Smart teaching technology. Case e-tutor mathematics in Hasselt University.

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***Abstract*---In Hasselt University, students in applied economic sciences experience problems when learning mathematics. Students need to take a preparatory course before entering, but because they have different background and different math attitude they need all different and more personalized guidance in the first year math course. A math e-tutor to assist the students in learning mathematics has been developed.**
This paper reports about the research done before designing the system. Math teaching today is more focusing on conceptual understanding and as a consequence active and experiential learning activities following the learner centred concept will be organized. The learning environment has changed drastically in the past several years and online learning activities can best be blended with face-to-face activities in a hybrid course model. Lecture capturing is becoming popular as a development method of online learning courses.
This paper reports about the case study, about the implementation of these concepts and methods and about the e-tutor itself, how it is assisting the students in learning mathematics.

***Keywords*--- mathematics course, learning assistance, e-tutor, blended, experiential learning, online learning, lecture capturing, stepwise solving exercises, handwriting**

I. A PEDAGOGICAL DIVIDE IN TEACHING

In math teaching and learning two main patterns do exist. Traditionally, attention was and is still focused on computational fluency, linked with the capacity of solving mathematical exercises around learnt methods. But more and more the focus is changing to a new pattern of conceptual understanding, defined as understanding the mathematical concepts and procedures, resulting from applying in practice the learnt math concepts while solving business problems. [8]
The challenge for the educational team when developing a math course , is to facilitate both, the conceptual as well as the procedural math thinking. As a consequence in some math courses, teaching of topics or concepts is reduced in time and more attention is paid to providing practical applications of concepts and on developing mathematical models. In the learning process, a mix of activities is designed to foster both, the procedural fluency and the conceptual understanding. The course will be a hybrid course, in an experientially based format by including an integrated lab component. An important driver in this evolution is for sure the existence of intelligent calculators that can be used to solve mathematical exercises of derivatives, integrals, …., and as a consequence time spent to it can be limited.
To increase students motivation and to improve student-learning, a model of contextual learning can also be set forward. Another evolution is the relation of the course content with a business professional situation and as such the mathematical competencies will be linked to those professional competencies.

II. CHANGED LEARNING ENVIRONMENT

A. Active and interactive face-to-face and online learning activities

The learning environment has changed drastically in the past several years. Implementing active and interactive methods and tools has impact on students learning quality. It is enhancing students' involvement in classrooms. Concepts are: active and cooperative learning, learning communities, inquiry and problem-based learning and team projects. [3]
More interactive learning concepts are: games, videos, interactive learning with real-time response, modeling activities, quizzes, team activities and reporting (presentation), and group discussion. [2]
Online videos including learning content can complement or replace part of the face to face learning content and lessons. Watching the videos will be integrated in the learning process, either by watching it before or after the lesson. In case before, students learn from the video and the instructor is afterwards repeating and explaining the learning content and can already focus on applications. In case after the lesson, the students will see the video to reinforce the concepts learnt in the session.
Following students' opinion in a research project at Singapore University of Technology and Design, those active and interactive online activities are adding valuable learning experience, but will not replace the face to face sessions. To learn mathematics concepts, students need as much classroom and online practice as possible. They prefer a balanced mix of face to face lectures with online self-paced learning and with face to face and online organized problem solving activities. [4]

B. Active and experiential learning activities in "learner centered learning"

Learners today want to leave their passive role and to play an active role in the development and the organization of the learning process. The learning process can be personalized to a certain extent for a group of learners or even for the individual learner.

