

# SMART TEACHING TECHNOLOGIES USED IN BLENDED E-LEARNING COURSE MATHEMATICS

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## **Abstract**

A literature study about changes in learning models and learning environment is reported and relevant best practices were described in the first part of the paper. An e-tutor solution for the course mathematics of first year bachelor business economic sciences in Hasselt University has been developed, based on these concepts.

LAB lecture capturing has been used for the development of presentation video's.

Attractive visual presentations of the theoretical modules are focusing on the concepts, the exercises and applications in business context. These life lecture presentations/ simulations of the face-to-face lectures are developed using the software Lecturescribe (Clemson University). Spoken explanations and handwritten input on a Wacom display are integrated and published as a flash file.

A system supporting the process of stepwise solving exercises has been developed to support students when solving exercises in the module selfstudy exercises.

Keywords: Smart teaching technology, blended e-learning, course mathematics.

## **1 CHANGES OF LEARNING MODEL AND LEARNING ENVIRONMENT**

The learning environment has changed drastically in the past several years. Implementation of active and interactive methods and tools is impacting students learning quality. They are based on the concepts active and cooperative learning, learning communities, service learning, cooperative education, inquiry and problem-based learning and team projects.

Online videos including learning content were used.

The courses are evolving to hybrid courses, blending online and classroom activities, flipping classes with experiential learning in the classroom and sometimes including an integrated lab component and often in collaboration with external experts. Virtual classroom facilities are supporting these learning activities.

### **1.1 Blended learning an evolution**

Main advantages of e-learning are the possibility of learning at anytime and from anywhere and the relative low cost of the organization of learning. But e-learning are not providing sufficient choices, engagement, social contact, relevance, and context needed to facilitate successful learning and performance. So e-learning courses are not engaging and are not motivating enough the students to stick with it and finish the course.

The advised learning model is blended learning sometimes called hybrid learning. It is mixing face-to-face and e-learning activities in the learning process. [1] Also more blended learning models do exist today. The development of the learning process starts from the pre-decided set of learning outcomes taking into account the pre-defined competences and the opportunities of learning technology. A special focus is on integrating experiences in the course. Practical exercises and experiments and problem-solving are organized as face to face sessions often in special lab rooms or even outside the classroom and on site of a project partner.

### **1.2 Blending e-learning and experiential learning**

#### *1.2.1 Experiential learning*

Experiential learning means the organization of learning activities preparing the students to perform well in their future (professional) situation. In the learning process students are active learning "by doing" and by "reflecting on their experience". Active learning includes practicums, research activities,

problem solving and project work about a real (business) problem in cooperation. In this project based learning model, the students are members of a project team in co-operation with a professional organization.

Learning can be linked with the professional environment by organizing hands-on laboratory experiments, field exercises, and studio performances. Functioning of students in different professional roles is simulated and is realized in cooperation with practice. Students can take a role of a producer, of a scientist, of a project manager... related to their future expected professional situation.

Experiential learning is a cyclical process [2] whereby knowledge is created through the transformation of experience. The centre of learning is experience, which serves as the main driving force in learning.

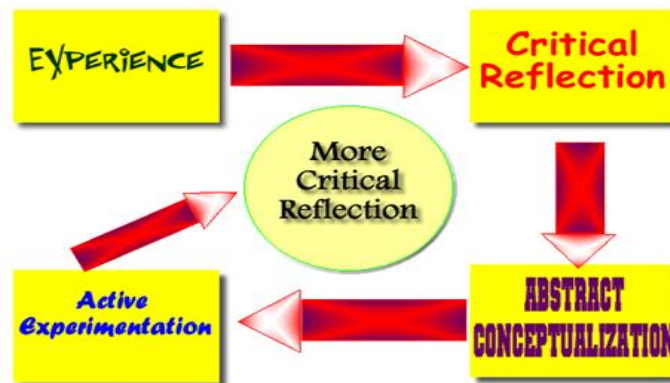


Fig.1: cyclical process of experiential learning [2].

The learners begin with a concrete experience, which then leads them to observe and reflect on their experience. Then students may conceptualize and draw conclusions about what they experienced and observed, leading to future actions in which the students experiment with different behaviours. This begins the cycle anew as students have new experiences based on their experimentation.

Learners benefit from experience-based learning. [3] Learning is something personally significant or meaningful for them. They understand why the lesson is beneficial to their personal and for professional lives. They are personally engaged. They are recognized for prior learning they bring into the process and they can reflect on their experiences during the process. They feel responsible for their learning. [4], [5]

### 1.2.2 Blending online learning and experiential learning

The “face to face” classroom teaching sessions must be limited in time and part of the theoretical presentations can be replaced by e-learning activities. By the way classroom time can be freed for more active and learner centered learning activities and learning can evolve to experiential learning.

There are thousands of schools incorporating innovative examples of new schools blending personalized learning technologies with hands-on and experiential learning.

