choose to respond to the assessment made by the EVS data by some kind of action. At various stages, research has so far assumed that the formative assessment in EVS is accurate enough for the actions taken from them (Beatty 2006, Draper 2004, Cutts 2006), however this research has attempted to take the same assessment and use it outside lectures in different situation, and has therefore in cases made some assumptions on the authority of the assessment in this context. In order to use any assessment as a reaction, it may be necessary to identify if an assessment is accurate enough to justify the actions, if in fact it is formative enough to spawn an action, and if it is the correct action to take. The question to address in this section is therefore: How well do one or more EVS questions, even though formative, represent how this individual student or group of students currently deeply understand any given topic and if we intend to act on this assessment what kind of actions would be correct to take from this? Or what importance does the response data really represent?

7.2.3 Assessment and student outcome

Starting from the end of term results, the analysis indicated that there was a connection between how correctly a student answered the EVS questions and their class test and degree examination respectively. However, when visually inspecting the relationship in Figure 22 - Relationship between correctness and class test and degree examination - one would have to be very optimistic to take this connection seriously from a statistical

point of view. Another measure to add to the equation is the fact that students attempting more questions were significantly less correct than students attempting fewer questions, which should have turned the relationship the opposite way.

It also seems reasonable to assume that students prior to the class test and degree examination went through a brief period of intense rehearsal and revision which should make the student more prepared for these tests than they would otherwise have been if it was 'only' a lecture. It seems reasonable to conclude that as expected, **EVS questions cannot predict the students' final outcome from the course**.

Students did report that using EVS questions made them more attentive in lectures:

> *"I think you pay more attention because you know that you're going to get asked a question about it."*

But at the same time they admitted to not exactly being well prepared for the lecture:

> *"… Not actually read up on anything". "I usually see what the next lecture's on about 15 minutes before it".*

If students did not enter the lecture theatre well prepared they would only have encountered a concept initially when asked the EVS question, which also meant that they had not had many chances of practising the concept in action and had no hands-on experience. One tutor also identified this early encounter with the material when she argued that *"some students would need time to reflect and reanalyse the material"* and that the EVS vote therefore *"would not necessarily make sense"*. From this it seems that the EVS questions mostly reported how well a student understood a concept as a function of the imparted knowledge in the lecture. The connotation of using EVS questions for assessing deeper understanding of the students' skills seems therefore invalid if the students had not had the time to further reflect or experience the topic. In the second questionnaire students suggested how EVS questions can be used as an indicator

> *The EVS questions were a good indicator of how well I was doing on the course (M=3.72 out of 6)*

This indication was also suggested from one of the students in the focus groups.

> *"The questions checked that you understood the topic"*

That the EVS questions in fact were perceived as a check that the student understood the topic, yet still not necessarily reflect the individual students seems hard to understand, but one student actually provided a hint for this conception when asked a direct question:

> ***Do you see the fact that you've got the answer right mean you think you're pretty confident on that topic now?*** *"Yes, well it would depend on how hard the question was."*

In the student's own words, it depends on how hard the question was, or probably to be more precise **that the ability of using an EVS question as a true assessment of the students' deeper learning depended on the nature of the individual question**.

7.2.4 The value of the individual question for assessment

In order for any EVS question to be used as an assessment it must be identified as valuable for assessment. It must be engaging and challenging enough for all or most of the students to participate. Problems which seem to alter the perception of assessment include:

- **Too easy question** in the question text or in the discriminators. Most students would succeed at answering the question providing an incorrect indication of understanding in the lecture.
- **Too hard question.** Many students may choose not to attempt in which case the results do not include the correct level of misunderstanding amongst the students.
- **Non-challenging questions.** Some questions may be seen as irrelevant to the student and the student may not attempt to deeper reflect before answering. In fact, students in one of the focus groups happened to touch on their experiences with another lecturer's use of EVS, and reported in this other setting that *"I don't think anybody really cares. You just pressed any [button]. It didn't matter at all".*
- **Error in question.** There may be an error in the question which may provide invalid results. In fact, the question in Nenya which generated the highest amount of student's views (85) was apparently not easy to interpret judging by the comments from the students.
- **Student use of strategies**. Students may also choose to use other strategies than deeper reflection to answer a question. This could be explicit, such as a student merely guessing from a set of probably solutions, or the student may choose the answer based on it placement in the rank of options. A recent study (Sedlmeier 2006) reveals how students' judgement might be influenced by other factors, and that in fact the correct answer is most often placed in the middle. Students may also make their choice unwarily for these reasons.
- **The sum of votes**. It is often assumed that all students participate and the response therefore is representative of the entire class. However, since only 56% of all possible answers were collected in lectures and afterwards in Nenya there appears to be many questions which do not. This includes technical reasons such as students not verifying that their vote had succeeded but also that some students did not manage to generate an answer within the time given.

From the examples above, there seems to be four distinct sources influencing the quality of the question: The *lecturer*'s use of questions, the *question* itself, the *students* answering and *other* reasons, which include technical reasons. These are outlined in the following figure.

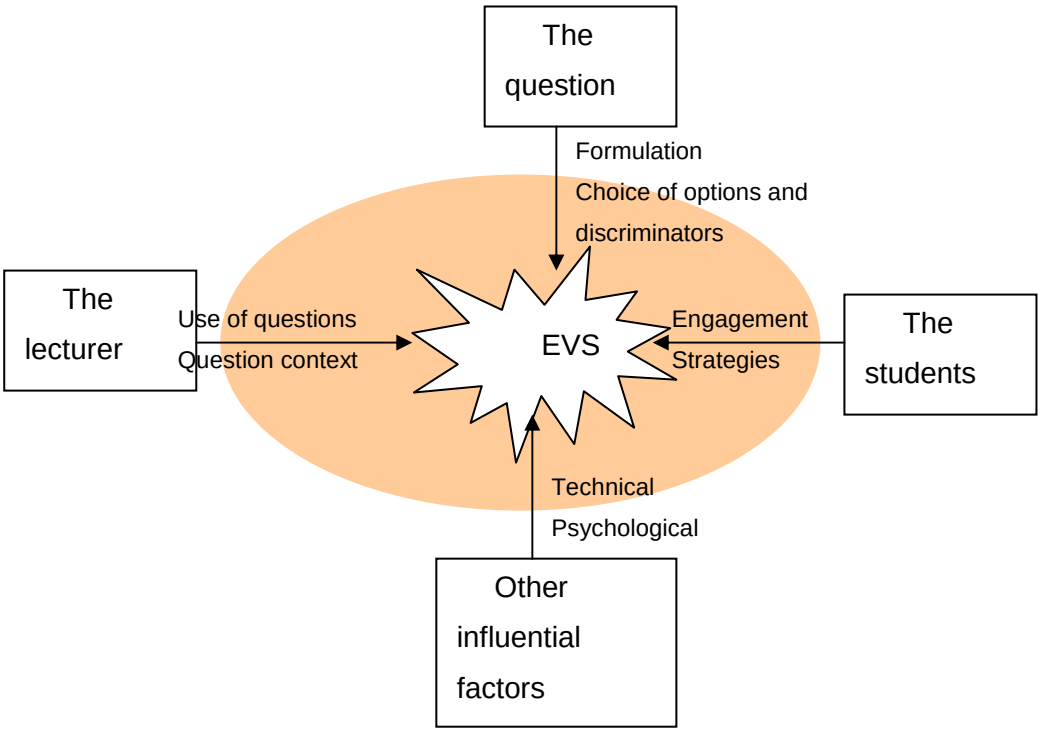

Figure 23 - influential factors in using EVS for assessment

The factors above outline the *degree of freedom* which must be incorporated into any judgement based on an EVS question. **Each question being asked using EVS incorporate a degree of freedom in its quality, which influences the reliability of any assertion based on the question.** In order to understand the assessment, it is therefore important to interpret the degree of freedom which exists within each influential factor. Earlier studies (Draper 2002, Stuart 2004, Draper 2004, Cutts 2006) reported the use of EVS as a comprehension of the current understanding of the topic, even when used formatively, and this could imply that the studies were biased when speaking unconditionally about valuable formative assessment.

7.2.5 The reliability of using EVS for assessment

The extent of the degree of freedom in placing a reliable assessment into an EVS question is mostly intrinsically understood within the context of the question, i.e. by the people attending the lecture. They may recognize a slight misunderstanding in the question; the lecturer may have failed to explain something important prior to the question;

the students may partly discuss amongst themselves, or simply abstain from voting. Once outside the lecture, having only the question text and the response data, there is limited information to ascertain the quality of the question. To illustrate consider these two examples:

> *- 50% of the class answered a question wrong. Did the students fail to understand, i.e. have we discovered a major misunderstanding, or did the lecturer fail to explain it properly, e.g. using an example earlier which was easy to misinterpret?*
> *- 95% of the class answered a question correctly, however the tally only counted 100 students (as opposed to 187 registered). Did the rest fail to attend or perhaps fail to produce a vote on a difficult problem and if so how would their outcome have altered the assessment?*

It appears immediately that a question in itself seems more reliable within context. However there is also evidence that the opposite is true in (Cutts 2006) where the lecturer reported "*easy misinterpretation of the response data in lecture as a consequence of the pressure and limited time available*". **The reliability of an assessment using EVS will always have an inherent error margin. Higher reliability comes from controlling the influential factors and understanding of the degree of freedom it entails.** It seems likely that being within the context of the lecture promotes a more reliable assessment than not participating in the lecture, yet even inside the lecture assessment may not be truly assertive.