[6] *Schreurs 2012:* ***"Learner centered learning*** *means learning that includes active learning, cooperative learning, and inductive learning. In active learning, learners solve problems, answer questions, formulate questions of their own, discuss, explain, debate, or brainstorm during class. In cooperative learning learners work in teams on problems and projects. In inductive teaching and learning learners are first presented with challenges (questions and problems) and learn the course material in the context of addressing these challenges. Inductive methods include inquiry-based learning, case-based instruction,* ***problem-based learning, project based learning****, discovery learning and just-in-time teaching. "*

When the "active" learning activities will be linked with the professional environment, they are part of ***Experiential learning [15],*** being the organization of learning activities that are preparing the students to perform well in their future (professional) situation. In the learning process students will "learn by doing" and by reflecting on the experience. Experiential learning activities can include, but are not limited to, hands-on laboratory experiments, practicums, field exercises, and studio performances. Functioning in different roles has been simulated or are realized in cooperation with practice. Students can f.e. take a role of a producer, of a scientist, of a project manager …..related to their future professional situation.

ICT has its place in learning. Information delivery and sharing, communication supporting individual and team activities and ICT tools supporting modeling, analysis and reporting activities, are embedded in the learning process. Also learning on distance can be organized by implementing e-learning solutions.

C. Blending online learning and experiential learning as a hybrid course model

Starting from the traditional teacher centered approach, the teacher centered face to face classroom sessions can be limited in time, by the way **freeing classroom time** for more learner centered learning activities: research activities, problem solving, project work. Teaching of some theoretical concepts can be organized as online activity. The learning process will be a mix or blend of face to face sessions and online activities.

As a part of the learning process l**earning activities** will be planned in which the learners will be active and will participate in relevant experiments and in **problem solving** of a lab case or even of a real business problem. In this **project based learning model**, the students will be members of a project team in co-operation with a professional organization.

This approach is based on the concept of constructivism and connectionism that is set forward. [6]

Learning activities, even online learning activities can be organized as synchronous and as asynchronous activities.. Online learning can be organized synchronously as a virtual online classroom.

In [10] we can find the CSU policy (CSU-N: California State University Northridge): " To be successful in teaching and monitoring students learning mathematics, CSU faculty and staff increasingly need to augment traditional classroom-based instruction with intensive face-to-face as well as online learning opportunities, being a hybrid course model". Their innovative model pairs an existing course with a supplemental hybrid course including a remediation component. This remediation component is web-based and as a consequence students can either come to the computer labs where they get help from peers and tutors, or access the online course part when it best suits them."

III. SMART TEACHING TECHNOLOGIES TO DEVELOP ONLINE LEARNING.

A. lecture capturing

Lecture capturing is increasingly in demand as a method of developing online lectures. Life lecture capturing is creating videos of the life lectures and is publishing them afterwards in the intranet, the LMS(learning Management System) or on YouTube. Lab developed lecture capturing is creating videos in a lab of a simulation of the lecture.

B. Life lecture capturing

Following are 3 types of life lecture capturing methods to create online lectures:

- *Life video lecture capturing during the face to face session.*

Oregon State University has implemented lecture capturing as a solution on institutional level. [14]

- *Capturing life video by combining the input with input from using a digital interactive whiteboard (smartboard)* in connection with a PC, a projector and whiteboarding SW. The whiteboard accepts PC output (prepared in advance) and finger and pen writing on the whiteboard (during the session). The end presentation file combining all the info will be available after class.

Missouri State university is a good example. (http://www.youtube.com/education?category=University/Mathematics)

KBC, Belgian Bank and Insurances company, has implemented the concept as a method of e-learning development.

- *Screencasting* of PC screen output (prepared in advance) and handwritten pen input on wacom display (during the session) and screen capturing SW, results in a life presentation.

Hasselt University is capturing computer screen output created by combining in advance prepared presentation in PFD format with life handwriting annotations on a Wacom display (http://www.wacom.com/en/business-and-education/products/pen-displays) added as annotations during the session. After class the presentation can be available as a file or can be available as an online web video presentation

C. *Lab developed lecture capturing*

Even more valuable is the concept of "lab lecture capturing". It means computer screen capturing of a combination of prepared content (pictures, ppt slides, …) with handwritten content and voice input , all created on a computer whiteboard and in a screen capturing software environment. The simulated lecture is published as a flash-file or as a video-file and made available on the web.
An online simulation/ presentation of a life lecture can be prepared offline using screen capture software and hand-writing facility on a Wacom display or another tablet.

