Development of a Real-time Formative Feedback Student Response System

Anders Avdic[1], Pontus Grönberg[2], Johan Olsson[3] and Francisco Guerra Riveros[4]

[1] School of Technology and Business Studies, Dalarna University,
Röda vägen 3, Borlänge Sweden,
aav@du.se

[2] Örebro University School of Business,
701 82 Örebro, Sweden
gronberg.pontus@gmail.com

[3] Örebro University School of Business,
701 82 Örebro, Sweden
johan_olsson@live.com

[4] Örebro University School of Business,
701 82 Örebro, Sweden
francisco.g.r@hotmail.com

***Abstract*: This paper is focusing IT-supported real-time formative feedback in a classroom context. The development of a Student and Teacher Response System (STRS) is described. Since there are a number of obstacles for effective interaction in large classes, IT can be used to support the teachers aim to find out if students understand the lecture and accordingly adjust the content and design of the lecture. The system can be used for formative assessment before, during, and after a lecture. It is also possible for students to initiate interaction during lectures by posing questions anonymously. The main contributions of the paper are a) the description of the interactive real-time system and b) the development process behind it.**

Keywords: *Student Response System, SRS, STRS, interaction, formative feedback, agile development*

I. Introduction

This paper is focusing on IT-supported real time feedback in a classroom context. Feedback in learning is defined as" the transmission of evaluative or corrective information about an action, event, or process to the original or controlling source" [11]. Feedback is "specifically intended to provide feedback on performance to improve and accelerate learning" [16:77]. In pedagogical research there is overwhelming evidence that feedback is important for learning for example Biggs [2] and Ramsden [15].

In a classroom, feedback can occur when students ask the teacher about things they don't understand or want to have clarified. Teacher can also ask students questions of control reasons. Did the students understand the lecture? In that situation there are some circumstances that could turn to be obstacles for communication between teachers and students. For example there could be physical distance, seating arrangements, impersonal atmosphere and a large number of students in a classroom constraining student involvement [6]. In large classes, the direct communication with students becomes difficult not only because of the big number of students but even of the perplexity among each other. They can feel intimidated from their peers and prefer not asking questions about arguments they don't understand. What is commonly labelled as traditional lectures also tend to be teacher centric which could result in passive students, which is considered to have a negative effect on the learning process [4].

It is difficult for the teacher to assess if the students understand the subject being taught during lecture. In the traditional lecture format it is difficult to test the comprehension of the material and make students reflect about what was being teach. They rarely receive feedback concerning their thinking prior to the exam, and instructors have a difficult time assessing students' understanding of particular material.

Furthermore, the ability of students to stay focused during lecture falls dramatically after about 20 minutes. This makes them lose an important portion of the lecture because of the incapacity to catch up. In addition, the impersonal and anonymous nature of the large course reduces students' sense of responsibility for class interaction [31].

Burns [32] found in his study from 1985 that "(1) impact appeared to be greatest during the first 5-minute portion of the presentation, with impact sufficient to cause students to report about 35% of all ideas presented; (2) impact declined, but was relatively constant for the next two 5-minute portions, and dropped to the lowest level during the 15- to 20-minute interval; (3) enumerated items shown with numbers and print on the screen to accompany photographs had heightened impact; (4) enumerated items listed first had greater impact than those listed later; (5) when pairs of parallel ideas were presented, the first one presented was likely to have greater impact than the second; (6) presenting a fixed number of ideas in a shortened time span did not necessarily decrease the impact or retention, unless the material was too compressed for comprehension; and (7) presentations with more than about 40 ideas or bits of information were likely to be less efficient, with impact dropping off as the information load increases" [32].

Drawing on Burns a relevant aspect regarding feedback is that the knowledge retention rate of lecturing is relatively low to other more active learning approaches. According to National Training Laboratories Bethel, Maine in USA, who adapted the experience cone of Dale [29] the knowledge retention rate increases when students are more active [29]. In the famous pyramid metaphor inspired by Dale (see Figure 1) it is claimed that the knowledge retention when students passively listen to lectures is 5%. Corresponding percentages are for Reading 10%, audio-visual activities 20%, demonstrations 30%, discussion groups 50%, Practice by doing 75% and teaching others/immediate use as much as 90%.

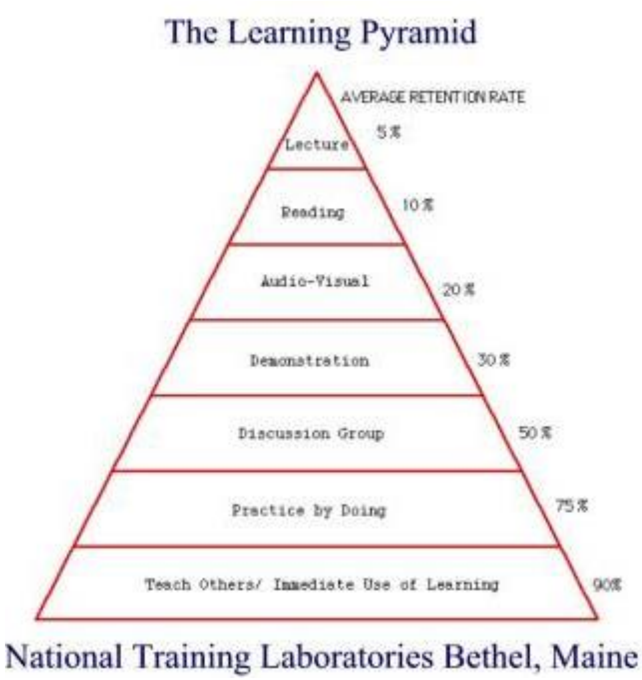

Figure 1 The Learning Pyramid inspired by Dale [28] [29]

Even though it seems as not quite transparent where these numbers actually come from and what for example 90 % average retention rate actually means, the pyramid demonstrates how active and passive learning are related to the outcome of teaching. Learning is in most cases more effective the more active students are. Introducing formative feedback in the classroom is a way to activate students by making them reflect actively about various domain related issues during lectures.

