# Learning Strategy and Students' Perception of Different Learning Options in a Blended Learning Environment

## *A Case Study of a First Year Engineering Course*

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Abstract: This case study presents a teaching strategy for an engineering dynamics course using a range of different learning options supporting different learning styles. The teaching strategy was implemented in a blended learning environment by combining traditional lectures with online resources. A set of questionnaire was given to evaluate the students' perception of the different learning options. The study shows that the students found online pencasts very useful as a means to increase the outcome of studying a traditional textbook. In addition, the implementation of an electronic audience response system to enhance active learning by peer instruction in combination with traditional lecturing was highly appreciated by the students. Finally, the study indicates that according to the students the proposed teaching strategy leads to increased motivation and engagement in their study.

# 1 INTRODUCTION

Helping young students to become skilled and innovative engineers is not an easy task. One of many issues is how to transfer knowledge earned in a theoretical course into useful competencies when dealing with real engineering problems. The Faculty of Engineering at the University of Southern Denmark has tried to address this problem by assigning 1/3 of the student's work load each semester to a specific semester project comparable to a real-life engineering problem. The idea is that the students learn how to use the theory discussed at the more traditional courses, thereby finding the theoretical courses relevant and in fact crucial for their education. In spite of all good intentions with these semester projects, it does not always work that ideal! For instance, when talking engineering dynamics, it is striking that while students might be good at solving text book exercises, this does not imply that they are able to use their knowledge in more realistic engineering problems that they encounter in a semester project (Schmidt, 2012). As an attempt to overcome this challenge the teaching strategy in a theoretical course in fundamental engineering dynamics was changed by setting up a blended learning environment.

With the advancement of technology the use of blended (or hybrid) learning at university level has developed a lot over the last decade. This teaching strategy can be defined as 'a mix of several didactic methods and delivery formats' (Kerres and de Witt, 2003). Moebs and Weibelzahl (2006) advocate for blended learning being the integrated learning activities such as a mixture of online and face-to-face learning. In this context we will adopt to a type of blended learning where different traditional teaching styles are combined with different kinds of e-learning - a definition that seems to be more often used in the literature (Oliver and Trigwel, 2005).

The increased use of blended learning is a consequence of not only the progress in technology but also of the economical and political conditions for educational institutions and of the globalization in general. Many universities face a reality where they have to teach more students with fewer teachers (Peercy and Cramer, 2011). Blended programmes have been suggested as a way to increase cost-effectiveness in education, i.e. the learning outcome is maintained or even increased despite a reduction in teaching costs (Graham et al., 2005). The increased access and flexibility offered in a blended learning environment enhances distance learning, too, and thereby gives a possibility to reach a larger

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student volume with a positive influence on cost-effectiveness as a result.

On the other hand there are a range of reasons of more pedagogical nature, why blended learning by some have been proposed even as the ideal teaching concept for the future (Cortizo et al., 2010 and Granic et al., 2009). This is due to the fact that as student population growths the teachers find themselves with an impossible task: to choose the optimum teaching style for the students. Even if all the relevant teaching styles are known, it is not possible to implement all these teaching styles simultaneously at class to meet the students' needs (Felder and Brent, 2005). Students who have different needs, different background levels of knowledge and different learning styles are equally not satisfied with traditional teaching and learning environments (Limniou and Smith, 2010). Implementation of blended learning is seen as a promising strategy to address this problem, since it allows integration of traditional learning with web-based or computer-based learning tools and combinations of a number of pedagogical approaches (Dzakiria et al., 2006).

As pointed out by Peercy and Cramer (2011), successful blended learning cannot be a mish-mash of traditional lecturing with some online content but needs to involve a thoughtful redesign course pedagogy implying meaningful new interactions with students. This paper reports how a blended learning structure was established in a second semester engineering dynamics course. Special emphasis was put on facilitating several learning styles and on increasing the learning output by stimulating active learning. At the end of the semester a survey was carried out in order to measure the students' perception of the efficiency of the different learning options as a first indication of the strength of the proposed learning environment. In addition it was possible to track the number of students viewing the online materials and in this way getting data on the use of these materials.