D. *Famous examples*.

Following are case examples of application of ***Lab developed lecture capturing*** to develop online courses

1) Missouri State university: http://www.youtube.com/watch?v=kQCy0U0Zjg4

Life lectures have been captured in an advanced technological environment and we can see computer input and handwriting facility and voice input are mixed.

2) KHAN Academy: http://www.khanacademy.org/math/differential-equations/first-order-differential-equations/differential-equations-intro/v/what-is-a-differential-equation

This is the most famous lab developed lecture capturing example. Khan produced thousands of math modules and made them free accessible worldwide. Presentation of the intro in the topic is presented in an attractive blackboard simulation.

3) NROC: http://nroc.remote-learner.net/course/view.php?id=181

Producing and making available lab developed lecture captures of mathematical concepts is an initiative of NROC : http://nrocmath.org/
The videos are part of their tutoring math system.

4) COURSERA: https://www.coursera.org/course/mathematicalmethods

It is another example of lab lecture capturing where the handwritten text input is replaced by typed one. Characteristic in their approach is the inclusion of the instructor in the video.
Coursera is services organization cooperating with Us universities in developing their online video courses.

IV. LECTURE CAPTURING IS A WAY TO REALIZE A PEDAGOGICAL TRANSFORMATION

Often the capture is not seen as a lecture replacement or archive, nor the classroom experience has been replaced. Often it must be seen as a support of classroom teaching. It allows students to download lectures and content. If downloaded to portable electronic devices, it facilitates study anytime and anywhere It is seen as a way for learners to review materials and, when necessary, catch up when they are forced to miss a class. F.e. capture can be especially helpful to student athletes, who often must miss some classes when they travel to away games.
Because the lab-capture of a lecture can be of high quality, it is even possible to organize the captured lectures as replacing some classroom sessions by self-study online learning sessions, by the way freeing classroom time for more student centered learning activities: research activities, problem solving, project work also based on the concept of constructivism.
[5] Shannon 2013: "*Transforming traditional pedagogy through such uses of screencasting supports an integrated framework for mathematics instruction that emphasizes acquisitionist elements from cognitivism and participationist elements from social constructivism. From cognitivism, this approach emphasizes supporting the individual learner in connecting new information to prior knowledge, moving from the concrete to the abstract and presenting new information in conceptual chunks. From social constructivism, this approach emphasizes the active construction of knowledge through interaction and shared creation and the application of conceptual understanding and problem solving in a collaborative environment."*

[6] Schreurs 2012: "*Constructivism based learning models are becoming implemented by organizing learning activities in which students are participating in knowledge construction processes while linking mathematics competences to (business) practice applications competencies."*

[11] Franciszkowicz, 2008: "*Lab lecture capturing is suitable especially applicable to mathematics content delivery in the online learning environment where both visual and audio media "[are] crucial in demonstrating multistep problem solving approaches".*
Screencasting can actually make material more accessible to a wider range of learners [12], and support an active learning environment with activities of problem solving and supporting deep conceptual understanding.

V. CASE E-TUTOR MATHEMATICS IN UHASSELT

A. *Problem: incoming students are not ready for course mathematics*

First year students in applied economic sciences experience problems with the course mathematics. Some incoming students are not ready to start the course math. They have to be motivated to enhance their mathematics knowledge level before the start of the academic year. All those candidate students can now test themselves and can participate in a face-to-face organized preparatory course to improve their math knowledge level.