7.2.6 The validity of using EVS questions for assessment

Besides reliability, there is one additional factor, which may not necessarily change the value of the assessment but which strongly affects the usability of EVS questions for assessing student's deeper understanding. This factor is the instrument, i.e. the EVS question itself. The instrument affects the measurement, or in this case asking an EVS question in itself affects the assessment which the question might have intended to measure, and hence invalidating the result immediately. There are two dimensions of this validity:

- **Revelation**. Once the correct answer to a question is revealed, it must be assumed that if the exact same question were to be asked again, even without remediation, most or all students should be able to get the question correct due to memorization.
- **Time**. The assessment is affected because the immediate result may lead to cognitive action, which may change the understanding of the students, and hence the assessment needs to be performed once again to measure this new understanding.

Especially when students answer wrong, they seem to react to the question and "do something":

> *Getting an EVS question wrong initiated me to do something extra afterwards (M=3.94 out of 6)*

But secondly and probably more importantly, the lecturer will normally remediate on the response and this seem to change student understanding even more, as explained by this student in the focus groups:

> *"Once or twice, he's went over something and I've thought I understood it, and then he's asked a question that I've got wrong, it turns out I haven't actually understood it, and I'd have went away quite happily thinking that and done it in my assignments and probably got it wrong in the exam"*

Students also seem corroborative about learning from the remediation:

> *I might have gotten an EVS question wrong, but Quintin's comments afterwards usually corrected my mistakes (M=4.92 out of 6)*

It might be that these changes only occur when students face minor misconceptions in the topic as opposed to major misunderstandings or more seriously lack of understanding. A student can take from no action to a great deal of action from when the question was asked to when it was used by any other party. However, this still does highlight that even though establishing some form of assessment from the EVS questions, **after the lecture when the assessment is eventually put into use it may no longer be valid, either because of lecturer's action or the students' own action, which may alter the student's conceptual understanding and hence invalidate the measure**.

7.2.7 The value of cumulative assessment

The last dimension to consider is the effect of cumulative assessment, either multiple responses to a single question or multiple responses to multiple questions. Inspecting the individual's vote on an EVS question may not accurately measure the comprehension of the individual within the specific topic because the simplicity of the votes being either correct or incorrect does not relate well to the degree of freedom in the question and to the reliability and validity of the question. However, there were indications that when any student had attempted multiple questions there seemed to be a better coherence, as this students pointed out.

> *"…if you've consistently got them wrong, you think ah, I better look over that"*

Secondly from the lecturer's point of view the cumulative responses from the students are used by the lecturer immediately as the result becomes clear. The lecturer chose to remediate or instigate a class-wide discussion usually based on the distribution of the votes. Inside the lecture theatre, the lecturer was well aware of the influential factors and

therefore the reliability of the response to a question. The question would be inherently useful in this setting. This would indicate a belief that the cumulative set of responses is mostly perceived as being representative of the cumulative understanding of the students, even though as previously quoted there could be "*easy misinterpretation of the response data in lecture as a consequence of the pressure and limited time available" (Cutts 2006)* **It seems as if the perceived error of the assessment is slightly less when using cumulative views, either one particular students multiple results or the cumulative response of a group of students.**

7.2.8 The consequence of erroneous assessment

When using EVS as a tool for formative assessment, it is with the intent that the response data would be analyzed and interpreted, creating a judgement which again is used to provide feedback to the learning process. The assessment indicates the current 'performance' which gives reason to feedback which should "*empower students as self-regulated learners*" (Nicol, 2006). The ideal would therefore be that the feedback would be the correct information given at the correct time to the correct audience. However, an error in the judgement may lead to either of these two types of error:

- **Type I.** The judgement indicates a need for remediation or action when in fact it may no longer exist at this particular time or have never existed.
- **Type II.** The judgement indicates no need for remediation when in fact it would have been necessary.

If remediation is given to the students a type I error could eventually make students bored leading to not paying attention and a type II error could lead to lack of understanding. From the students perspective a type II error could also mean a student could falsely rely on consecutive correct answers as an indication of understanding.

"Yet if you get them all right, you think oh I understand that quite well"

Misjudging a formative assessment may result in too much or too little action taken, both may have serious repercussions on the learning situation.

7.2.9 Student assessment in CS1P

Having the EVS questions available after the lecture allowed the students to self-monitor their progress. Self-monitoring can be an important aspect of self-regulated learning (Zimmermann 1997, Woulters 1996). In the second questionnaire the students were asked about their use of Nenya for self-monitoring purposes:

I used the website to monitor my progress in the course (M=2.65 out of 6)

I used the website to compare myself to the rest (M=2.63 out of 6)

The difference in the formulation of these two statements relate to students goal orientation of either task mastery or ego-social ambitions (Woulters 1996, Bouffard 1995, Nolen 1998). Both scores were reported low as an indication as to no such admittance. However, when the students were asked again about general benefits of Nenya they reported the same issues slightly higher.

> *I could summarize how well I was doing just by seeing how many questions I had right or wrong(M=4.13 out of 6)*
>
> *I could compare myself to the other students and see how well I was doing on the course (M=3.6 out of 6)*

That these statements scored higher than the previous could probably be because the individual student did not self-monitor explicitly nor would admit ego-social tendencies respectively or that the second questions addressed probability rather than certainty. That the students in fact did or could use Nenya for self-monitoring was answered from the following question:

> *The EVS questions were a good indicator of how well I was doing on the course (M=3.72 out of 6)*

The students seemed to respond well to using the EVS as an indicator of their progress whereas the term monitoring may not be accurate of the kind of assessment. In the first questionnaire one of the students reported about his usage of Nenya as:

> *"I just generally had a browse and checked my EVS score"*

The term EVS score would probably mean an average indication based on the multiple EVS questions, and seems a good phrase for the indication of cumulative assessment of the individual. The pattern of viewing EVS questions to get an indication or an 'EVS score' seems consistent with the trace file, in which as the module progressed (week 9 and 10 especially) more students seemed to view the cumulative list of questions, which would be consistent with 'checking their EVS score'. It seems from the students' behaviour and reports that **irrespective of the true reliability and validity of the assessment it was still considered a formative assessment by the student when he or she observed the cumulative assessment.**

In Nenya, students had the ability to relate questions to their learning objectives or just work with the learning objectives in general. It was originally expected that students would a) see how they answered a particular question within a topic, and b) could see how well each topic should be understood i.e. the learning objectives. Since there was little interest in the individual question there was also little interest in this association, and there was otherwise little generic interest in the learning objectives. Had learning objectives been used more, it would imply a more focussed self-monitoring and higher goal-awareness

amongst the students. Given the low usage of objectives **students would generally have a low awareness of their expected goals**. This was also reported by the students:

> *"As long as we work through the programs you probably know most of the course."*

The behaviour of listing the questions in Nenya were mostly reported by students categorized with High Q, student which had a consistent higher usage of the website for using the EVS questions and especially using the hexagon exercise. These students would also have viewed the learning objectives more often than the rest. This would indicate that these students would be rather more engaged in the course and probably more self-regulated, and **that these students valued the EVS questions as formative assessment and feedback for learning**.

In the second questionnaire, the students were asked a more direct question on the use of EVS for assessment of progress:

> *Would posting the EVS data be a good way to get formative feedback on the course (87% agreed)*

When the students were asked which options to include when posting EVS data on the web, 41.5 % did feel it important to be able to summarize how well they were doing, whereas only 30.2 % felt it important to compare towards others. From these findings it seems that students in fact did use the EVS data cumulatively as an assessment of their progress in the course. Students were inherently aware of the reliability and validity of the questions and only placed value on an average score

7.2.10 Lecturer use of assessment in CS1P

The lecturer reported that many students usually got the questions wrong. This was consistent with the results from the trace file. However, the lecturer reported that after analysing the EVS data afterwards it was "*often over 50% of the class*". The lecturer feared that even after remediation many students still got related questions wrong. It was not possible to deduce whether the students getting related questions wrong were in fact the same or a subset of the student having the questions initially wrong. If the lecturer was correct, students would have not reflected properly on the assessment, or otherwise the lecturer would have reported a consistent Type I error.

The lecture reported that EVS could provide a decent assessment of the class's level of understanding, although it was far from perfect. This seems to indicate that the lecturer has a high awareness of the reliability and validity of any question, yet the lecturer should still be wary of the interpretation of the responses. **For as far as the assessment is mostly correct, this means that the lecturer gains valuable feedback from the immediate assessment**, contrary to non-EVS lectures where the lecturer would only

receive feedback from the marking in tutorials. However, there is no clear indication whether the assessment the lecturer receives and uses in EVS lectures is correct.

