

# Net Based Examination: Small Group Tutoring, Home Assignments, and Large Group Automatic and Peer Assessment

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**Abstract**—This paper deals with net based examination, tutoring and scaffolding of groups of different sizes: First for very small groups, then for normal sized groups around 100 students and finally for very large groups. The three different methods can be applied to internationally based courses. Methods which support deep learning through tutoring, scaffolding, project work and peer learning are also mentioned.

**Index Terms**—Examination, tutoring, collaborative learning, peer learning, peer assessment, flexible learning

## I. SMALL GROUP ACTIVE TUTORING

### A. Tutoring

Tutorials in very small groups constitute a method of learning with high quality in the sense that the method has the potential to strongly support active learning and to encourage a deep approach to knowledge and understanding. In a small group the tutor has the opportunity of providing a high level of feedback and guidance aimed at each individual student's level of understanding and learning strategy; see, e.g., Anderson [1], and references therein, or Biggs [2]. It is also easier for a tutor of a small group of students to reveal more of his or her own enthusiasm and skills; see, e.g., Marton et al [3] or Ramsden [4]. The more we decrease or remove lectures and problem exercise classes the more important role tutoring will get.

Students studying mathematics at the University of Cambridge meet each of two supervisors for an hour each week to discuss primarily the solutions to assigned sets of problems but also to discuss the contents of the lectures etc. Typically the tutor sits at a table with a student sitting on each side of him or her and develops a solution to a problem using pen and paper. This form of tutoring is particularly appropriate in all subject areas of the mathematical sciences in which there is a strong focus on problem-solving; see e.g. Zajchowski & Martin [5].

### B. Mechanics, models and misconceptions

An introductory (basic) course in mechanics is essential for most engineering schools. One reason for this is the mechanics studies *per se* of motion, forces and the relations between them; related to this is the basic vocabulary it gives, needed for studies in many

engineering and science courses. Another reason is that because of the subject's emphasis on problem solving, it develops the students feeling for mathematical modeling. A third reason is a general insight into scientific thinking and reasoning

It has been well known, for many years, that students find the study of mechanics difficult; the mathematical treatment *per se* may create problems but also physics misconceptions are common and students meet difficulties to distinguish between reality and model, have difficulties to select a relevant model and to perform physical and logical arguments [5, 6].

These more general difficulties manifest themselves in more specific discipline oriented problems as wrongly constructed free body diagrams with wrongly introduced contact forces, inability to time differentiate and integrate kinematics quantities (as position, velocity and acceleration) correctly, problems with using vector algebra, problems with understanding the difference between a definition and a theorem which lead to difficulties in handling formulas and derived quantities.

We believe that the use of non-traditional teaching and examination forms with project work in small groups and with support from interactive learning environments with intra- and inter-group peer support and instructor tutoring will create better learning and understanding in mechanics [5, 7].

### C. Small group distance tutoring

From 2005 we have used distance tutoring in mechanics. The actual tutorial takes place in real-time, however deciding on the time of tutorials usually meant correspondence using e-mail. Using Marratech [8] we have tutored individual students in Sweden, individual students in Uruguay, and a group of four students in New Zealand. Also a group of four students in Sweden has been tutored from New Zealand.

The choice of four students per group is based on how much funding a student brings in to the department for taking part in a particular course and the staff costs per hour. The figures for New Zealand and Sweden are quite similar and probably many other countries in the industrialized world would have similar figures. Assuming most resources in a distance course is spent on tutoring we found that the course would be economically viable if

tutorials have four to six students although probably six is more realistic.

#### *D. Conclusions*

Large tutorial groups will be necessary for most universities where the student staff ratio is much higher than at Cambridge or Oxford in the UK.

In fact traditional tutoring in mathematics, mechanics, *etc.* can only be done satisfactorily with at most two students, one on either side of the tutor. On the other hand computer networking allows a lecturer to tutor more than two students in such subjects. In fact it is not even necessary to use Internet if all the students can be physically in the same locality. A local computer network is enough and will probably not have the same technical problems we experienced. Thus economically there opens up the possibility of tutoring in mathematical subjects at campus universities with high student staff ratios.