As most teachers very well know, students' concentration might vary substantially during a lecture [8]. Cole and Kosc [3] describe how they were frustrated by student's Internet surfing during lectures and how they succeeded to turn students' attention to the lecture by using SRS with clickers.

To summarize, there are a number of built-in obstacles for communication between teachers and students that make it harder for teachers to know to what degree the students have understood the content of the lecture.

- Students might hesitate to speak out in class
- Students might be afraid they to demonstrate ignorance
- Seating arrangements might be unsuitable for communication
- Students' concentration can occasionally be low
- Students can surf on Internet with their smartphones instead of engaging in lectures
- Class time might be limited

The aim off this paper is to describe the development of a Student Response System featuring formative feedback as a) teacher-centered question-answer-feedback as well as b) student-centered question-feedback. The objective of the system is twofold; a) to give students formative feedback in their learning process; and b) to give teachers input for lecture adaption and design in order to improve learning and performance. John Hattie [24] notes that "giving is not receiving" which indicates that the important thing is how the learner understands the feedback. The nature of the feedback must be adjusted to the learner and the learning context. Teach back about

Relevant to the study described in this paper is that feedback from learners can provide the teachers with feedback about their teaching methods. It is not necessarily the students' fault that they don't perform as successful as the teachers expect.

II. Formative feedback

Feedback in a learning context can be carried out as a formative or summative assessment. Summative feedback takes place after a course, a seminar or a lecture. Summative feedback is for example comments to a home exam or a report. According to Merry et al [34] insights can be unlearned if students wait for a summative assessment rather than getting specific information on their progress.

Formative assessment takes place during a learning event and is defined as "…as information communicated to the learner that is intended to modify his or her thinking or behavior for the purpose of improving learning" [18:154]. Formative feedback moves the feedback process away from being an 'after the assessment event' transmission of information from teacher to student and towards an ongoing dialogue to help build students' knowledge, skills, confidence and perception about themselves as learners [5].

The main goal of formative feedback is "…to enhance learning, performance, or both, engendering the formation of accurate, targeted conceptualizations and skills." [18:175]. A literature study of the field by Shute [18] concludes that feedback generally improves learning, even though there are gaps in research regarding the role of interaction between task characteristics, instructional contexts, and students' characteristics.

Formative assessment can take many forms. According to Shute [18] categories of the formative feedback are: no feedback, verification, correct response, try again, error flagging, and elaborated feedback.

Elaborated feedback implies provision of an explanation why an answer was correct or not. In the case of the STRS the following feedback subtypes are relevant.

a) Attribute isolation "presents information addressing central attributes of the target concept or skill being studied".

b) Topic contingent is "providing the learner with information relating to the target topic currently being studied".

c) Bugs/misconceptions is "provides information about the learner's specific errors or misconceptions (e.g. what is wrong and why)" [18:160].

There are a number of formative feedback models focusing different aspects. The five-stage-feedback-cycle model of Bangert-Drowns et al. [1] is focusing the learners role in the feedback process, which is presented as a constantly ongoing cycle. The stages are the following: [1:217]

1. Learner's *initial state*. (Degree of interest, goal orientation, degree of self-efficiacy, and degree of prior knowledge.
2. *Search and retrieval* strategies are activated by a question. It is presumed that information stored in a richer context of elaborations would be easier to locate in memory because there are more pathways providing access to the information.
3. The learner *responds* to a question and has some *expectation* about what feedback will indicate.
4. The learner *evaluates* the response in light of information given in feedback. The nature of the evaluation may depend on the learner's expectations about the feedback and the nature of the feedback.
5. *Adjustments* are made to relevant knowledge, self-efficiacy, interests, and goals as a result of the response evaluation.

In the case of the STRS it is not just the learner that is focused but also the teacher. The system is expected to give the teacher input for adjusting lectures to become more effective regarding the students' learning process [13]. To this end we are using the model of Narciss & Huth [12] since it is also focusing the instructional factor. The Narciss & Huth model depicts the following three factors [12], [18]:

1. *Instruction*. The instructional factor consists of three main elements: a) the instructional *objectives* (e.g. learning goals or standards relating to some curriculum), b) the learning *tasks* (e.g. knowledge items, cognitive operations, metacognitive skills), and c) *errors* and obstacles (e.g. typical errors, incorrect strategies, sources of errors).
2. *Learner*. Information concerning the learner that is relevant to feedback design includes a) learning *objectives* and goals, b) prior *knowledge, skills, and abilities* (e.g. domain dependent, such as content knowledge, and domain independent, such as meta-cognitive skills), and *academic motivation* (e.g. learners' need for academic achievement, academic self-efficiacy, and metamotivational skills).
3. *Feedback*. Consists of three main elements: a) the *content* of the feedback (i.e. evaluative aspects, such as verification, and informative aspects, such as hints, cues, analogies, explanations, and worked-out examples), b) the *function* of the feedback (i.e. cognitive, metacognitive, and motivational), and c) the presentation of the *feedback* components (i.e. timing, schedule, and perhaps adaptivity considerations).

As for the STRS, the learner is of course representing the main focus, since he/she is supposed to improve his/her learning process via the STRS. Still the system is meant to assist the teacher in didactical decisions regarding selection and presentation of the course material. Therefore, the instruction and feedback factors are together with their components of specific interest when developing and evaluating the STRS.