7.2.11 Use of assessment in tutorials in CS1P

The tutor could use the EVS questions for assessment of the individual students or the tutorial group. The assessment of the individual was intended to be used for pastoral care whereas the assessment of the entire tutorial group was intended to be used as a basis for additional reflection. When discussing assessment of the individual student based on EVS questions with the tutors, they all agreed that consistently wrong answers might provide an indication that a student would be either struggling or not paying attention. One tutor also reported using Nenya in the beginning of the course to *"get a feel for the good/bad students"*. **The assessment of the individual was used as an early indication of the conceptual understanding and perception of the student**.

Later on the tutor did not use Nenya, because he "*knew his students well enough*", which seems to indicate that the tutor **became capable of judging the individual student better from personal experience or other measures rather than through the EVS score**. As previously discussed, the conversational dialogue from lectures was meant to continue in the tutorials, and the tutors would therefore be provided with the assessment of the tutorial group in order to shape this conversation.

From the previous discussion, it would appear that tutors would not be well informed about the reliability of the assessment, and the assessment may not be valid when used in the tutorial. Yet, one of the tutors described an interest in using the response data in tutorials, and the students also seemed to concur:

> *Would it be a good idea if the tutor was given a summary of how your tutorial group answered the EVS questions in the relevant lecture (M=3.81 out of 6)*

The other two tutors seemed to rely more on the students to raise issues within the tutorials. Given the outcome of this experiment **it was not possible to conclude neither how sound the assessment would be nor how sound the assessment should be in order to be used in tutorials for reflection**. Even though the assessment of the individual or the group seems beneficial in tutorials, there is another aspect when the tutor uses the EVS data for assessment.

In the second questionnaire students also reported that providing the tutor with individualized information might not be a good idea:

> *Would it be a good idea if the tutor was given a list of each individual answer (M=2.72 out of 6)*

Tutors also reported that using the EVS data more extensively could "*add a degree of 'need to perform'*" on the students whereas it now was considered "*stress-free*".

The tutor who did use Nenya reported that he stopped using it, because he "*knew his students well enough not to have to check up on them via the EVS system*".

The dimension here is the reverse side of pastoral care, **that the information can be used to control the students**. Tutors must be given some instruction or intuitively have a common sense as to how much emphasis to place on the results. Even though the control may not exist it can easily be imagined by the students and therefore endanger the usability of EVS inside lectures.

7.2.12 Summary

When using EVS data as formative assessment the response data can still provide an indication of the current comprehension of the students. However, many factors influence the reliability and validity of the assessment providing a degree of freedom to be aware of when using the assessment. Assessment seems to be more precise when being cumulative either of a student's formative assessment or the assessment of a group of students. The assessment is important to the cognitive process insofar it facilitates feedback to the learning process, but the assessment may still lead to too much feedback or not enough feedback if not being wary.

Students reported a beneficial use of the EVS data as a formative feedback when seen as a score over the cumulative votes. The lecturer reported beneficial use of the assessment as a catalyst to reflection. Tutors were positive about using student's assessment as an indication for pastoral care, but seemed partly reluctant to use the EVS questions for further reflective dialogue even though it was perceived as beneficial. It also became apparent that if the assessment of the individual students is being used more explicitly by either the lecture or the tutor, the student may feel or in fact be controlled and this could negatively affect the use of EVS in lectures.

It seems reasonable to conclude that the assessment of students' understanding may not have been valuable enough to act authoritatively on.

7.3 The value of EVS as a persistent record

Independent of the previous variables, there seems to be an aspect which influences the equation, the value of the EVS data as a persistent record of a situation occurring. Having the information available after the lecture may benefit those present as well as those absent.

7.3.1 The lecturer

The lecturer must utilize the time carefully and there may be situations where having the EVS data afterwards does in fact help the lecturer. The lecturer reported issues such as misinterpreting the response graph in lecture and not having enough justification to address all discriminators in the lecture. Both problems could be rectified after the lecture. In fact Nenya did allow the lecturer to further remediate a question and comment on the discriminators and it was very appreciated by the students

The lecturer may add additional useful comments (83%)

The lecturer can comment on all options and not just the popular ones (67.9%)

The lecturer also reported that having the discussions of previous lectures and the subsequent analysis of the EVS data would half of the time lead to either the lecturer having something to say at the start of the next lecture or small adjustments to the flow.

7.3.2 The students present

Having the EVS data available afterwards does allow students to assess themselves and occasionally reflect on the questions as described earlier. The data analysis of Nenya did show an interest in the EVS questions just prior to the class test, and it therefore seems plausible that some students used the data for revision. One benefit reported by the students in the second questionnaire was in fact the applicability for revision.

I could read over the questions again during revision (4.09 out of 6)

This option (58.5%) together with the lecturer's annotations was considered the most favourable options when posting the EVS data. However, when asked about the usefulness of Nenya in the second questionnaire 57% of the students reported a useful value within the semester and 33% reported a useful value during revision. There was a small difference between having the ability and actually doing it.

From the first questionnaire students also reported using an EVS question as an example:

"To remember how to do some procedures when doing a lab". "To remember how to do some procedures when doing a lab (looked at the questions)"

As some of the questions did include specific actions, it could provide some more or less detailed examples for the students to use.

7.3.3 The students absent

One purpose of Nenya was to provide students who were absent from a lecture with an insight into the lecture and giving them the challenge of answering its questions. For every 14 votes inside the lecture, one vote was provided outside of the lecture. The students voting may have been present in the lecture and merely forgot the handset or experienced

technical problems, but some of the students were probably absent. Most students answering using Nenya were the students who were categorized High Q. These would already have attempted or completed the hexagon exercise, and the proportion of answers in the hexagon exercise versus the ordinary EVS questions were 2 to 1, indicating some willingness to use the system for answering both kinds of questions.

In the second questionnaire the students were presented with a statement on posting the EVS data for students not attending.

When I wasn't attending I could still get a feel for the topic (3.10 out of 6)

This result indicated a small disagreement with the statement. This feature was however not considered a good reason to all students (26.4%) for posting EVS data. It seems that even though EVS questions do provide a snapshot from the lecture, they are not likely to be considered useful for absent students. From a study on the use of e-notes (McGrabe 2005) McGrabe published scaffold lecture notes as well as full lecture notes on the internet. The full lecture notes would provide an even more detailed record for the absent student. McGrabe found that students categorized as Frequently Absent Students downloaded the lecture notes less often than students categorized as Seldom Absent Students, which could lead to the interpretation that students would not necessarily bother to retrieve lecture notes. This may be even truer of the EVS data given that they only highlight a few issues in the lecture. It seems that EVS data might be less interesting than other immediate resources (lecture notes, student notes, examples from the lecture, podcasts, etc) as a persistent record of the lecture for students not attending. If the purpose of posting the EVS data is to enlighten the absent student then there seems to be better mechanisms for doing so.

7.3.4 The institution

When defining the institution here the lecturer is excluded insofar it concerns imparting knowledge and addressing student feedback. Otherwise the lecturer and the tutor as well as other persons related to the course may be defined as the institution. Having access to EVS data after the lecture could provide benefits for the institution. Having individual votes can actually be used as a measure of attendance, insofar that having cast a vote in the lecture means the students' handset (and therefore probably the student) is in fact present. However, the opposite cannot be deduced. If a vote is not placed by a student, the student may well have been present anyway. Making attendance checks has not been a focus of this study.

Another aspect of having the individual votes is the immediate feedback it provides. One tutor reported initially to *"get a feel for the good/bad students"*. By simply collecting the individual votes, the institution can get an indicative assessment of the individual early

in the process. Normally a student would have to have completed and handed an exercise in for marking before any assessment could be made of the individual. With the EVS votes, this feedback can become more upfront. The cumulative votes of an individual student may be used for pastoral care, but great care should be taken in placing authoritative value in the results because they may be unreliable and invalid, and approaching students from the individual votes must be considered very carefully.

As was the intent of this project the EVS data can be given to the tutor in order to extend the dialogue from the lecture. Tutorials are the natural place for students to engage into further dialogue, because of its placement right after the lecture and its limited group size. Students use it as an immediate resource (97.85% of the students marked it with an average priority of 2.87), and they were more likely to ask questions in tutorials (M=5.12) as opposed to in lectures (M=2.15). Tutorials tend to revisit topics from the lecture based mostly on the instructional design, the experience of the tutor as well as information from the lecturer and the students.

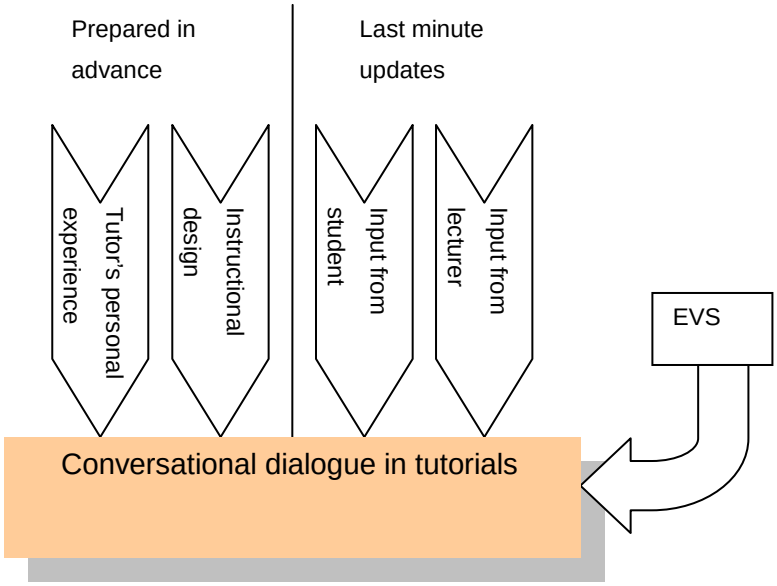

Figure 24 - Input for conversational dialogue in tutorials

By having the response data from the EVS available, the tutors had the ability to include it into the pool of information for the conversation, but apparently did not have time, have need or just did not know this fact. The major points from the previous sections when taken the EVS data outside for continual dialogue are:

- **The relevance of the question itself**. Students have worked through the question and the question itself may no longer be relevant to dialogue even though the relating topic might still be.