## II. NET BASED HOME ASSIGNMENTS

### *A. Learning, projects and laboratory work*

A common problem in higher education with sometimes classes of more than one hundred students is the problem faculties will have to handle the learning and the conceptual problems of students. Sending out questionnaires or course evaluation notes does not solve the problem. Students have seldom the insight of their own problems; neither can they verbalize them, especially not at an early stage of a course. Sitting in a group of students to hear their views of what has been dealt with during a course is neither efficient nor encouraging and most often students with little problems will raise their voices. Those students who really need most help usually can't address their questions as they do not know what is going on in a course. Even if a lecturer or a teacher get good hints on how to continue a course it will not give a picture on how well student understand and learn.

A better method is to introduce project tasks. Project tasks can be produced and delivered during a course. Students will give very similar answers to questions and work in small groups. Small groups are necessary to keep work load at reasonable level for teachers and assistants.

Project work often has two severe limitations which can be dealt with. The mayor problem is to know who have done what in a group of students. Distributing different parts of a task to different students of the group can meet this contribution problem. The group will collect the different contributions and send the result to the teacher. Still we must check that not a small number of students do most of the work in a project. Oral presentations can be used to check if all the group members have been active. Another drawback of projects is that only a part of a course can be covered by project tasks.

The most positive side of projects is that students learn how to work together and how to write and present a report. Working with small number of students it is a good tool and is widely used. Working in large groups the balance between work load and positive output can be discussed. Projects are an important pedagogical tool and most students like to work together with other students but as a tool to find misconceptions or other learning problems projects do not work well. Projects are also time consuming both for teachers and students.

Practical laboratory work has become less and less frequent at university level. The reasons are several: At universities suffering from hard economical conditions the less cost effective parts are excluded. Working in small groups with students is not cost effective and is then often omitted. For science education this means that laboratory work is reduced, sometimes removed completely. Earlier students' laboratory reports were the only opportunity they had to express themselves with their own words. Through the reports, faculties got a glimpse of students' conceptual framework. Today that way to visualize what students have learned or understand is in practice not existing.

### *B. Creating efficient study habits with home assignments*

We need a more efficient way to reach all students to get a hint of their learning status. At the same time there is a need for a curriculum which creates better study habits. Usually most students do not spend more time than necessary in a course. Neither most students realize how they must learn before examination or assessment. It is then questionable how well students learn and understand the course. They think seldom in terms of learning for future needs. This way of "quick crammed - fast forgotten" learning may be short term effective but is hardly efficient for solid knowledge.

Teaching and evaluation models must create habits, which makes it important to use good student strategies. Students accept pedagogical models if they bring positive outcomes and if students gain some kind of credits for their extra work. Continuous learning during a whole course is vital for manifest learning.

We introduced home assignments in physics courses more than ten years ago. In the beginning the home assignments were delivered on paper, were checked manually and registered manually. Later a mixture of paper versions and assignments delivered electronically were used. Now assignments may only be downloaded from the course home page and have to be returned through the same home page.

Home assignments are more and more used at our university. Mostly all students get the same questions. As these assignments require much work, students do not want others to use their results. Some students, however, like to work in groups and help each others. For them there is a need for more personal questions. Even with personalized questions there have to be some extra benefits if students should adopt this pedagogical method.

Students get credits when they have solved their assignments. These credits are used to enhance assessment credits. With this strategy almost 100% of the students solve their home assignments. The students who do not solve all their assignments are also those who mostly fail their examination; not due to less credits achieved by the home work, but because of poor discipline understanding.

### *C. Practical use of home assignments*

Twelve homework tasks distributed over twelve weeks seems to be most effective. We used Personal Identity Number/Social Security Number as parameter values as input to an algorithm which makes all questions unique and not two students will then have the same results. As the Swedish Personal Identity Number consists of ten

digits, three to five parameters may have two to three digits which give precise results in calculations.