According to Shute's literature study [18] there are cognitive mechanisms of formative feedback that can be beneficial to a learner. Firstly formative feedback can elicit a gap between the learners' level of performance and a desired level. Bridging this gap can motivate the learner to work harder. Secondly, formative feedback can reduce the cognitive load of the learner through supportive feedback. This is specifically beneficial for beginners or low performing learners. Thirdly, information from the teacher can help the learner to correct less appropriate strategies or misconceptions. The more specific the information is the better for the learner.

It is notable that formative feedback is not always successful. In her literature study Shute [18] found that formative feedback resulted in negative effects in one third of the studies. The reasons for the negative effects were that critical or controlling feedback could be counterproductive. Further on, learning can be hindered by grades or assessment, especially when the feedback is vague or less specific.

Valerie Shute has formulated guidelines meant to "maximize the power of feedback" [18]. John Hattie [24] has selected a number of these guidelines that he considers to be specifically important.

1. focus feedback on the task not the learner,
2. provide elaborated feedback,
3. present elaborated feedback in manageable units,
4. be specific and clear with feedback messages,
5. keep feedback as simple as possible but no simpler,
6. reduce uncertainty between performance and goals,
7. give unbiased, objective feedback, written or via computer,

8. promote a learning goal orientation via feedback,

III. Student response system (SRS)

A Student Response System is a learning technology for use mostly in classrooms. This technology is designed to provide interactive student-teacher communications systems. Various names are used such as Student, Personal or Group Response Systems (SRS, PRS, and GRS), Classroom Communication Systems or "Clicker" Systems. The basic technology has a potential as an additional pedagogical tool for classrooms. SRS can "contribute to improved frequency and quality of interactions and encourage a collaborative active learning environment" [9:11). Further on the use of SRS has been found to increase student engagement and participation in learning situations [10].

Briefly, an SRS is a technology that enables the teacher to ask questions to the students, often in the form of multiple-choice quiz, and the students respond with a small handheld device, often referred to as "clickers". Responses can be given anonymously, reducing the border for student participation in the classroom [7].

The main objective of a Student Response System (SRS) is to improve feedback in classroom lecture. A Student Response System (SRS) is a system that allows the teacher to pose questions during an educational session, for example a lecture. Students are expected to give answers via some device and the teacher receives information on how students have understood a certain concept, construct or situation [5].

Functions of a Student Response System can be different sorts of questions, like Multiple choice, Single Choice, True/False, and Open answer. There could also be more advanced features such as quizzes or team competition. [26],[27] Further on there is a teachers interface where the teacher can create and release questions. The students' answers can be shown as diagrams presenting frequencies for various answers or in free text. The teacher can sometimes choose if he/she wants to show the answers in real time to the students or wait until all students have answered the questions.

Factors that contribute to students' positive attitude to SRS are "a desire to be engaged, a view that traditional lecture styles are not the best, valuing of feedback, class standing, previous experience with lecture courses, anticipated course performance, and amount of clicker use in the classroom" [20]. Perceived benefits for classroom environment are increased attendance, attention levels, participation and engagement [21]. Learning benefits are: improved interaction, discussion, quality of learning, and learning performance [21].

Naturally there are challenges too. Kay & LaSage mention that students must adjust to new methods of learning and that some students feel monitored [21]. Challenges for teachers are lack of training, time, incentives, and sometimes conflicts with professional identity, when pedagogy seems to be more important than research [22]. Some teachers also consider the sudden demand to answer to students' instantaneous feedback to be a challenge [21].

There are a number of existing SRSs that demonstrate the features mentioned above. Various techniques are applied. Some use clickers, other are web based. There are pros and cons to all techniques. The clicker technique includes certain equipment in the classroom, which might imply some planning and room allocation. On the other hand it does not cost the student anything. Web based systems are possible to use anywhere, where it is possible to access the Internet.

Even if existing systems can improve the quality of communication it is still teacher centric. Students answer questions formulated by the teacher. None of these systems provides the option of allowing the students to initiate anonymous interaction based on their understanding and their point of view. To our knowledge there is a gap with regards to an interactive SRS where both students and teachers can initiate interaction in real-time. We call such a system a student and teacher response system, a STRS.

The STRS described here can be found at http://t.studentresponse.se (teachers view) and http://studentresponse.se (students view).

IV. Methodology

A. Strategy

The overall strategy has been a design and creation approach [14] and the chosen method is the agile method Scrum [17]. The reason for choosing Scrum is the inherent potential to adapt to changes and to produce testable modules. From the very beginning the aim was to be open to input from teachers, students and other stakeholders. The outspoken nature of agile methods is therefore appropriate for the aim of the project.

B. Scrum

Scrum roles used during the project were Product owner, Scrum team and Scrum master. Product owner was a teacher with special interest in IT-support for pedagogical feedback. The Scrum team was rather small, just three persons. One of the team members was appointed Scrum master, responsible for meetings, contact with stakeholders and administration in general.

First we carried out a feasibility study. The initiator and product owner was interviewed in order to collect requirements and make first version of the product backlog. During the project there were daily Scrum meetings as much as was possible. The work was organized in sprints of approximately one month length. The product owner participated in sprint meetings where the product backlog was updated.

Regarding the design of the system we applied a three layer architecture for the sake of flexibility and we used .net as software environment. The database was normalized for maintenance flexibility.

C. Quality assurance

As quality assurance model we used the Quality framework of Zeist & Hendriks [19] to organize and complement aspects initiated and not initiated by the product owner. The characteristics of the framework are depicted and prioritized in Table 9999 below. Priority 1 is high, 2 is medium, and 3 is low.