- **The degree of freedom in the assessment**. The factors which influence the responses are not inherently perceived if the user, in this case the tutor, was not present in the lecture, which could lead to erroneous assumptions.
- **The reliability of the assessment**. The assessment may not be an accurate assessment of student's deeper understanding of the topic which could lead to incorrect feedback or lack of necessary feedback.
- **The validity of the measure**. As a result of in-lecture remediation, further study or conversation with other students, the result may no longer be a valid assessment of the student's understanding
- **The effect on students**. Using the answers more explicitly may make students refrain from voting. This can devalue the use of EVS.

The factors here may be enough for the tutors to discard the information as being useful, which could have been the situation with Nenya, however it is still seems reasonable to link lectures and tutorials more closely to uphold conversational dialogue and the snapshot of EVS data may provide valuable information that the lecturer or the students otherwise would not have shared with the tutor.

7.3.5 Summary

Using EVS data as a persistent record is mostly beneficial for the lecturer to provide effective remediation. Students present may use the information for self-assessment and reflection or just as an example too use, but it generally seems unimportant compared to other learning tools. Students absent can use the information too, but may not find it useful compared to other resources such as notes, examples and podcast. The institution may use the information to initially gauge the individuals and provide indication for pastoral care. They could include the information to other learning environments, such as the tutorial, which could benefit from the initial dialogue, but this still needs to be verified.

7.4 Impact on the learning design

During the course of this project it has become increasingly clear that the use of EVS with respect to reflection and formative assessment in many ways depends on the surrounding learning environment; the instructional design and the students learning behaviour. Therefore it also seems imperative to suggest viewing EVS questions in the context of the particular learning environment and by these means enhance the reflection and formative assessment by using the EVS questions differently. The best way to approach this would be to reconsider EVS in the light of Laurillard's conversational framework and by providing suggestions for further work.

7.4.1 Conversational dialogue in CS1P

At first we need to revisit the conversational framework and its applicability in CS1P. Laurillard's model from Figure 1 - Laurillard's Conversational Framework - (Laurillard 2002, Laurillard 1999) describes learning as existing at two distinct levels, a conceptual level addressing teacher's and students' conceptual understanding and a practical level where students experience the concepts in a constructed environment of goal-action-feedback. Laurillard also describes how traditional lectures fail to address conversational dialogue and would usually only provide item 1, Theory and ideas, imparted to the student.

EVS in lectures changes the nature of lectures into two-way communication in which conversation can take place, as the simplified model of Laurillard's Conversational Framework (Cutts 2004) Shown in Figure 3 - Simplified Laurillard's model. This would lead to lectures covering item 1 through 4 in the original model. The lecturer would present the theory, ask engaging questions to gauge students' comprehension and correct common misunderstandings and misinterpretations.

Some research (Cutts 2004, Cutts 2004-2, Cutts 2005, Cutts 2005-2) seems to argue that using EVS allows the lecturer to ask questions in which students are forced into action, and that using EVS provides full benefits of the conversational dialogue. However, there is limited amount of time available in the lecture and, given that the theory must be covered at least to some extent, there is little time in lectures to have sufficient tasks to cover an entire topic, especially when the only tool is multiple choice questions, and there is little individualized feedback. The goal-action-feedback cycle is usually postponed to tutorials, laboratory and self-study time.

In CS1P, the problem solving skills take time and the results must be tried on a computer, the students must be able to create computer programs, and so CS1P requires hands-on experience by the students which cannot be had in the lecture (Cutts 2001). Tutorials and lab sessions are therefore the mechanism of the constructed environment in which students perform active experiments and receive concrete experience. Tutorial groups are also small in size and students are more willing to engage in dialogue with the tutor about underpinning concepts of the course. It seems plausible to conclude that in CS1P the lecturer interacts with the students on the conceptual level while the tutor interacts mostly on the practical level.

7.4.2 Learning cycles (or lack thereof) in CS1P

Laurillard's Conversational Framework is iterative insofar as the teacher and student must engage in a continuous dialogue and that the student must switch between

conceptual articulation and the constructed task environment. However, the instructional design for the student in CS1P seems to work in a waterfall model rather than in a cyclic model.

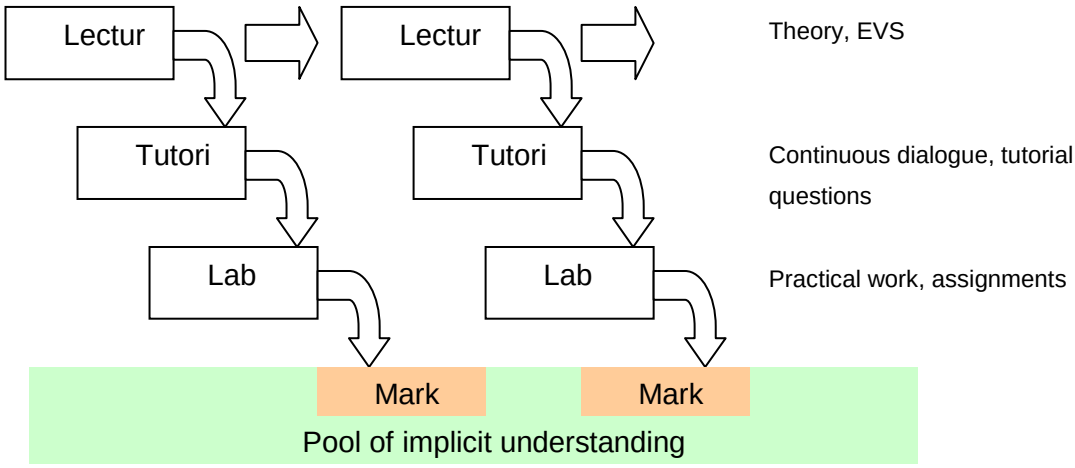

Figure 25 – Student's perspective on instructional design of CS1P

The model above is the design as imagined from a student's perspective. The lecturer introduces a topic, then additional work in tutorials before really working towards an assignment in the lab. To students, each lecture introduces one or more new concepts in a well-defined order, building upon comprehension of previous concepts. If the students miss one lecture they feel compliant to catch-up somehow before the next lecture in order not to fall to far behind. There is no explicitly defined process of reflection on concepts in light of experience (Item 11 in Laurillard's model), only feedback (item 8). Students evaluate their progress on the course in view of the assignments, and through these appear to work towards implicit conceptual learning.

The lecturer is the authoritative entity in CS1P and responsible for the instructional design within the curriculum. The lecturer initiates conceptual understanding and sets the constructed environment in which the students must work. However, the engagement with the individual students is delegated to the tutors in the tutorial group.

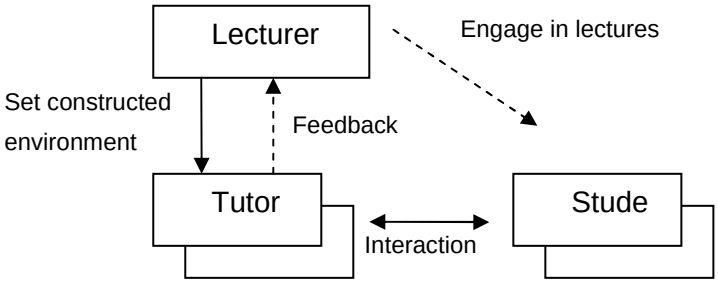

Figure 26 - Lecturer's role in dialogue

The lecturer holds the initial lectures with the student and sets the task environment for tutorials. The tutors interact with the individual students providing feedback and conceptual understanding. If the lecturer should reflect upon learners' actions to modify conceptual descriptions (item 12 in Laurillard's model) the lecturer must receive feedback from either tutors or students. In CS1P the lecturer would receive feedback regarding learners' actions from these three sources:

- **Being the tutor.** The lecturer worked simultaneous as tutor for one tutorial group. This tutorial group was always scheduled first, so the lecturer could provide instructional feedback to the additional tutors about topics to address.
- **Input from tutors.** The official feedback from the other tutors was student marks and unofficially also the occasional chat around the coffee machine.
- **Input from students.** This feedback was provided from the EVS in the cases where the lecturer used the first 5-10 minutes on a contingent issue.

These are all instruments for the lecturer to become aware of the conceptual understanding of the students.