## 2 RELATED WORK

When designing a course structure to benefit from blended learning it is important to strive for the blend to involve the strengths of each type of learning environment and none of the weaknesses. Osguthorpe and Graham (2003) have identified six general goals to aim for in this context: (1) pedagogical richness, (2) access to knowledge, (3) social interactions, (4) personal agency (learner control), (5) cost effectiveness, (6) ease of revision. It is crucial to consider how or to what extend these goals can be achieved when blended learning is implemented into a course design.

In engineering educational research quite some work on how to use a blended learning strategy has been published, but not particularly in engineering dynamics. Boyle (2005) shows how such a strategy used in an introductory programming course can address a common problem dealing with the abstract nature of certain programming concepts. Here a development of multimedia learning objects enabled the students to engage visually with these concepts and hence overcome the problem of abstraction. Another study on a blended learning approach in a computer programming course for first year engineering students indicate that online tools can be very beneficial for the students, and it improves the student satisfaction with the course (El-Zein et al., 2009). Groen and Carmody (2005) found that in teaching first year engineering mathematics the blend more closely mirrors the professional practice and is more likely to encourage a deep approach to learning. The majority of the students responded favourably to the blend. Similar results on positive student feedback and especially regarding improved student motivation in engineering mathematics has been reported by Wan Ahmad et al. (2008). A particular interesting approach to design a mathematics course within a blended learning framework has been suggested by Markvorsen and Schmidt (2012). They consider the technology enhanced learning of first year engineering mathematics and especially the application of different e-learning objects and principles. Because of a yearly intake of 750 students at this course, it has been possible to allocate a significant amount of resources into producing introductory videos, interactive web-based tutorials, online textbook materials, pencasts, and podcasts of the lectures etc. Even though the effect of their non-linear multimedia technology and e-learning principles is not yet fully analyzed, they can report that it strengthens and enhances the students' desire and ability to prepare for teaching, and they have received positive response from the students regarding the facilitation of different learning styles.

In engineering education it has been explained that e-learning in general is most effective when used as a supplement to more traditional strategies rather than a replacement for them (Lux and Davidson, 2003). In fact, traditionally the science- and mathematics-based engineering courses are the hardest to teach online because of the need for

laboratories and equation manipulation (Bourne et al., 2005). Newer research shows that to improve the success of blended learning the teacher should adopt strategies that promote not only teacher-student interactions, but also enhances class attendance, student-student interactions and motivation (Martínez-Caro and Campuzano-Bolarín, 2011). These findings agree with a study on students' perspectives on learning in a blended environment (Limniou and Smith, 2010), where students stated that their learning output could be improved by using a more interactive teaching approach with the use of collaboration tools and receiving individual feedback. A method to facilitate a more interactive learning frame is to include peer-instruction in the classroom. This teaching style has been found to be very efficient also in a mathematics-based topic as dynamics and in physics in general (Mazur, 1997). Peer-instruction can be enhanced by introducing an electronic audience response system like 'clickers' in the teaching (Fies and Marshall, 2006; Nagy-Shadman and Desrochers, 2008). Some results on students' satisfaction with clicker-induced learning in engineering dynamics has been reported by Fang (2009), who found that students appreciate this teaching approach and the exam performance seemed to be enhanced, too. Another study on peer instruction supported by clickers in an engineering dynamics course revealed that it led to an increased learning output, especially regarding the students' conceptual understanding of the subject. Furthermore, the data showed the students to be very satisfied with this teaching style and they gave high rankings on several parameters, which are important to the learning process (Schmidt, 2011).

Hence, there is a wide range of learning options that can be facilitated in a blended learning environment. However, it is important to keep in mind that the course structure should be very transparent to the students in order to help the students managing their time in such environments and maintaining their self-motivation (Marino, 2000). Since the development of a range of learning options is a resource demanding process, this will usually be a limiting factor, and especially for smaller classes. This was very much the case for the course considered in this paper. The blended learning environment developed here is outlined in the next section.

# 3 BLENDED STRUCTURE IN AN ENGINEERING DYNAMICS COURSE

## 3.1 Course Setup

The course studied was a second semester engineering dynamics course. Topics were dynamics of rigid bodies and it was a follow-up on an introductory course on particle dynamics at the first semester.

A total number of 56 students from three different engineering programmes were enrolled at the course. By the study administration the students were divided into two classes because of the use of two teaching languages (Table 1). Both classes were taught by use of the same blended learning approach and by the same teacher, hence in this work all 56 students are treated as belonging to just one sample. Lectures of 90 minutes were given once a week to each class. The students were evaluated for their final grades at an oral examination.