## 1.3 The expeditionary learning school. [6]

Blending online and experiential learning isn't a new idea, many of the expeditionary learning schools have been doing it successful for more than a decade.

In these expeditionary learning schools students are often engaged in case studies and learning expeditions, projects, fieldwork, and service learning designed around compelling topics connected to real-world issues and needs. Guiding questions are challenging them to incorporate this knowledge to craft products worthy of a real audience.

The classrooms are alive with discovery, inquiry, critical thinking, problem-solving, and collaboration. Teachers talk less. Students talk and think more. Lessons have explicit purpose, guided by learning targets for which students take ownership and responsibility.

## **1.4 Flipped class**

### *1.4.1 Flipped class*

In the traditional educational model students are required to listen to a lecture in class and then complete homework based on the information. In a flipped class model, the traditional in class activities (like lecture) are moved to homework time, and traditional homework activities are moved to the class meeting time. [7] This approach blends online instruction with classroom learning activities. The online or e-learning results in more effective learning outcomes.

The flipped model is more effective. Educational psychologists have understood for decades that people generally learn better through interactive conversation, engagement and opportunities to explore, practice and reflect.

The flipped classroom is rapidly becoming popular because learning via internet is becoming easy because of the virtually infinite access to info, even very complex info, provided by the internet. From the other side is creating great online content so quickly and inexpensively that anyone can make online content in about the same amount of time it takes "to say it in class".

The advantage of flipping the classroom comes from the time gained to work directly with the students. It frees the faculty to use their time with students in a learning environment more consistent with what we know about effective pedagogy: active students interacting with their instructor and fellow students rather than passive students sitting in a lecture hall. Students receive instant feedback and do not get as frustrated. [8]

Poor learning outcomes and prevalence of online video by the availability of online video and increasing student access to technology, have paved the way for flipped class room models.

### *1.4.2 Online lectures in the flipped class*

Many universities (Boston Univ. College of Engineering, Univ. of Washington School of Business, Clemson, Michigan State, The University of Texas and many others) are experimenting with changing from in-class lectures to video lectures. Lectures were captured live or in lab. The video lectures were posted on their LMS, on private intranet or even on You Tube, giving students convenient, anytime access.

### *1.4.3 Activities in class*

Universities are using class time to support students in class, to explore the challenging and more difficult aspects of course content, by revisiting concepts students don't understand. Faculty can devote time to helping students develop synthesis and explore applications during class time through: experiential exercises, team projects, problem sets,... doing labs or interactive activities.

### *1.4.4 Example: Algonquin College*

Professor Susan Murphy [9] is using flipped methods to teach her students about social media. She has taken her lectures online. After just a few months using the flipped classroom model, she notes some benefits, including a much more relaxed classroom atmosphere. Students who struggle with the material are much less stressed trying to keep up, and all students are able to tailor the learning experience to their own pace. She states: "my students are confident and most importantly they are having fun learning new things. Attendance in class is at an all-time high: in fact many of them are in class and already working when I show up!"

## **1.5 A mix of e-learning and live virtual collaboration**

### *1.5.1 Learners need also live online collaboration facilities*

E-learning is powerful for delivering complex information, understanding detailed processes, allowing users to learn at their own pace, repeated learning, performance support and measurement of success. Students are able to learn at their own pace, anytime and anywhere, but there is a need also to meet peers and teachers. Face to face contacts and the social aspects of classrooms are important. Students ask for facilities on campus to discuss the learning content and problems in an informal way, even independent of the organised course activities

Classrooms are excellent at maximising collaboration in real time and also provide powerful networking opportunities for participants. Online activities are often missing these social aspects.

Web technologies are nowadays allowing to meet fully online for real-time meeting without the constraint of having to meet at the same place. Students will meet in a live online synchronous class. [10]

### 1.5.2 Adding virtual classroom to the learning mix

Using the classroom to communicate complex processes to large groups has historically been difficult to achieve efficiently and without devoting significant resources. This deficiency can be fulfilled to some extent by introducing live or virtual classroom.

As organisations become more sophisticated in their use of learning technologies, they can offer online learning solutions that maximize the speed, efficiency and enjoyment of collaborative learning too. Live online training – or virtual classrooms (VC) – are gradually becoming an integral part of the learning solutions. [11]

The entire learning process does not have to run in real time. One can blend the self-paced (asynchronous) e-learning with the life classes (synchronous) together to make an advanced virtual classroom. Ways of incorporating virtual classroom/ life e-learning experience are : to have chats, discussions, threads, group works, and real-time class meetings with whiteboard and file-sharing.

We can see that also in MOOCs services, students are brought together in open learning environments. Students are using blogs, wikis, second life, and are meeting in social community groups (facebook). This blended model is a favourite one for professional learners.