7.4.3 Usage of EVS in lectures in CS1P

The lectures have mostly been introductory with the intention of students having deeper engagement later on. The lecturer has been using EVS in lectures for many years now; each year reported a success by the students. The method in which EVS was being used in the lecture theatre conformed well to existing (Stuart 2004, Draper 2004, McCabe 2003, Boyle 2003, Poulis 1998) and continuing research (Beatty 2006, Bates 2006) in this area. Questions were simple, engaging, activating the students to reflect deeper and addressed and emphasised common misunderstandings, whether the misunderstanding was a result of newly imparted knowledge or misconceptions from previous experiences.

Results from this research indicated that students did not seem to use the EVS data much for reflection afterwards. They believed that remediation from the lecturer had been mostly successful and that they did not need to engage into deeper reflection because their next scheduled session and upcoming workload would ensure they would progress deeper into the topic. Results also indicated that the formative assessment of EVS was useful in the lecture, but lead to very little reaction outside lectures. Misunderstandings that may have been addressed in one lecture were at least to some degree present in the next lecture. The students either believed from the remediation that they understood it or that upcoming labs and tutorials would provide feedback, which would be of more formative value to the student. Their ability to act upon the assessment from the EVS was limited.

It seems therefore legitimate to proclaim that most CS1P students' reflection in lectures was of deeper initial comprehension of the lecture material, rather than deeper comprehension of the underlying concepts as the students would have had no time to fully apprehend[1] the material. The EVS was only formative assessment within this context and students' reaction to the formative assessment was limited in terms of deeper learning. Not all students worked in this way. Some students recognized some reflection on the EVS questions and some reaction to the formative assessment, and this could probably be contributed to their attitudes towards learning in CS1P.

In this research, tutors did not use the information from EVS as part of their tutorials, even though one tutor described that it might have been beneficial to get at least partial insight into the lecture. It seems likely explained by the high workload and the instructional design laid out for the tutors. They were not told to explicitly continue working with the conceptual understanding and would mostly engage in the goal-action-feedback loops with the student.

7.4.4 Need for conceptual understanding in CS1P

The use of EVS data outside the lecture seemed only to provide a few benefits. These benefits were mostly evident because of the attitudes towards learning from some of the students as well as some of the tutors. This seemed to fall back to the working model of CS1P and the use of EVS herein despite its reasonable coherence with existing EVS research. It seems as if the use of EVS provided students with the best possible start towards learning computer programming, but it fails to provide deeper reflection between

[1] Apprehension versus comprehension is used here as defined by Kolb (Kolb 1984), in which concrete experience is referred to as grasping via apprehension, contrary to abstract conceptualization which is referred to as grasping via comprehension

lecturer and students because at the time of using EVS the students may not have enough hands-on experience yet. Students do not seem to react to the assessment using EVS because at that time they have little practical experience and they value feedback on actions as a better formative assessment.

Introductory Programming at the University of Glasgow teaches students the basic skills and understanding that any computer programmer, despite the actual programming language, needs to succeed. These skills are exemplified using one particular computer programming language. Any programming language contains its own set or rules and details and most often a rigid syntax and semantic, in which many students struggle. However the purpose of the course is to conceptually understand the underlying mechanism of computer programming in general and not the specific language used. This purpose is not clearly communicated to or comprehended by the student, which means that the student does not understand which reflection process to base on the actions in labs and tutorials. CS1P is one of the fundamental courses in Computing Science and failing to understand basic concepts may influence further studies significantly.

7.4.5 An alternative learning design

EVS is a valuable tool to initiate deeper learning in CS1P, but there are still students who do not seem to learn enough or continuously struggle with concepts. This was the initial reason leading to the suggestion that using EVS data outside lectures could benefit learning. This reason was then formalized in this hypothesis and tested, but did not find major benefits to learning in CS1P for students in general. It seems therefore reasonable to suggest that changes to the instructional design may actually provide more beneficial use of EVS in lectures rather than reusing EVS data outside of lectures.

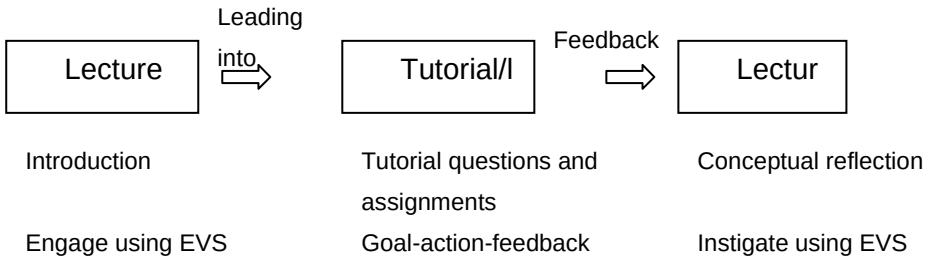

Figure 27 - Suggested instructional design in alternative learning design

The figure above outlines the structural components of the suggested instructional design. The first component is the lecture. This is similar to current design in which it introduces topics and discusses it as original. EVS are used within the lecture as early

engagement and '*reality check*', as with the current design, which has so far been proven useful.

The second component is the tutorial and/or lab. This is mostly identical to the current design. Students work through tutorial questions and assignments while the tutor still provides goal-action-feedback. However, in this scenario the tutorial and labs also serves the purpose of collecting feedback from the students on their actual actions in the questions and assignments. The intent of this feedback is to collect students' difficulties and misconceptions from their action and provide enough information to reflect upon goal-action-feedback and conceptual understanding.

The third component named Lecture' (notice the mark) is a conceptual follow-up between lecturer and all students about general problems and misunderstandings in the material. This component is an "agile lecture" (Beatty 2006) as a response to students' actions. This lecture would benefit from using EVS in order to promote deeper reflection and would probably provide better formative assessment for the students. The purpose of the lecture is to become the second loop of the Laurillard model, in which reflection on previous action leads to re-descriptions ultimately leading to modified understanding and behaviour. The format should promote active reflection and conceptual understanding and be much more contingent. The lecturer would initially ask a question similar to an observation from the tutorial/lab using EVS. Since students already have been into action the response here would probably be a more accurate assessment of students' current understanding. Depending on the result the lecturer would have at least three options:

- The lecturer can choose to present material prepared just prior to the lecture to further address the issues (Just in time teaching) (Novak 1999).
- The lecturer can show the students the response graph and from here start a class-wide discussion to investigate underlying strategies (Nicol 2003, Boyle 2003).
- The lecturer can keep the answer private, and ask the students to discuss with their immediate peers before having a second vote (Peer-Instruction) (Crouch 2001, Nicol 2003).

Either way the second lecture becomes much more agile and contingent, providing improved reflection on deeper understanding amongst the students. The assessment from the second lecture might be more representative of the underlying nature of student's learning. However, it will no longer be needed by tutors explicitly, but can be used by the lecturer to identify certain pertaining misconceptions, and perhaps provide a more accurate measurement of the student's individual progress.

7.4.6 An alternative learning design in CS1P

Based on the results from this project as well as recent research CS1P was restructured around this alternative learning design in the course immediately after. In this scenario the second lecture was named Large Group Tutorial (LGT) but was still a session between the lecturer and students. Feedback from tutors was used to craft a session to target exactly the confusions brought up in the action. Within the LGT the question format would mostly be using Peer-Instruction. Students was asked to individually vote on a question using EVS, and then instructed to discuss with their peers and provide arguments for the correct and incorrect options. By having previous experience and by having to provide argumentation the students would be engaging much more deeply into each question. This became apparent from the increased activity and engagement and reported by people monitoring the experiment in the lecture theatre.

It seems likely that this design provide deeper learning for the students, and that the formative assessment of the students in the LGT will be more correct, providing basis for further contingent teaching and pastoral care. However, there may be underlying social concerns that influence this result. Final results from this study are still pending of the time of writing, but current responses are positive.

7.4.7 Summary

After reviewing Laurillard's Conversational Framework and approach from the students' perspective, it seems that using EVS in lectures may not have provided deep enough reflection amongst the students. From the lectures students are usually sent into practical work without explicit reflection. As CS1P relies on practical work, deeper reflection should only take place once students have had an opportunity to try out the practical skills. An alternative learning design was described in which students are lectured initially, then sent into practical work before finally re-approaching the lecturer. The second session would be based on problems and misconceptions from practical work and therefore provide an explicit deeper learning session. This learning design has been incorporated into CS1P for additional evaluation.

8 Conclusion

The initial idea of this research was to find the extent to which data from the EVS, data which already existed, could be reused outside lectures to support learning within an Integrated Learning Environment. That the students, who enjoyed using EVS in lectures, seemed reluctant to corroborate this idea has spawned further investigation into deeper understanding of the learning situation, which has in many ways surpassed the original hypothesis. This chapter is therefore divided between a conclusion drawn towards the hypothesis, a conclusion drawn towards the ILE and a conclusion drawn towards the research.

8.1 Conclusion on the hypothesis

From the onset of this research, the aim has been to justify the hypothesis of using EVS data outside of lectures to support learning. This research has suggested providing EVS data to lecturer, students and tutors in order to enhance learning within Higher Education and the following sections attempts to conclude on each hypothesised benefit.

8.1.1 Providing EVS data to lecturer

The lecturer manages and controls the EVS in lectures and may often be aware of the responses in lectures. However, it may be profitable for the lecturer to re-analyse the EVS data after the lecture to provide additional feedback and to support additional contingency.