Table 1 Quality criteria

Attribute	Criterion	Priority
Functionality		
Suitability	Address relevant requirements	1
Accuracy	Correct implementation of requirements	2
Security	Keep security in mind	2
Reliability		
Fault tolerance	Errors should be handled and logged	3
Recoverability	Efficient recovery after error	*3*
Maturity	Few errors	2
Usability		
Comprehensibility	All sorts of users should understand the application	1
Learnability	Easy to learn for students and teachers	1
Operability	Clear functions and according to specification	2
Attractiveness	User should navigate easily and enjoy the interface	3
Efficiency		
Time behavior	Low response time to data base, server and client	2
Maintenability		
Analyzability	Errors should be traceable	2
Changeability	Not prevent further development	2
Stability	Keep stability when further developed or changed	2
Testability	When changed, no need to test existing functions	2
Portability		
Adaptability	Should work in most web readers	1
Installability	No installation should be needed	1
Portability compliance	Should be able to use anywhere at any time. Internet connection necessary	2

The criteria and priorities were validated with the product owner in meetings throughout the development project.

D. Risk analysis

Another quality assurance measure was to assess risks of various kinds and to plan for how to mitigate the risks. In table 3 below we list the identified risks (col 1) together with probability (P, 1-5), effect (E, 1-5), and perceived risk (PR, 1-25). 1 is low and 5/25 is high. In column 5, Measure we have noted the measure for each risk in case the risk turns to an incident. Risks with no measures did not occur.

Table 2 Risk analysis

Risk	P	E	PR	Measure
Inadequate time planning	2	4	8	Reprioritize specification
Requirements not finished on time	2	4	8	Reprioritize specification
Inadequate specification	3	4	12	Create use case
Inadequate communication with product owner	1	2	2	
Inadequate communication in the project group	1	5	5	Daily scrum meetings
Inadequate ability to manage requirements change	2	5	10	Identify key requirements
Sickness in project group	3	4	12	Reprioritize specification
Lacking commitment of product owner	1	2	3	

E. Tests

When the system was testable we tested it in a lecture with 48 students. The teacher had prepared questions to the students, which they answered via the STRS. The students could also send questions to the teacher during the lecture.

The students were asked to answer questions via questionnaires before and after the lecture. Before the lecture we asked about their attitude toward asking and answering questions during lectures. After the lecture we asked the students about

- If the system was easy to understand
- their understanding the teacher's answers,
- how the feedback questions affected their interest
- if they wanted to use such a system on regular basis

Further on we have analyzed the STRS from the learners' perspective according to the model of Bangert-Drowns et al. [1]. The feedback types of the STRS have been classified using the Shute [18] model. Finally we have used the Narciss & Huth [12] model to reflect upon how the STRS can be used by the teacher to adapt teaching strategies.

V. Result

A. The development of the system

The feasibility study revealed a number of requirements from the stakeholders. Important stakeholders were students, teachers, department manager, and quality manager. All of them were interviewed in order to complete the product backlog. The product backlog finally contained 41 requirements, which took more than 600 hours to implement. The two most time consuming requirements were 140 hours for "The WCF-service must be secured", and 80 hours for

"Allowing the teacher to see students' questions". The WCF-requirement was planned to take 40 hours to complete and was obviously the most problematic requirement to implement since it took 100 hours more. The most crucial requirements were for teachers to be able to pose questions before during and after lectures. Another one was to be able to see the responses without the students seeing them and thereby being guided by other students' answers. Another equally crucial requirement was for students to be able to pose questions anonymously during lectures.

With reference to the Quality framework of Zeist & Hendriks [19] we took a number of measures to improve system quality, see table 1.

Table 3 Design characteristics and measures

Characteristics	Measures
Functionality	Regular contact with the product owner to capture requirements. All requirements were documented in the Product Backlog. Some examples: Anonymity, students must fell safe to put "dumb" questions. Low cost, students must be able to afford using the system. Usable, the system be must be enough easy to use so that the teachers feel it is worthwhile.
Reliability	The main priority is to minimize the number of potential errors. The code has been validated over and over. All input is validated. A static class logging all errors has been implemented.
Efficiency	This is mostly about code efficiency, which has been improved through tests and validation.
Usability	This is both about design and layout. As for design, especially the teacher interface has to be enough easy to use so that the teachers perceive it as worthwhile to use the STRS. As for layout, standard layout guidelines have been applied. [13)] The STRS is tested in a class with 48 students. We distributed questionnaires to students before and after the lecture. The teacher was interviewed afterwards. A user manual is available.
Maintainability	A three layer architecture is applied and documented to make maintenance easier, see Figure 1. The programming code is XML-commented. Names and classes are named in a logical and descriptive way. The database is normalized into nine tables. There are two interfaces, one for teachers and one for students. Standard modules were used as much as possible.
Portability	The STRS is tested in several web browsers and platforms. Responsive design has been used. No installation is necessary.

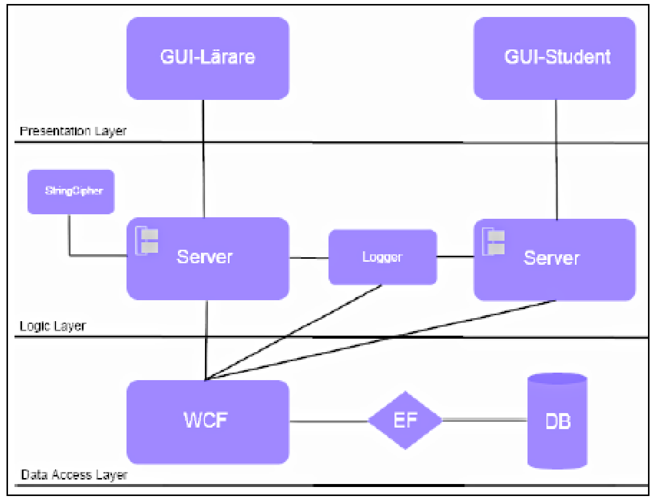

Figure 2 Three-layer architecture

B. The Webservice

The following methods were implemented in the developed webservice:

bool AddTeacher(Teacher _teacher): Adds a new teacher to the data base. Uses private class ToTeacher(_teacher) To transform to an object of teacher that can be inserted in the DB by EF.