Table 1: Demographic data.

| Language | Engineering programmes | Number of students |
|---|---|---|
| English class | Mechatronics Innovation & Business Interaction Design | 42 |
| Danish class | Mechatronics | 14 |

## 3.2 Learning Options and Resources

The following study materials were offered to the students. All materials were available online at the course web-page, except for the textbook.

*Pencasts*. A pencast is a computerfile where a hand-written note is recorded along with the instructor's vocal explanations. This file can be watched by the student in real-time. One advantage is that the student can repeat difficult steps over and over and hear the instructor's explanations for exactly this part as many times as wanted. To each lecture a pencast of 6-9 minutes were developed telling about the main concepts of the week and how they were related to each other and to previous discussed concepts.

*Lecture notes*. These were hand-written pdf-files consisting of theory and examples for the week's topic. The purpose of the lecture notes was a two-fold: To prepare the student before reading the

textbook and save time at the lectures because students did not have to takes notes all the time.

*Textbook*. The textbook used was a standard engineering dynamics textbook by Meriam and Craige (2008).

*Voting Tests*. These tests consisted of six to nine multiple choice questions for each lecture. The questions were made to challenge the students' general understanding of the topic and their conceptual understanding in particular. At the lectures the students voted (by use of clickers) on the answers they found to be correct and the results were used to stimulate peer-discussions. Mainly, the voting tests were uploaded in order to give the students the possibility of working with the test questions not only at class but after class, too.

*Hints and Answers*. To each lecture a number of exercises were recommended for individual study or group work. To encourage students to work on these exercises a file with hints and answers were uploaded to the web-page each week.

*Discussion Boards*. The students had to hand-in three individual assignments during the course and to each of the assignments a discussion board was created in order to facilitate student-to-student interactions regarding this work.

*Other Materials*. Occasionally, the students were given links to existing online materials, youtube clips, etc. and online materials suggested by the students were distributed on the web-page, too.

## 3.3 Suggested Learning Strategy

At the beginning of the course the students were carefully presented for the range of learning options. They were recommended to start up applying the learning strategy sketched in Figure 1 as this was seen as a strategy that probably would suit a majority of students.

As shown in Figure 1 the students were suggested to start a new topic by watching the pencast. This should prepare them to achieve a better outcome when studying the textbook before attending class. The lecture notes were supposed to help the students with this task, too.

Hence, when students met in the classroom, they had already studied the subject and gone through some sample problems in the textbook. For this reason, the teacher gave only a short presentation to cover the most important parts of the topic (typically 10-15 minutes).

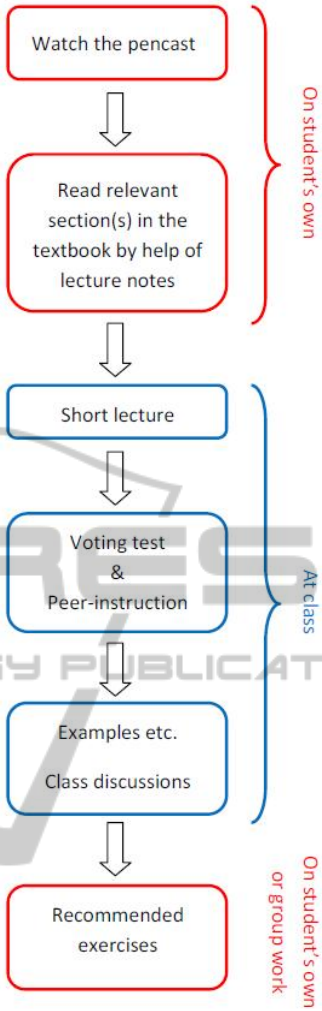


Figure 1: Suggested blended strategy.

Then the voting test was carried out. After presenting a question on the screen, the students were asked to answer the question on their own and give in their answer anonymously through a clicker handed out to each student at the beginning of the lecture. Automatically, the distribution of given answers were shown on the screen to motivate the students for the following peer-discussion. After some minutes of discussions, the students were asked to vote again on the same question. Normally, the second voting showed much better agreement as a result of the peer-discussions. A concise conclusion to the question was stated by either one of the students or the teacher. Usually, this voting-session took up 30-40 minutes. The remaining part of the lecture was held in a more traditional form with focus on working out examples and problems, some of them covered by the lecture notes and some not in order to give possibility to have class-

discussions on different problem solving strategies. Occasionally, experiments were carried out at class to demonstrate specific concepts and to relate to real world examples.