8.1.1.1 Provision of additional feedback

Two common types of feedback were provided by the lecturer, additional remediation to the entire question and remediation addressing specific discriminators

Additional remediation

The lecturer usually provided remediation in lectures which the students seemed to find sufficient to understand the topic. The additional remediation afterwards seems within this argument therefore to be unnecessary. However, the EVS question and additional remediation provides a persistent record which gives students an additional resource for later reflection and revision. The lecturer reported the additional reflection beneficial 80-90% of the time, and 83% of the students asked would prefer to have this information available even though their actual usage would be limited as will be explained when addressing student reflection.

Addressing misunderstandings

Even though the lecturer usually provides remediation to EVS questions in lectures, there may be little time in the lecture to address all discriminators, especially when only few chose these options. Providing additional feedback after the lecture can ensure that each discriminator will receive due attention as a response to the students attempts. Students in the focus group explicitly appreciated this option, and the second questionnaire corroborated this finding.

8.1.1.2 Supporting contingent teaching

The lecturer would after selecting some EVS questions, instigate a class-wide discussion to bring out common misunderstandings and students' strategies. From these discussions and later reflection with the EVS data, the lecturer would usually have something to say at the start of the next lecture or the lecturer would provide small adjustments to the flow. In this contingency the EVS data is only part of equation, however still reported beneficial.

8.1.2 Providing EVS data to students

Even though students also participate in lectures and therefore would be aware of the responses, students would benefit from having EVS data available outside lectures.

8.1.2.1 Provision of formative feedback

From attempting the EVS questions the individual student would receive immediate formative feedback, which the students reported relating well to the student's current understanding. Having the EVS data available outside the lecture provided the students with a record of their performance in the progress of the course, from which the students could monitor their comprehension. However, the students failed to appreciate the conceptual goal related to their performance focusing mostly on the practical aspect of the course, and hence the feedback would only work as an insignificant mark or score. There was behavioural evidence that only some students had an attitude towards learning which lead to using this feedback. In order for the students to benefit further from this feedback, the students would need to have a more self-regulated attitude towards learning and be able to understand the importance of conceptual understanding.

8.1.2.2 Absenteeism

The EVS questions could also provide students absent with some information about the lecture. From the relatively small amount of votes by students outside of lectures it appears that students did not look to the EVS question when they did not attend lectures. The most reasonable argument would be that having not attended the lecture the questions were not likely to be of any benefit to absent students.

8.1.2.3 Additional reflection

Posting EVS data should make it possible for students to reflect on the questions outside the lecture either actively or passively. In general, there seemed to be little retrospective interest in the EVS questions despite their popularity in the lecture theatre. There was some interest in the questions as examples, and to some extent for revision. From the behavioural studies, it seemed as if only few questions were likely to illicit further exploration from the students according to the nature of the question and the effectiveness of the remediation in class and that it was only some students who had an attitude towards learning which lead to this kind of exploration. Most of this behaviour could be instigated by asking additional related questions outside the lecture, exercises which showed significantly higher attendance by the students even though it was optional.

This would lead to the conclusion that students believed the lecturer's remediation was sufficient or that reflection would occur in tutorials, labs or through discussion with peers. Should the students benefit from additional reflection, there is little interest in browsing previous questions but rather engaging in additional questions.

8.1.3 Providing EVS data to tutors

Tutors are involved in the conversational dialogue with the students, yet they are not present in the lecture theatre during the lecture. From the EVS data the tutor would be provided with additional information to enhance students' learning.

8.1.3.1 Extending the lecture

Providing the EVS data to the tutors was intended to create more coherence between lectures and tutorials. Students reported that tutorials were a natural next level of information and an environment in which there would be more dialogue than in the lecture. For these reasons it seemed plausible to continue the dialogue using evidence from the EVS questions. When tutors continued the dialogue from lectures they usually used information provided from the lecturer and the students rather than information in the EVS data. Evidence seems to suggest that the EVS question and the students' response may

not provide a reliable and valid assessment and that it only provided limited knowledge of the entire lecture. However, the idea, still unproven, seems likely to be beneficial to some students.

8.1.3.2 Pastoral care

Providing tutors with the response from the individual students were hypothesised to promote pastoral care amongst the tutors. Three patterns emerged from this hypothesis.

Supporting struggling students

From the cumulative results of an individual student it seems plausible to approach this student for further discussion, yet the cumulative results may not be a reliable or valid assessment and contains no authoritative indication. No tutors used this information and the benefit is still unproven.

Initial indication of students' abilities

An unexpected benefit from providing the tutors with the EVS data is the ability for the tutor to get an initial understanding of the individual students in the tutorial group by observing their responses. This benefit is only perceived valuable until the tutor can provide his or her own judgement of the students through exercises and discussions.

Negative effect on students

Students reported dislike to providing tutors with the response data of the individual students, and tutors seemed to agree that using EVS data for other purposes than conversational dialogue could actually add unnecessary strain on the individual and by these measures be disadvantageous to the nature of EVS.

8.2 ILE conclusion

Given the amount of effort it required to build and maintain software there seems little reason for building an Integrated Learning Environment to provide support for EVS data outside lectures. Using an ILE require that students and tutors actively seeks to retrieve information and from this experiment there seems little to suggest an active participation but from few students. The largest benefits from the ILE seem to be features not directly related to EVS data, features of which there are many other software products for.

However it seems also reasonable to conclude that the information which benefits from sharing can be delivered through other mechanisms, such as emails and reports etc. If a persistent record is necessary, the recommendation would be to integrate EVS into existing learning software whenever EVS data needs to be used outside lectures.

8.3 Research conclusion

From the work of this research it became apparent that using EVS data outside lectures did not seem very successful to tutors and most students. The students seemed mostly reluctant to use EVS data for further reflection and there appeared to be little reliable value in the assessment of students when used outside lectures. Students provided a strong indication that learning went from theory onto practice and they were not explicitly required to provide deeper conceptual reflection. As conceptual reflection is important in CS1P, even though CS1P has a high practical emphasis, an alternative learning design was proposed, which introduced lecture time for reflection after practical engagement.

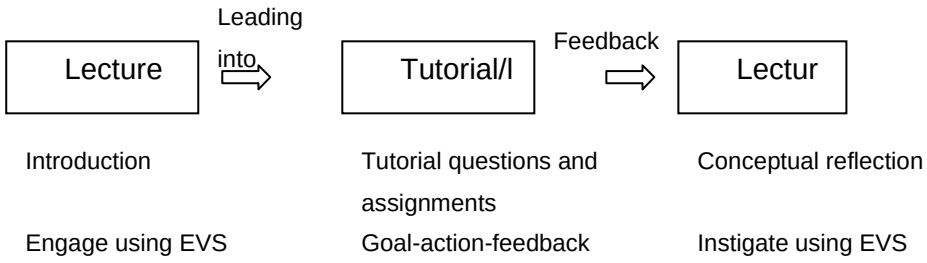

Figure 28- An alternative learning design (revisited)

If students are re-approached after practical tasks students have better basis for deeper reflection. The second lecture would therefore be based on feedback from practical tasks and much more oriented towards addressing relevant conceptual understanding. This completes the students cycles from conceptualization to practice and back to conceptualization. The alternative learning design supports using EVS in both lectures, and hence EVS data can be extracted from both. Using EVS data from the first lecture would probably corroborate findings from this report. However, the EVS data from the second lecture would presumably provide a better assessment of current understanding, which could be re-used outside lectures.

The alternative learning design is currently implemented in CS1P and currently tested with seemingly promising results so far.

Appendix A – Questionnaire 1

Evaluation of CS1P Website

1. How well do you think you are coping with the CS1P course so far? (tick one)

Very well, Well, Ok, I find it tough, I find it very tough

2. What is your previous experience of computing science? (tick all that apply)
None,
Standard Grade Computing,
Higher Computing,
Higher Information Systems,
Advanced Higher Computing,
Advanced Higher Information Systems,
Work experience,
Other (please specify)_____

3. How would you characterize yourself as a student? Put an X on the horizontal line, to indicate how much to either side you feel that you tip.