bool Update Teacher(Teacher _teacher): Updates information about a specific Teacher.

bool ChangePassword(string _input, string _password) Description: Changes Teachers password. The Teacher to be changed is found by Username or Mail.

bool AddLecture(Lecture _lecture): Adds a new lecture to the database. Uses private class ToLecture(_lecture) to transform to an object of teacher that can be inserted in the DB by EF.

bool AddQuestion(Question _question): Adds a new question into the DB. Uses private classs ToQuestion(_question) to transform into an object of a question that can be inserted in DB by EF.

bool AddAnswer(Answer _answer): Inserts a new answer into the data base. Uses private class ToAnswer(_answer) to transform into an object of answer that can be inserted in DB by EF.

bool AddStudentQuestion(StudentQuestion _studentQuestion): Adds a new studet questions to the DB. Uses privete class ToStudentQuestion(_studentQuestion) to transform into an object of studentQuestion that can be inserted in DB by EF.

bool AnswerStudentQuestion(int _studentQuestionID, string _studentQuestionAnswer): Adds an answer to a student's question to DB.

bool AddLoggedError(ErrorLoggern _errorLoggern): For error logging in DB

List<Lecture> GetTeacherLecture(int _teacherID): Fetches all lectures created by a teacher.

List<StudentQuestion> GetStudentQuestions(int _lectureID): Fetches questions from students.

Lecture GetLecture(string _lectureCode): Fetches a lecture.

string GetLectureName(string _lectureCode): Fetches a lecture name.

int GetNumberAnswers(int _questionID): Counts the number of answers to a question.

Question GetQuestion(int _questionID): Fetches information about a question including the alternative answers.

List<Question> GetQuestions(string _lectureCode): Fetcj´hes all questions for a lecture including the alternatives.

Question GetQuestionAnswers(int _questionID): Fetches the answers to a question including frequency of answers to the alternatives.

Teacher GetTeacher(string _username): Fetches a Teacher using Username.

Teacher GetTeacherMailOrUsername(string input): Fetches a Teacher using either Username or Mail.

string GetPassword(string _username): Fetches password for a username.

bool CheckUsername(string _username): Checks if a username is already used.

bool CheckUsernameOrMail(string _test): Checks if a Username or Mail is in use.

bool CheckLectureCode(string _lectureCode): Checks if a lecture code already exists.

bool LoginTeacher(string _username, string _password): Login function checking if username and password matches.

bool LoginStudent(string _lectureCode): Login function for students.

bool QuestionStart(int _questionID): Changes status of a question from ”NOT” to ACTIVE” for a specific question.

bool QuestionStartRest(string _lectureCode): Changes staus of questions from ”NOT” to ACTIVE” for questions not active for a specific LectureCode.

bool QuestionStartAll(string _lectureCode): Changes status of a question from ”NOT” or "DONE" to ”ACTIVE” for a specific LectureCode.

bool QuestionDone(int _questionID): Changes status of a question from “ACTIVE” to “DONE” for a specific question.

bool QuestionDoneAll(string _lectureCode): Changes status of a question from “ACTIVE” to “DONE” for all question for a LectureCode.

C. *Interface*

The system is developed with two interfaces and two domains, one for teachers and one for students. Teachers can use their interface to enter questions and alternative answers, see Figure 2. It is also used to receive answers to the questions and also questions from students. Students' interface is used for students to answer questions and to pose own questions to the teacher, se Figure 3.

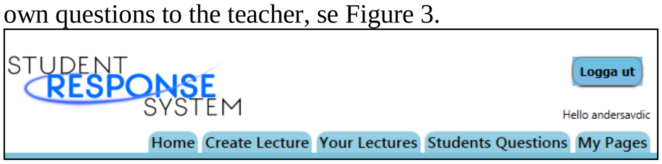

Figure 3 Screenshot of teachers' view

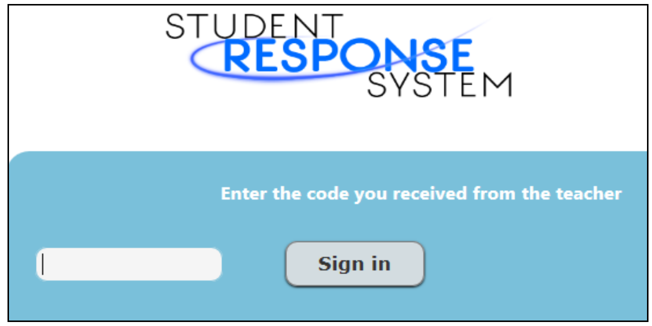

Figure 4 Screenshot of students' view

D *System in use*

Firstly the teacher creates a login name and a password. After that the teacher can create a course and a number of questions with alternative answers.

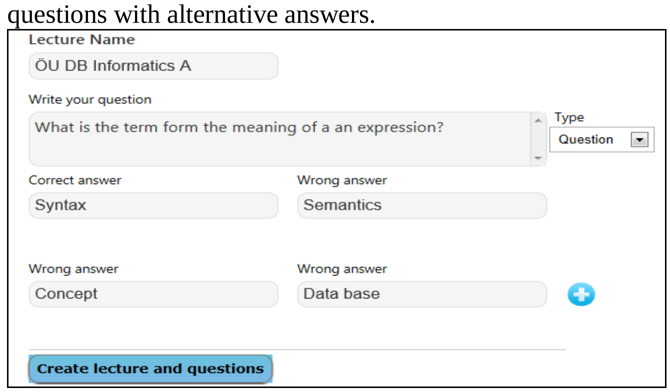

Figure 5 The teacher enters a question and available alternatives.