## 1.6 An optimal blend: a sound mix of e-learning and experiential learning activities in the classroom, supported by life virtual class facilities

Creating a sound mix of e-learning, face-to-face experiential learning and a virtual class is our challenge.

<p><b>e-learning</b></p> <ul style="list-style-type: none"> <li>• intro in the learning content</li> <li>• additional information</li> <li>• assignments as part of learning process</li> <li>• testing</li> </ul>	<p><b>Classroom</b></p> <ul style="list-style-type: none"> <li>• Discussions about topic, problems and solutions and deeper learning of the topic</li> <li>• Experiences (practice, projects), sharing them with peers, experts and reflect on them</li> </ul>
<p><b>Virtual classroom</b></p> <ul style="list-style-type: none"> <li>• Tutoring in selfstudy,</li> <li>• discussion with peers about it,</li> <li>• virtual meeting,</li> <li>• team reporting on distance</li> </ul>	

Fig. 2: a sound mix of e-learning, classroom and virtual classroom.

Learning activities can from one side be organized as synchronous and as asynchronous activities, and from the other site as face to face and on distance. Learning activities can be coordinated by the teaching team or be self-paced.

A mix or blend of e-learning (selfstudy), experiential classroom activities and virtual class activities is the most flexible and social hybrid model for the learner. It guarantees an effective learning process, in collaboration with peers and teaching team and external experts and expertise and prepares the learners best for their future professional functioning.

Our course e-business strategy is a good example of mixing selfstudy of the theory and projectwork in collaboration with KBC Bank. To become more flexible, the communication between the project team members can be organized online, by extending the blend e-learning – classroom with a virtual class component. An additional advantage will be the opportunity to welcome international students and also professionals to join the course in a virtual class.

## 2 SMART TEACHING TECHNOLOGIES TO DEVELOP ONLINE LEARNING COURSE

### 2.1 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.

### 2.2 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. [12]
- 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

### 2.3 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.

### 2.4 Famous examples.

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

- 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.
- 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.
- 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.

- 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.

### **3 BLENDED E-LEARNING COURSE MATHEMATICS: CHANGES IN MATHEMATICS TEACHING EDUCATIONAL MODEL**

#### **3.1 A pedagogical divide in teaching of an entry-level mathematics course in a business economics study program**

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.[13]

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.

#### **3.2 Teaching math**

In expeditionary learning schools, math is integrated into projects, case studies and learning expeditions whenever possible. Teachers of all disciplines support mathematical thinking in areas such as numeracy, statistics, patterns, and problem-solving. Teachers ensure that students develop procedural fluency, calculating with accuracy and efficiency. There is an equally strong focus on problem-solving skills and critical thinking to enhance conceptual understanding and problem-solving. Students learn to use appropriate technology tools strategically in problem solving. Tools are used not as a substitute for learning foundational facts, but to enhance conceptual understanding and problem-solving dexterity. Teachers design math specific projects and case studies that allow students to apply their math understanding to real-world contexts; Teachers integrate math into learning expeditions when its integration compels students to learn rigorous skills and concepts.

#### **3.3 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.

[14] 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.*"

[15] 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.*"

[16] 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 [17], and support an active learning environment with activities of problem solving and supporting deep conceptual understanding.

## **4 E-TUTOR MATHEMATICS IN UHASSELT**

### **4.1 Hybrid blended e-learning model**

#### *4.1.1 A hybrid blended e-learning model*

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. 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"

#### *4.1.2 An optimal hybrid course model*

Based on the innovative technology-enhanced hybrid course model developed by CSUN (California State University, Northridge [18], 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

### **4.2 e-tutor**

#### *4.2.1 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.

#### 4.2.2 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.



Fig.3 lab lecture capturing infrastructure.

#### 4.2.3 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](http://www.algebrakit.nl) and in [www.usolveit.be](http://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.

## 5 CONCLUSIONS

A literature study about changes in learning models and learning environment and a study of relevant best practices resulted in the insight that it is a challenge for teachers to include in the learning process an optimal mix of classroom, e-learning and virtual classroom activities. Applied to the course mathematics the teaching team decided to organise a blended model, composed of the following 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.

An e-tutor is developed and implemented including 3 types of activities:

- Presentation of Theory as video's, being simulations of the lectures and being created via lab lecturing capturing,
- Presentation of example exercise and
- a self-study module to support students in stepwise solving exercises.

LAB lecture capturing has been used for the development of presentation video's. Attractive visual presentations of the theoretical modules are focusing on the concepts, the exercises and applications in business context. These life lecture presentations/ simulations of the face-to-face lectures are developed using the software Lecturescribe (Clemson University). Spoken explanations and handwritten input on a Wacom display are integrated and published as a flash file. A system supporting the process of stepwise solving exercises has been developed.

Additional and more interactive math applications will be developed as part of the selfstudy module of the e-tutor.

Virtual class facilities are not yet implemented.

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