But even if students have done this remedial activity, many of them still have a lot of problems in the first year course mathematics for business economics. Those students have a different mathematical attitude, and as a consequence need a different guidance. Some students need additional help to succeed in math. We need to offer them the instruction they need. We decided to develop an e-tutor , presenting online simulation of the classroom sessions and the possibility of guidance in solving mathematical exercises

B. Educational model and learning process of the course "mathematics for business economics"

The learning process is a blended process including face to face sessions and self-paced learning activities following the constructivism model of learning.

Procedural fluency is still a goal in balance with conceptual thinking, though the main focus will change more to conceptual thinking in the future.

In the face to face sessions, an intro in the theoretical background is presented and explained and examples of applications and solving exercises are also shown. In a practice session, students are trained in solving exercises.

In the future, once the institutional policy about using of advanced math-calculator will be implemented, these will be used in solving exercises. As a consequence the main focus will change to business problem solving. Students will learn how to model real business practice and problems and to solve them using the right methods and tools of mathematics.

C. Project: development e-tutor mathematics

The development of a web-based intelligent tutoring system for mathematics is set forward. In literature more examples of e-tutors can be found. An example of a system is presented in [9]

1) Action to remedy and to support students:

3 obstacles had to be overcome:

- Weak mathematical knowledge of some students when entering in the course
- Lack of math-passion for mathematics and so lack of motivation to learn mathematics
- Poor teaching practice due to mass-teaching for a heterogeneous student group

Online tutoring is the main solution we set forward in this e-learning development project. An e-tutor is developed and is focusing on a deep conceptual understanding of mathematics.

The new e-tutoring approach is delivering and integrating individual computer-assisted work with classroom instruction. In the face-to-face classroom sessions, students were introduced in the math concepts and in the practice sessions students are solving math exercises and problems with guidance from an instructor/tutor. In the online e-tutor system students can find additional online tutoring.

The e-tutor emphasizes both procedural work and conceptual thinking. Students can select for each chapter of the course between different online learning activities, some of them being more presentations and other more interactive learning activities.

2) An optimal hybrid course model: Based on the innovative technology-enhanced hybrid course model developed by CSUN (California State University, Northbridge[10], we decided on the following hybrid course model, composed of 5 components:

- (online) individualised remediation of pre-requisite math knowledge.
- interactive online lectures introducing the concepts of the theory, and the applications in a business environment
- a practice session in the classroom where students are guided in solving exercises
- online simulations of lectures and practice sessions to support individual learning
- online selfstudy exercises and problems guided by the system

3) Learning activities included in the e-tutor:

LA1: Presentation Theory: The theory of the chapter is presented as a video, being a sequence of boards, being a simulation of the classroom lecture. The student can access the online lecture or parts of it.

LA2: Presentation example exercises: Students will be shown solving some example exercises

LA3: self-study stepwise solving exercises: Solved exercises are available in a question base. Students can select exercises and they will be trained in solving the exercises in a stepwise way. While a student is solving an exercise he can ask for a next step of the solution, or he can ask for the final outcome

LA4: self-study Stepwise solving problems/ activities: Solved mathematical applications in business are available in an application base. Students can select applications and will be trained in stepwise solving them. While searching for a solution, the student will be asked to make choices for next steps. By the way, students take active part in the application process and will learn from his mistakes by correcting his wrong decisions.

In the following table the increasing level of interactivity is given.

TABLE1

E-TUTOR LEARNING ACTIVITIES WITH GROWING LEVEL OF INTERACTIVITY

Learning activities	Rôle of sudent	increasing level of action, interaction
PRESENTATIONS		
• LA1: Simulation: intro theory	• See, listen, understand • Personal selection of chapter or section of course	
• LA2: Simulation: solving exercises	• See, listen, understand • Personal selection of chapter or section of course;	
SELF-STUDY		
• LA3: Stepwise solving exercises	• Personal selection of exercise • Asks for the solution OR • Asks guidance, to receive the next step/ part of the solution	
• LA4: Stepwise solving problems/ activities (*still under development*)	• Personal selection of problem • Student will answer questions about solution of part of the problem and asks for guidance to solve next parts of the problem.	