The interaction can be designed in various ways. The teacher can ask a question and give a number of alternative answers. The teacher can also provide questions/statements that are answered using the Likert scale e.g. Strongly agree, Agree, Neutral, Disagree, Strongly disagree. The scale can be modified to include various alternatives and a various number of alternatives.

During the lecture the teacher will provide a code, generated by the STRS. The teacher can activate the questions when he/she likes; before, during or after the lecture. The questions can be activated one-by-one or all at the same time.

The students can log in to the course using the given code and answer questions when the teacher activates them, see Figure 5.

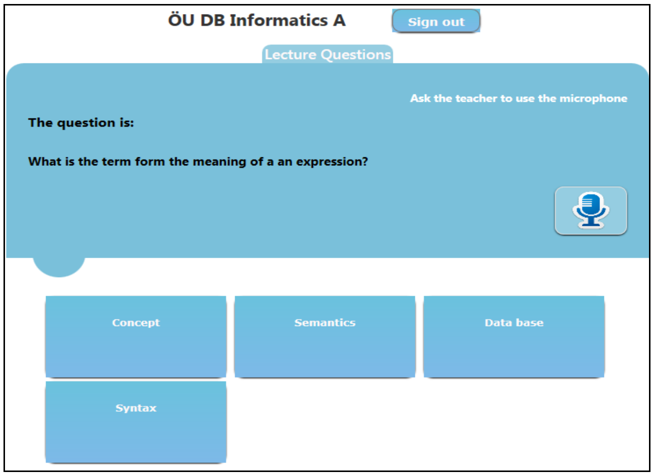

Figure 6 The student answers a question

By clicking the course button, the teacher can see the distribution of answers, see Figure 6.

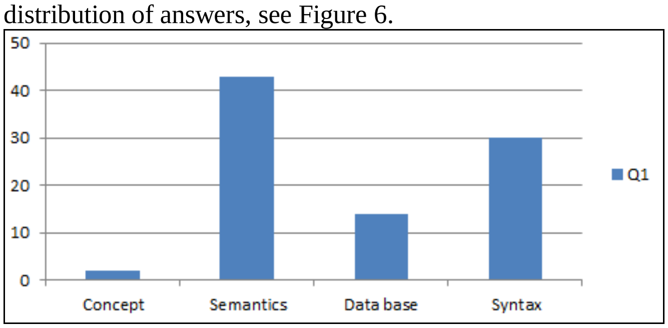

Figure 7 Example of distribution of answers

A special button is available for students who want to alert the teacher to use a microphone, in case the classroom is large or the acoustics is problematic in some way. Students can also use the student-centric module 2 to ask specific questions online to the teacher, see Figure 7. This is designed to be anonymous. The teacher is alerted via the STRS that there is a question waiting for an answer. The teacher can choose to answer during the lecture or after, via the learning platform. If the teacher prefers to answer after the lecture, there is a template, which can be uploaded ti the Blackboard learning platform.

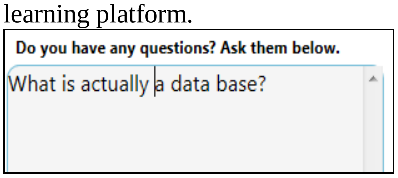

Figure 8 Students asking the teacher a question

E. *Test of system*

The tests were carried out in two classes of approximately 50 undergraduate information systems students in each class. The course was Information Systems Basic Course. The majority of the students studied their first semester at the university.

The teachers were asked to prepare questions to be delivered during the lectures. The questions were about basic information systems and computer science knowledge.

As an example one question was: One of the following alternatives is an operating system, which one? Alternatives: MS-Windows 7, Java, MS-Office 2010, RUP.

Before the lecture the students filled in a questionnaire with questions about their attitude to ask and answer questions during lectures. 20% agreed that it was not easy to pose questions to the teacher during lectures. 20% agreed that it was not easy to answer questions in class. 16% had never dared to pose a question during lecture and 10% had never dared to answer a question during lecture. 20% claimed it was tough to talk in front of class.

The after class questionnaire gave the following result:

- 100% thought the system was easy to understand
- 90% thought that their understanding of the teacher's answers was improved
- 100% thought it was easy to answer a question
- 85% thought that the feedback questions affected their interest positively
- 95% claimed they wanted to use such a system on regular basis

100% of the students owned a smartphone (60%), a laptop (36%), or a tablet (4%). In Sweden 78 % of the population used smartphones in 2013 [30] and for younger people the frequency is even higher. Since all students could use the university WiFi, there are no costs related to the use of the STRS, which is an important democratic aspect. According to Trees & Jackson [20] a high number of devices and students active in answering questions via SRS promotes use whereas low number of devices and active students will lower the use of SRS.

Half of the students provided free text answers. Half of these students were all positive. Typical comments were: "Good idea!", "Good initiative", "BIG UP!", "Good work", "Perfect for those students who do not speak perfect Swedish", and "You will be rich!". Other comments : "Not always easy to understand the questions". "I want to see the %-distribution". "Adapt better to smartphones". "Scrolling was not smooth". The lecture lost some flow". "Better with an app. Web is old fashioned".

Even though the development and testing was overall successful and much appreciated both by students and teachers, some problems were identified. The most significant problem was security. It was very time consuming to configure the web service to be secure. Coverage was another problem. Wireless coverage was not that excellent in all classrooms. There were no examples of abusive anonymous messages during the tests, but the question of possible misuse was raised by the interviewed teachers.

F. *Theoretical Analysis*

The models presented in section II Formative feedback are all general models not taking computer support into consideration. In this section we are relating these general models to the STRS in order to elaborate how the system supports formative feedback.