To each home work there are normally three or four questions. There is a strong correlation between how the students have solved their assignments and their progresses in our course. Continuous studies during the course and personal tutoring of students who give wrong answers help to diminish misconceptions and poor understanding. Students are entitled to supplement their answers if they fail. With twelve home work assignments with three or four questions in each both faculties and TAs get good insight into every student's progress during the course. From evaluations we have got positive response from students who want feedback from faculties and who feel more motivated to follow the lectures and course when they get positive feedback. The home assignment system with help of an LCMS also makes it easier to administrate credits and makes it easier to identify those who need help and guidance during the course. For the faculty it is very positive as we instantly during a course can follow the study status for each student.

#### D. Conclusions

The use of home assignments drastically increased the number of students passing physics courses. Examinations directly after a course raised from 25-30 % pass to 80-85 % and on re-examinations from 40-45 % to more than 95 %. We are going to replace written examinations and assessments by assessments on-line. With Personal Identification Number we have a check on that the right person has answered the questions and with questions where it is easier to solve the questions with own numbers than cheating we think on-line examination will be the most used method in future.

### III. AUTOMATIC AND PEER ASSESSMENT IN LARGE STUDENT GROUPS

#### A. *Flexible course design successfully bridges the knowledge gap between school and university for large student cohorts*

Since 2005 KTH offers net based courses for large student cohorts. Today there are about 20 such courses, some of them in English and some offered in cooperation with other universities. Five courses are preparatory courses for students leaving high school to enter as freshmen university students. Every year about 5000 Swedish students have studied a preparatory mathematic course online. Since 1997 KTH Mathematics has evaluated the discrepancies between freshmen actual knowledge of mathematics and the KTH faculty expectations. The course curriculum in the mathematical bridging courses is based on these discrepancies. From 2006 a similar physics course has been introduced.

Learners may start at any time and may study at their own pace. By filling in and submitting an electronic enrollment form they can acquire a username and password to the educational platform within minutes. After that it's just to log on to the course and start working.

To students this has proven to be a focused and goal-oriented approach to learning, flexible in both time and place, which helps them become successful in their university studies [9]. By joining these courses, they also

become part of a large virtual community where they can get support during their entire study time, if they want to.

#### B. *Scaffolding and peer learning keeps students on task*

Each course has been subdivided into suitable parts or lessons with a detailed outline for easy planning. Learners become engaged because they can see how the course fits with their desires and immediate interests of becoming "tuned in" for upcoming studies. The search for understanding inspires and provokes. As they receive instant feed-back on assessments they feel sure they have grasped all relevant parts, and they are offered extra help if needed.

To provide students with an effective yet thorough learning process, all online material has been developed by educational experts, using multiple learning strategies and including instructional scaffolding by personal mentors, when needed. All learners will obtain a personal mentor that they can contact by e-mail or telephone, if they have questions or need individual support. Their mentor will also contact them if they are inactive for longer periods than 2 weeks. Online mentors are recruited among 2<sup>nd</sup> or 3<sup>rd</sup> year university students that have recently studied the subjects themselves. They are working together in a call center which gives learners easy and quick access to support whenever they need it. The mentors also help each others at the call centre. Last summer 10-15 full-time mentors could easily support more than 6000 simultaneous learners.

Instructional scaffolding is a teaching strategy that was named for the practical resemblance it bears to the physical scaffolds used on construction sites. The strategy consists of teaching new skills by engaging students collaboratively in tasks that would be difficult for them to complete on their own. By providing a pathway or route for the learner, each "net based scaffold lesson" is somewhat like the guard rail of a mountain highway. It provides structure and guidance coincident with each step of the journey. Each time a student is asked to move along a path, the steps are outlined extensively. No need to wander, stray or stumble. Learners may "take the curves" without fear of going over the edge. True learning occurs when information is integrated into an individual's knowledge base [10]. Graves and Braaten [11], defines scaffolding as the process by which an expert provides temporary support to learners to "help bridge the gap between what [the learner] know[s] and can do and what [he or she] need[s] to accomplish in order to succeed at a particular learning task" (p. 169). Upon completion of a certain task, a learner is better able to make the connection between prior knowledge and new information. Scaffolding helps this happen by allowing interaction with the learner by asking leading questions and providing information in order to help them discover the information they need to successfully complete a task.