I'm very structured/organized	⇔	I'm very unstructured/unorganized
I'm always prepared for class	⇔	I'm never prepared for class
I study to understand the problem	⇔	I just study to pass marks
I discuss the topics/work together with fellow students	⇔	I work alone

Note, for the following two questions: Your answers given are used for research purpose only, and kept strictly confidential We therefore encourage you to help us

4. Is it ok to crosslink your answers here with statistics from the PRS website?
No/Yes If yes, please specify your account username _____ (e.g.0504302n)

5. Is it ok to contact you after the class test for further questioning?
No/Yes If yes, please specify your account username _____ (e.g.0504302n)

6. Which of these resources do you use to understand a topic/objective? Prioritize them in ascending order (1 is the first place/person, 2 is the second, and so on, leave no marks at resources, you do not use)

Lecture (i.e. attend the lecture)	
Tutorial (i.e. attend the tutorial)	
Lab (i.e. attend the lab exercise)	
Recommended Book(s)	
Other books recommended by others	
Other books found in the library	
Internet articles	
Internet discussions	
PRS website	
I ask a fellow student, known prior to this course	
I ask a fellow student, I met on this course	
I ask my tutor inside tutorial/lab	
I ask my tutor outside tutorial/lab (including by mail)	
I ask questions inside lecture (in theater when all present)	
I ask my lecturer outside lectures (including by mail)	

Website usage

7. Whether you use the CS1P website or not, in your opinion which of these best describes its purpose: (tick one)
I see no purpose to the website
Just a repository for the result of the PRS questions and a discussion forum
An online course guide with optional comments, questions, discussions
A mechanism for additional feedback between students and lecturer
Other (please specify)_____

8. In your opinion, who would be the intended audience of the website: (Select all that apply)
Students, who find the course tough/very tough
Students who find the course ok
Students who find the course well/very well
Tutors
Lecturers

9. How often do you browse the website: (tick one)
Daily,
2-3 times a week
Once a week
Once a month
Less than once a month (How many in total, then ___)
Never used it

10. If you have used the website, why did you use it, and how did you use it?
_____
_____
_____
_____

11. If you have only used the website once or twice, what did you do, and why did you not use it again?
_____
_____
_____
_____

12. If you have not used the website, what stopped you from using it?
_____
_____
_____
_____

13. What would make you use the website more?
_____
_____
_____
_____

14. If you use the website, how often have you (answer all, please)
- Answered a question, just to see the result ____
- Answered a question to see if you could get it right _____
-commented upon anything _____
- created a discussion topic _____
- performed a search for something _____
- chatted with anybody _____

15. How much do you feel you have benefited from the website (pick one)
Definitely have benefited
Have benefited
Neutral
Not benefited
Definitely not benefited

How (or why not) was it beneficial?

_____
_____
_____
_____

16. How easy is the website to use (of those that have used it)
Very easy
Easy
Neutral
Difficult
Very difficult

What contributes to this ease or difficulty of use

_____
_____
_____
_____

17. Do you have any comments on the appearance of the website

_____
_____
_____
_____

18. If the website looked differently, would you use it more (yes / no)

19. What features would you like to see added to the website

_____
_____
_____
_____

Appendix B – Focus group introductions

For the focus groups the facilitator was given a description of each of the three areas that we intended to investigate. The following presents these descriptions. For each topic there is an introduction text (in a box) and a set of questions. The bold ones are the most important ones if time should become short.

Learning objectives

Approximately time 10-15 minutes

What we intend to investigate is how the students find out what they are supposed to know/do in order to pass marks. Do they know the curriculum, have they read the study pack, is there a discrepancy between what is shown in the study pack and what the students perceive.
Are they capable of structuring the objectives of the course, or is it more like muddling through and hoping to succeed

Furthermore we investigate their options when there are things they do not understand. Do they seek remediation of any form?

How do you know what you are supposed to know/be capable of?
- with the topics of the course e.g. for-loops?
- What are required of a student in this course?

How do you know that you are (or are not) ready for examination?
Do you set goals for yourself, or do you not need to?
Have you read the goals and objectives of the study pack? Do you use them
Would knowing what was to be learned (i.e. objectives) benefit your learning?
Do you usually give yourself or others rehearsal questions (always or just at exam)?
Do you usually give yourself or others rehearsal exercises (always or just at exam)?
If yes to any of the above, how do you know whether they are relevant?
What other kinds of tasks do you use for learning
What do you do if there are things you do not understand?
Where/how do you seek further explanations?
How do you recognize there are things you do not understand?

Purpose and value of lectures/tutorials/lab

Approximately time 10-15 minutes

I want to establish what the students feel about the educational setup with lectures, tutorials and labs, and what each of these can be used for, and their values.
They may think that lectures are just an introductory talk on a topic, which requires no preparation, and spawn no further action on their parts, or they may think that they must have prepared for a lecture, because it highlights the interesting points only, and pinpoints the hard parts.
They may find tutorials more intimate than lectures, and have more dialogs in the tutorials than in the lectures. However, it must become clear whether tutorials are natural extensions to lectures.
It would be likely that they place emphasis on the lab sessions as necessary for passing marks, because it is where the skills must be practiced. However, we absolutely do not care about the lab work in this project ☺

You have lectures, tutorials and lab sessions. What are they for (What are they good for)? And how do they differ? i.e. purpose(concepts/training), amount of preparation, homework/assignments etc.

Are lectures just an introductory talk on a topic or must one be prepared in order to follow a lecture?

Why do you (as a student) attend these sessions?

Why does (or doesn't) anybody need to attend any of these sessions ?

- What do they gain from the sessions?

- How much value do they put into each?

Which are the most important to attend to, and why?

What are the links between the different elements?

What is the synergy between lectures, tutorials and lab sessions? Can they be more integrated? Should they?

Strike a line between theory and practice (and being at university and at home)

How much time of the study is/should be in concepts or exercises

How much or where do you learn most

How much work is done before lectures, after lectures etc.

Purpose and value of handsets inside and outside of lectures

Approximately time 20-25 min

The PRS questions can be any of either:
- Merely an appetizer to keep students attentive
- An introduction before covering an area
- Summative/Assertive. To check whether you have understood the topic
- Tricky questions, which tests more or less extreme parts of a topic
What I want to investigate is whether PRS is useful with respect to learning, and what they think they should do, after having answering a question (Should we actually try to remediate what we know, if we failed to answer a question, or do we just take it as a quiz-tool to keep us on the edge in lecture.)
Furthermore we need to investigate whether the PRS data can be useful outside the lecture, perhaps into tutorials.
Do they realise why we created the website with the PRS statistics, and can create a synergy between what they should know and what is published.

Do you think handset voting benefits your learning? How?

Can PRS questions be categorized? Provide categories.

What do you (or should you) do when you get an answer right

What do you (or should you) do when you get an answer wrong (How do they seek remediation)

Do you get enough or proper feedback on the questions from the lecture?

Do you ever think of the questions when leaving the lecture theatre?

What is the effect of the handsets in-lecture on your learning? (Could the time be spent on better matters?)

Do you ever discuss questions with fellow students after leaving the lecture theatre?

Do you ever revisit the questions on the web afterwards?

Is there any value to posting the questions afterwards as we did? Which?

Is it good that people not attending the lecture at least can see the questions afterwards?

Can the web be used for additional reading/questioning?

Can you make use of PRS voting data from the lecture in tutorials or labs?

Would it be good to have the tutor comment on the PRS Lecture questions

What if the tutor had a group summary of the PRS votes in the tutorial?

What if the tutor had a list of individual responses to the PRS questions?

Appendix C – Questionnaire 2

The second questionnaire was distributed using web technologies, and is available at http://survey.logical.dk for the time being. The questions below are only the textual content of the questionnaire.

Introduction

Nenya is a research project, which aims to investigate the use of handset outside of lectures. So far research has proven a few points as to the applicability of handsets in lectures, but we would like to further investigate whether the data from the handset can be used in another context.

You are invited to participate in this survey, because you have already used the handsets in lectures and have been at least told about the connected website https://prs.dcs.gla.ac.uk. **Your participation is voluntarily and not related in any way to your grade in any class.**

The questionnaire asks you about your study habits, learning skills, use of PRS inside and outside of lectures and tutorials. The questionnaire comprise of five pages in total. You will mostly be given a set of statements, which you may agree with or disagree with, using a scale between 1 and 6. Answering these should not take more than 10 minutes.

The data given here will be analyzed by a research students and not by your lecturer. You lecturer will only see summative results of the survey, so please answer as truthfully as possible, and please do not feel biased.

Note! All things here are confidential and used only for research purposes. There will be no publishing of any personal information nor anything that could identify any individual. By taking this survey you are agreeing to participate and content to correlation of your outcome.

This questionnaire is related to the CS1P course only. Please, consider questions within this context only, unless otherwise explicitly stated.

Page 1

The following questions ask about your motivation for and attitudes about learning. Use the scale on the right to answer the questions by selecting the number that best reflects your response. If you think the statement is very true, select 6.If a statement is not at all true of you, select 1.

- I like to study quietly if possible
- I want to do as well as I can on the course
- I want others to think I am smart
- I force myself to work harder if I do not meet my goals
- I want to do things as easily as possible
- I rarely find time to revisit notes or reading before completing assignments or activities
- I aim for a specific grade
- I don't mind asking for help if there is something I don't understand
- I seek feedback on what I learn often (Lecturers, assessments, etc)
- I set intermediate goals during the course
- I follow the course like the lecturer suggest but rarely do more than this
- I ask the instructor or my peers to clarify concepts I don't understand well
- I put a lot of effort into learning because it pays off
- I want to learn as much as possible
- I carefully pick the best study environment available
- I usually rehearse everything I read until I understand it
- Even if I have trouble learning the material I try to do the work on my own, without help from anyone
- I want to learn something new
- I make good use of my study time
- I'm very creative when it comes to ways to learn stuff
- When I have problems with something I need answers, not hints
- I use as many sources (library, web etc) as possible to learn something
- It is important to do better than the other students (better than average)
- I want to do as little work as possible
- I usually know by myself how well I am doing on tests
- I reward myself when I meet my goals

In the following question, a course forum is an internet forum or similar internet resource for discussions to help you discuss the course, such as forums found on the PRS website, in Moodle, or any other virtual learning environment or Wikis, blogs or other. Select the number than best reflects your response. If you think the statement is very likely, select 6. If a statement is not at all likely of you, select 1

How likely would it be for you to:

- Ask a question in lecture publicly
- Answer a question from the lecturer publicly

- Answer a question from the lecturer using PRS
- Ask a question to the lecture right after the lecture
- Ask a question in tutorials publicly
- Answer a question from the tutor publicly
- Ask the tutor a question right after a tutorial
- Ask a question on a course forum publicly
- Ask a question on a course forum anonymously
- Answer a question on a course forum publicly
- Answer a question on a course forum anonymously

Page 2

These three questions were asked in the questionnaire in December. Please repeat your answer from December as well as you remember them (If you did not answer the questionnaire in December, answer these questions as you probably would have believed back then.