1) *Development of presentation video's:* LAB lecture capturing in UHasselt

The presentation part of the e-tutor is developed as a "lab lecture capturing" application. Attractive visual presentations of the theoretical modules are focusing on the concepts, the exercises and applications in business context. Life lecture presentations/ simulations of the face-to-face lectures are developed using the software Lecturescribe (Clemson University) or Camtasia. Spoken explanations and handwritten input on a Wacom display are integrated and published as a flash file.

The lab infrastructure (figure 1) is composed of a multimedia desktop and a Wacom display with pen. LecureScribe is the open source software to develop the flash file.

Figure 1: lab lecture capturing infrastructure

2) *The self-study "stepwise solving exercises" activity is a self-developed web-based system, managing the creation and the access to a database of exercises.*

The idea of presentation of stepwise solving exercises is based on the work found in www.algebrakit.nl and in www.usolveit.be.
The self study learning activity "stepwise solving exercises" is organised via a self-developed web-based system, managing the creation and the access to a database of exercises.
Solved exercises are available in a question base. Students can select exercises and they will be trained in solving the exercises in a stepwise way. While a student is solving an exercise he can ask for a next step of the solution, or he can ask for the final outcome.

VI. THE IMPLEMENTATION OF THE E-TUTOR

A. *Implementation and measuring the impact of the e-tutor*

The e-tutor is now online available for the students of the course mathematics. The availability of the e-tutor and the use of it is promoted by the professor during his first lecture. Access is organised as part of the Blackboard course environment.
To be able to measure the acceptance by students of the system and to measure the impact on learning and on students attitudes towards mathematics ,a group of students are prepared to function as a testing group. Those students are asked to prepare their classroom lecture by reading in advance the online lecture. At the end of the semester, as part of the course evaluation, some questions will be included about the evaluation of the e-tutor.
A set of quality criteria has been identified and
will be used for measuring the acceptance of the e-tutor by the students and their evaluation of the quality of the e-tutor in terms of impact on learning and on students attitudes towards

mathematics. (No individual system tracking of e-tutor use is available).
Those students will be asked to advise on possible improvements.
All other Students are free to use the e-tutor services. All students will be asked about their use of the e-tutor in the end of the semester course evaluation.

B. Development of an additional interactive learning activity: self-study: Stepwise solving problems/ activities: under development

Solved mathematical applications in business will be available in an application base. Students can select applications and will be trained in stepwise solving them. While searching for a solution, the student will be asked to make choices for next steps. By the way, students take active part in the application process and will learn from his mistakes by correcting his wrong decisions.
Using scientific calculator will be motivated to solve the mathematical exercises and focus will be more on mathematical modelling and problem solving.
The self-developed system will manage the creation and the access to a database of business applications, with access for the students to solve the problems in an interactive way and guided by the system.

C. Future changes of our hybrid course model: more student centered active sessions.

In the future when solving exercises as part of procedural fluency will become less important due to using intelligent calculators to solve math exercises, the focus will be more on conceptual thinking and on problem solving. Some learning content can be moved to the online environment thus freeing face-to-face lecture time for more problem solving activities in the classroom.
In that case the quality of the online sessions have also to be increased by organising synchronic virtual online class activities to support the communication between the students and with the teacher.

VII. CONCLUSIONS

Some students of the first year do not have the required knowledge to start the first year course mathematics. And after taking a preparatory course, they still need assistance during the first year in studying mathematics. A math e-tutor has been developed, after carefully researching the learning concepts, the use of technology in learning and the method of developing attractive simulations of the classroom sessions by lab development lecture capturing. The e-tutor includes 4 online learning activities to assist the students.
A first test of the effectiveness of the system is planned for the first semester course. The acceptance of the e-tutor by the students and the impact on learning will be measured by the students belonging to a test group.

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