Online forums let learners discuss and interact with each other and with their teachers throughout the course. Besides being a dynamical communication channel, it creates a community spirit where many learners blossom and coach each other. In this virtual community, learners easily find new friends, interested in or studying the same subjects as they themselves are doing, but maybe at a different university. With several thousand participants the activity level is high in these virtual discussions.

Questions are therefore rapidly answered, either by peers or by our specially engaged mentors.

### C. Automatic and peer assessment essential learning activities

Stepwise, net based examination conducts learners through the different parts of the course. The course is divided into suitable sections; each one is tested on the proper cognitive level [12]. The most important work is always done by the student. We simply provide the outer structure.

First the learning outcomes are explained to the student. Then they are related to the literature, to different learning objects as well as to relevant learning activities and examination procedures [13]. Learner's basic knowledge, deductive reasoning and synthesis are tested by combining different online tools, throughout the course [14]. Basic facts are tested with multiple choice questions. Problem solving capability is tested by sets of randomly generated questions, where learners submit answers to the problems that are then automatically corrected. If they fail to answer all questions in the set correctly, they will get a new set of questions, randomly chosen from a database. Each learner receives individual and instant feed-back on their progress. Self-correcting exercises help them know how well they have reached the learning outcomes [15]. Continuous assessment makes sure they have grasped all relevant parts, before they move on to the next step.

At the end of a course, the capability of explaining a thought or a solution (instead of only giving the correct answer) and the capability of reading and discussing explanations given by other learners will be tested. Each student has to send in several individual assignments. As soon as they have done this, they are automatically directed to a participant pool. When this is filled with a pre-determined number of learners (usually four) a virtual study group will be formed automatically. The group members are directed to a special communication area where they have to discuss their individual assignments and, through this (often asynchronous) decision process determine a best solution to each given problem. The result will be presented in one document and submitted as their final group assignment. This cooperative work creates quite good solutions, being sieved through four brains. Finally the group members are asked to submit a peer and self assessment [16], declaring in what way each of the members has fulfilled the individual and group assignment and achieved the learning outcomes. A faculty member can then quite rapidly study the solutions and self-evaluation report, follow the messages in the communication area and from that determine the grade. The same grade is given to all members of the group, if they have actively participated in the group discussions. If not, they will manually be parted from the group and returned to the pool group.

### D. Conclusions

Net based tools and a thorough course design has made it possible for a small group of teachers to organize learning for some very large student groups with high pedagogical quality. Scaffolding and peer learning keeps student motivated and supports deep learning. Organizing courses for thousands of simultaneous learners is possible when handled in a well-planned and effective work-flow, using an educational platform with extensive statistical

tools. The tools make it easy for teachers to get a bird's view of the course as well as homing in on a particular group of learners or individuals, when needed. The method can be adapted to most disciplines and levels. It is also well suited for international cooperation in distance education.

Leadership plays a key role in all ICT integration in education. Many online learning projects have been undermined by lack of support from above. It's not enough that the president of your university is strongly in favor of the concept; you need to get the administrators "on board" as well. For online learning to be effective and sustainable, administrators themselves must have a broad understanding of the technical, curricular, administrative, financial, and social dimensions of ICT use in education. This has proven to take a lot more time and effort to achieve, than we planned.

An expected long-term result of the introduction of a national online bridging course in mathematics in 2006, could be that higher university standards also will help recruit more qualified students to the Swedish universities. If world wide online bridging courses were introduced, they would form a standard which could be used as a benchmark for an introductory university level. This would promote student mobility, making it easier to take courses in other places than in their native countries.

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