How well do you think you are coping with the CS1P course so far (Back then!)

- Very well, Well, ok, I find it tough, I find it very tough

How often do(did) you use the PRS website (Between October and January)

- Daily, 2-3 times a week, once a week, once a month, less than once, never

How much do(did) you feel you have(had) benefited from the website

- Definitely have, have, neutral, not, definitely not, did not use it

The following questions also relate to the original PRS website, located at https://prs.dcs.gla.ac.uk. If you did not use the PRS website (and answered never to question 8), please do not answer these questions, but continue to next page.

I found the website most useful

- During the year, During revising for the class test, Either, Neither

Posting the PRS data on the web helped me learn CS1P because:

- When I wasn't attending I could still get a feel for the topic
- (If you were always attending, please answer 1)
- Quintin added more comments, which I found useful
- Quintin commented on the incorrect options as well, which I found useful
- I could reflect on what the question was about at a later time
- I could ask additional questions on the PRS problem even after the lecture was over
- I could compare myself to the other students and see how well I was doing on the course

- I could summarize how well I was doing just by seeing how many questions I had right or wrong
- I could read over the questions again during revision
- It basically helped me remember the lecture
- Did not help me at all

How true are these statements?

- I used the website mainly because Quintin suggested it
- I used the website, because I learned something from it
- I specifically allocated time for browsing the website regularly
- I used the website to monitor my progress in the course
- I used the website to compare myself to the rest
- I used the website as a kind of virtual classroom
- I used the website to find things I could not find anywhere else
- I used the website as a channel to ask anonymous questions
- I used the website to discuss with others
- I used the website to read other peoples comments

Page 3

The following questions relate to the value of PRS in lectures. Think of the use of handsets and the type of questions used as an average of the lectures in CS1P and how Quintin used the system

How well would these statements suit you?

- The PRS questions in lecture really tested that I understood a topic
- Getting a question wrong meant I did not understand the topic
- I might have gotten a PRS question wrong, but Quintin's comments afterwards usually corrected my mistakes
- The PRS questions was a good indicator of how well I was doing on the course
- I hardly remembered the individual PRS questions after the lecture
- The PRS questions were mainly what I brought out from the lectures
- Getting a PRS question wrong initiated me to do something extra afterwards
- The PRS questions showed me what I should read up upon afterwards

For the next questions, we would like to know what you think about the idea of publishing PRS data on the web. Even if you did not use the provided website, think of whether or not you valued the availability of the PRS question data. You may even imagine it as a webpage showing the PRS questions, the graph, additional comments from Quintin and your own answer only.

Do you think that posting PRS data on the web is a good way of getting formative feedback on the course?

- Yes, No

Posting the PRS data on the web may help me learn any course because: (select)

- If I'm not attending I can still get a feel for the topic
- The lecturer may add additional useful comments
- The lecturer can comment on all options, and not just the popular ones
- I can reflect on what the question was about at a later time
- I can ask additional questions on the PRS problem even after the lecture
- I can compare myself to others
- I can summarize how well I am doing just by sing how many questions I have right or wrong
- I can read over the question again during revision
- I can remember the lecture more easily

Page 4

Now we ask questions on the use of tutorials and whether or not PRS can be used to link these together, and finally the use of a Virtual Learning Environment in CS1P

How well do these statements suit you?

- Tutorials have helped me understand the course
- Tutorials were highly related to the lecturer
- Tutorials reinforced my learning from lectures

Would it be a good idea to:

- To use 5-10 min of each tutorial to go over the PRS questions from the lecture
- If the tutor was given a summary of how your tutorial group answered the PRS question in the relevant lecture
- If the tutor was given a list of the answers for each individual student
- If the tutorial questions were asked on the website, together with the PRS questions

Would you value having a website (Virtual Learning Environment) alongside the course?

- No, Probably no, Neutral, Yes probably, Yes

Distribute points amongst the following statements, so they total 20. If you give 10 points to one area, it means that this is the area we primarily should consider in the next version, but it also means that there is only 10 points left. Therefore, you must weight the

points. If more than 20 points are given, we will discard your answer. If less than 20 points are given, we will add to the “do not spend time on the website”

- I would value PRS questions and statistics from the lecture, perhaps with additional comments from lecturer
- I would value additional multiple choice questions, to answer, submit and having reviewed by lecturer and/or tutor (like tutorial questions)
- I would value other multiple choice questions, which I could use to rehearse topics, by allowing me to answer as many times as I like (practice questions)
- I would value short answer questions, to submit and having reviewed by lecturer and/or tutor
- I would value having lecture guides and course objectives available, liked with relevant resource in the environment (forum, prs question, etc)
- I would value a well-moderated forum or wiki or similar construct
- Do not spend time on a website; spend it on other useful materials etc.

Appendix D – Tutor questions

Tutors were formally asked using email, in which a statement were given and a set of questions to relate to this statement. They were given 2 statements in total.

Question 1

Tutors are supposed to help students reflect on topics from the lecture, however, tutors are not present at lectures. Tutors depend on the lecturer to provide information about the lecture or the students to raise any issues from the lecture.

How well does this correspond to your tutorials?

- How much time of the tutorial would be used for matters from the lecture?
- Did you know what was covered in the lecture, and how well?
- How often did you have to re-engage in topics from the lecture, if at all?
- Did you know if students understood it or had any further questions or needs for reflection?
- Which was the main provider of information about the lecture, the lecturer or the students?
- Was the lecturer's information formally handed out in advance or did it include comments and observations from the lecture?
- Did you as a tutor feel like an extension of the lecturer and curriculum or rather like a safety net for the students or in any third way?
- How did you provide feedback to the lecturer about the learning outcome of the students? (assignments/marks/comments/brief discussions)

Question 2

In lectures using handset the response data was published on a website. It was possible for a tutor to see the PRS questions asked, further comments and remediation from the lecturer, the distribution of answers in class as well as individual answers for the tutorial group. The system was created to maximize dialogue.

Would any of this information be useful in tutorials?

- Were you aware of this at all?
- Would it be convenient to look at the PRS questions from the lecture as a mean to identify areas for further reflection?
- Did you or did you not make use of this information and how or why not?

- It could be argued that this would be beneficial for those quiet students who are rarely willing to come forward with their own misunderstanding; what's your take on this?
- It could be argued that this may seem intrusive to some; what's your take on this?
- Would you believe a weak or strong correlation between answering one PRS questions right/wrong and the assessment of that individual student?
- Of a correlation between answering multiple PRS questions right/wrong and the assessment of that individual student?
- Of a correlation between how a group answered right/wrong in general and the assessment of that group?
- If there were a correlation between how a student answers and his or hers progress, would it be appropriate for a tutor to use this information to help the student?

Appendix E – Lecturer questions

The following questions were used to initiate a discussion with the lecturer. The questions was asked in advance, and the response used as input to a one hour discussion session.

On remediation:

Was it beneficial to add additional remediation after lectures (always, sometimes, how?)?

What would you believe to be most beneficial for the student?

- Further explanation
- Explanation on all discriminators
- Reference to additional reading/work
- Other….

On PRS Posting:

If PRS website was not a novelty…

- Would you only look for new comments, really?
- Would you look twice on a question after posting it?
- What could be any benefit for a lecturer of revisiting a question after posting?
- Would you ever really consider the new spread in class because of new votes to provide contingency?

On contingency:

At what degree did you provide contingent teaching?

Based on impressions from the lecture

Based on impressions from the tutorial/lab

Based on impressions from EVS analysis

How often has the result of an EVS really changed the upcoming lecture versus how often the result of an EVS and the tutorial afterwards has changed the upcoming lecture?

On assessment:

Do you believe PRS questions provide a decent assessment of the class?

Do you believe PRS questions provide a decent assessment of a student?

Have you ever acted on behalf of PRS questions?

The assessment which a PRS graph provides, how long would you believe it hold true about the class?

- Until after the lecture
- Until after tutorial/lab
- Until class test
- Forever
- Other….

On the PRS questions:

Attached is a list of the questions and their views. Running through the list is there any consistent pattern to the amount of views?

(The full text is still available at https://prs.dcs.gla.ac.uk)

Appendix F – Source code

For anybody to study the ILE in details, the enclosed CD contains all source code used to build the entire ILE.

If you are viewing this version without a CD you can contact the author to obtain a copy of this CD.

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