The feedback type of the STRS is not fixed. It is up to the teacher to decide how to answer the students. He/she can choose any feedback type. But as the system is aimed at improving effectiveness of lectures, we can categorize potential feedback type as *elaborated verification* (Shute, 2008) regarding the teacher-centric aspect (module 1). The elaboration consists of attribute isolation, topic contingent, and bugs/misconceptions. The feedback is immediate, since the students know that the teacher have access to the their answers immediately. The student-centric feedback (module 2) is classified as an elaborated-topic contingent type of feedback, which means that the feedback is dependent on what type of question the student is posing. The feedback of the student-centric module can be immediate or delayed.

According to the learner-centered five-stage model of Bangert-Drowns et al [1] we can see the STRS as a trigger of the search and retrieval activity for all students in a class. The STRS would affect all students in their learning process by activating cognitive mechanisms. The nature of the STRS makes all students present in the class aware of the teacher's question and the distribution of the answers. All students will be able to take part of the teacher's response and they will be able to pose questions about the response orally or by using the student-centric module. Further on the teacher will receive input for (re)designing his/her lecture regarding content and/or design until next time he/she is lecturing on the same topic. Next time the course runs and the same question is posed, there will be an opportunity to compare the students' answers.

As we apply the Narciss & Huth [12] model, we can structure the contributions of the STRS further.

Instruction: Objectives and tasks are the basis for lecturing, answers and feedback.

Learner: From the teachers' point of view, the students' responses can give information about the students' prior knowledge, skills and abilities, which would be useful for designing lectures. In Information systems the component of pre-knowledge could vary substantially between students. Some students have been working professionally in the ICT sector before they start studying and are therefore skilled in certain subdomains, while other students are beginners to the information systems field.

Feedback: This factor relates to how the teacher chooses to answer the students. Considering the objectives, tasks and errors (instruction) and students' pre-knowledge, and estimated motivation (learner) the teacher will have basis for designing an answer addressing the students on an appropriate level.

The major achievement with using the STRS is that the teacher will via module 1 get a real-time overview of how the students perceive the content of lecture and can thereby immediately or with a delay reconsider how to address the students. Via module 2 he/she will provide an opportunity for students to elaborate their questions in order to understand and to make the teacher even more aware of what is not effectively communicated in the lecture.

VI. Discussion

From theory and from our inquiries, we can say that anonymity is important to a number of students. If no channels to interact anonymously are present, these students might not be able to understand the subject in question as much as they would if they had a chance to alert the teacher that they don't understand certain aspects of a lecture.

One reason for students to refrain from interacting during lectures is insecurity and a fear to appear as ignorant or even dumb. We believe that using the STRS would make it easier to share the responsibility of poor understanding between students and teachers. The fact that a certain aspect was poorly understood could just as well be caused by the teacher's way of lecturing as the students' ability to understand.

Notable is that the system can be used to give the teacher feedback before, during and after a lecture. The teacher can initially check the knowledge level of e.g. some central concepts. The teacher can also see, during the lecture, whether the students have understood specific aspects. After the lecture the teacher can pose some follow-up questions to see how the lecture was understood by the students. The feedback is this way mainly formative, which makes it possible for the teacher to adjust his/her teaching according to the knowledge level of the students. In informatics the knowledge level varies a lot between students. The STRS gives the teacher more specific knowledge about what is known and what is not known, and how the knowledge is distributed in the class.

In the literature studied for this paper, focus is normally on the students learning process directly. In our case we focus also on the learning of the learner as a result of the content and design of lectures. If the students have misunderstood a certain part of a lecture, there are reasons to believe that the lecture could be more effectively organized, regarding content and/or design. Our objective is not just to give learners feedback in their learning process but also to give teacher feedback in their lecture design.

There are two major contributions from this project. One is the double directed nature of the STRS. Students can initiate interaction, not just the teacher. The second contribution is the description of the development process of the system. Existing SRS:s have not provided that earlier.

The STRS is being implemented on regular basis at the department of Informatics at Örebro University as from fall 2013. One lesson learned from the tests of the system is that teacher might have to adapt their lecture planning to integrate the functions of the STRS in a more structured way. This will be the next project of the STRS research, to align the use of the STRS with lecturing in informatics. As for the system itself, we will continue to refine security and implement encryption in the entire system.

References

[1] R. L. Bangert-Drowns, C. C. Kulik, J. A. Kulik, and M. T. Morgan, ”The Instructional Effects of Feedback in Test-like Events”. *Review of Educational Research*, 61(2), pp. 213-238, 1991.

[2] J. Biggs, *Teaching for Quality Learning at University*. (2nd Ed.) Buckingham: Society for Research into Higher Education and Open University Press, 2003.

[3] S. Cole and G. Kosc, “Quit Surfing and Start “Clicking”: One Professor's Effort to Combat the Problems of Teaching the U.S. Survey in a Large Lecture Hall”. T*he History Teacher, vol. 43*(3), May 2010, pp. 397-410., 2010

[4] W. J. Ekeler, "The lecture method", in *Handbook of college teaching: theory and applications* K. W. Prichard and R. M. Sawyer, Eds. Westport, CT: Greenwood Press, pp. 85–98, 1994.

[5] Flinders University, Feedback to improve student learning. 2013. Retrieved 2014-06-19 from http://www.flinders.edu.au/teaching/teaching-strategies/assessment/feedback/

[6] J. Geski, "Overcoming the drawbacks of the large lecture class". *College Teaching vol. 40*, pp. 151–155, 1992.

[7] R. H. Hall, H. L. Collier, M. L. Thomas and M. G. Hilgers, "A Student response System for Increasing Engagement, Motivation, and Learning in High Enrollment Lectures". *Proceedings of the Eleventh Americas Conference on Information Systems*, Omaha, NE, USA August 11th-14th 2005, pp. 1-7, 2005.

[8] J. Johnson, "Individualization of Instruction". *Faculty Focus*, Fall 1996.

[9] J. Carroll, J. Rogers, M. Sankupellay, M. Newcomb, & R. Cook. "Systematic evaluation of GoSoapBox in tertiary education : a student response system for improving learning experiences and outcomes". In *INTED2014 Proceedings*, IATED, Valencia, Spain, 2014.

[10] G. Heaslip, P. Donovan, & J.G. Cullen. "Student response systems and learner engagement in large classes". *Active Learning in Higher Education*, 15 (1), 11-24, 2014.

[11] Merriam-Webster (2013) Retrieved 2014-06-19 from http://www.merriam-webster.com/dictionary/feedback

[12] S. Narciss, & K. Huth, "How to design informative tutoring feedback for multimedia learning". In H. M.Niegemann, D. Leutner & R. Brünken (Eds.), *Instructional design for multimedia learning*, pp. 181–195. Münster, Germany: Waxmann, 2004.

[13] C.M. Walsh. "Assessment of Competence in Pediatric Gastrointestinal Endoscopy". *Current gastroenterology reports*, 16(8), 1-10, 2014.

[14] B. J. Oates, *Researching Information Systems and Computing*. London: SAGE, 2006.

[15] P. Ramsden, *Learning to Teach in Higher Education*, 2nd ed. London: Routledge Falmer, 2003.

[16] D. R. Sadler, "Formative assessment: Revisiting the territory". *Assessment in Education* 5(1), pp. 77-84, 1998.

[17] K. Schwaber. and M. Beedle, *Agile Software Development with Scrum*. Upper Saddle River, New Jersey: Prentice Hall, 2001.

[18] V. J. Shute, "Focus on formative feedback". Review of Educational Research, 78(1), pp. 153-189, Mar., 2008.

[19] R. H. J. Zeist and P. R. H. Hendriks, "Specifying software quality with the extended ISO model". *Software Quality Management IV – Improving Quality*, BCS, pp. 145-160, 1996.

[20] A.R. Trees, & M.H. Jackson, "The learning environment in clicker classrooms: student processes of learning and involvement in large university-level courses using student response systems". *Learning, Media and Technology*, vol 32(1) pp. 21-40, 2007.

[21] R.H. Kay, & A. LeSage, "Examining the benefits and challenges of using audience response systems: A review of the literature", *Computers & Education*, 53, pp. 819-827, 2009.

[22] S. E. Brownell, & K. D. Tanner, "Barriers to faculty pedagogical change: Lack of training, time, incentives, and …tensions with professional identity?" *CBE-Life Scinces Education* 11, pp. 339-346, 2012.

[23] J. Biggs, & C. Tang, *Teaching for Quality Learning at University*. Buckingham: Open University Press/McGraw Hill, 2011.

[24] J. Hattie, *Visible Learning and the Science of How We Learn*. Abingdon: Routledge, 2009.

[25] P. Surgenor, "Teaching Toolkit – Summative & Formative Assessment". *UCD Teaching and Learning Resources*. 2010. Retrieved 2014-06-19 from http://www.ucd.ie/teaching

[26] Socrative.com, *Socrative.com*. Retrieved 2014-06-19 from http://www.socrative.com

[27] Mentimeter . *Mentimeter.com*. Retrieved 2014-06-19 from https://www.mentimeter.com/

[28] E. Dale, *Audio-visual methods in Teaching*. New York Dryden Press, 1954.

[29] Andy Hon Wai Chun, "The Agile Teaching /Learning Methodology and its e-Learning Platform". Advances in Web-Based Learning – ICWL 2004. *Lecture Notes in Computer Science*, Vol 3143, 2004, 11-18, 2004.

[30] Accenture, "Mobile Web Watch 2013". 2013 Retrieved 2014-06-22 from http://www.accenture.com/us-en/Pages/insight-mobile-web-watch-2013-mobile-internet-usage-survey.aspx

[31] J. Middendorf & A. Kalish, "The 'change-up' ion lectures". *The National teaching and Learning Forum*, 5(2), 2-5, 1996.

[32] R.A. Burns, "Information Impact and Factors Affecting Recall". Paper presented at the *Annual National Conference on Teaching Excellence and Conference of Administrators*, 7th, Austin, TX, May 22-25, 1985.

[33] A.H. Johnstone & F. Percival "Attention breakes in Lectures". *Education in Chemistry*, 13(2), 49-50, Mar 1976.

[34] S. Merry, M. Price, D. Carless, & M. Taras. *Reconceptualising Feedback in Higher Education: Developing dialogue with students*. New York:Routledge, 2013.

Author Biographies

Anders Avdic is born in Medåker, Sweden in 1950. Anders Avdic holds a BSc in information systems from Örebro University 1985, a PhLic in Information Systems from Linköping University 1995 and a PhD in Information Systems from Linköping University 1999. Anders Avdic's research focuses IT and learning.

Pontus Grönberg is born in Älvkarleby, Sweden in 1991.

Pontus Grönberg holds a Bsc in information systems from Örebro University Sweden. Pontus Grönerg works currently as systems developer/Scrum master at the Swedish transport Agency.

Johan Olsson is born in Örebro, Sweden in 1991.

Johan Olsson holds a Bsc in information systems from Örebro University Sweden. Johan Olsson works currently as international free lance systems developer.

Francisco Guerra Rivero is born in Uppsala, Sweden in 1988.

Francisco Guerra Rivero holds a Bsc in information systems from Örebro University Sweden. Francisco guerra rivero works currently as systems developer at Garantum, Stocholm Sweden.