The students were urged to work on the recommended exercises after class, either on their own or in study groups. If they were able to solve these exercises the students could see this as an indication of him or her mastering the topic! Only the mandatory assignments were handed-in and to these assignments the students received written feedback on the problem solving skills and presentation of the solution methods.

## 4 DATA COLLECTION

In order to collect information on how the students used the different learning options and how beneficial they found them, the students filled out an online questionnaire at the end of the course.

For each learning option the students were asked two questions:

(1) How often did you use the [learning option]?

(2) When you used [learning option] how effective (learning outcome per minute you spend) did you find it?

Answers were given on a 5 point likert-scale (1 = 'Never'/'Not effective at all' to 5 = 'Every week'/ 'Extremely effective' for question (1) and (2), respectively).

In addition the students were given the opportunity to answer two essay questions: One regarding the student's explanation on why some learning methods work well for him or her, and another one where the student should explain why some learning methods do not work for him or her.

Data from the questionnaire was gathered electronically and thus answers were given in fully anonymity. A total number of 50 students responded to the questionnaire (corresponding to 89%). The amount of qualitative data from the essay questions was quite significant since 45 students (90% of the respondents) gave input through this channel.

Finally, the number of students viewing the online materials was tracked as a means to monitor to which extend the different materials were used and also to track when they were accessed.

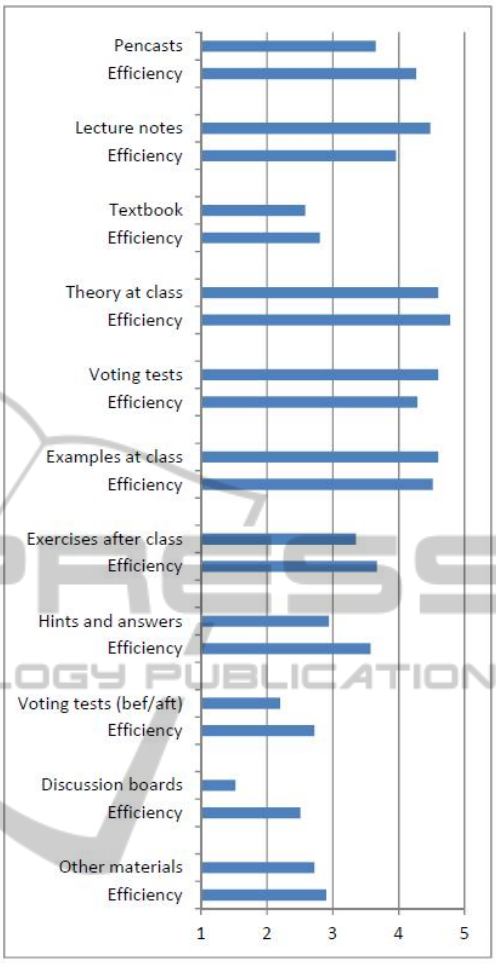


Figure 2: Average scores on use and efficiency.

## 5 RESULTS

Figure 2 shows the average scores for the different learning options regarding how much the different materials have been used as well as the students' perception of the efficiency. In general it shows that the students gave the highest ranking to the activities that took place at the lectures (presentation of theory, voting tests/peer-discussions and examples). Reading lecture notes and watching pencasts are considered quite beneficial too, while the use of the voting test questions outside of classes, discussions boards and 'other materials' are found to be more rarely used and with poorer efficiency.

Even though not documented here, when comparing the scores on the use of the different materials given by the students and the tracking of the number of views they seem to agree well. Hence, the results on the use shown in Figure 2 are

considered quite reliable. Regarding the data on efficiency, being of a more subjective nature, it is unfortunately not possible to make any kind of comparison in order to validate the data.

As an example of the kind of data received from tracking the number of students viewing the online materials, the student views of the pencasts during the semester is shown in Figure 3.

Results from the essay question will be part of the discussion in the following section.

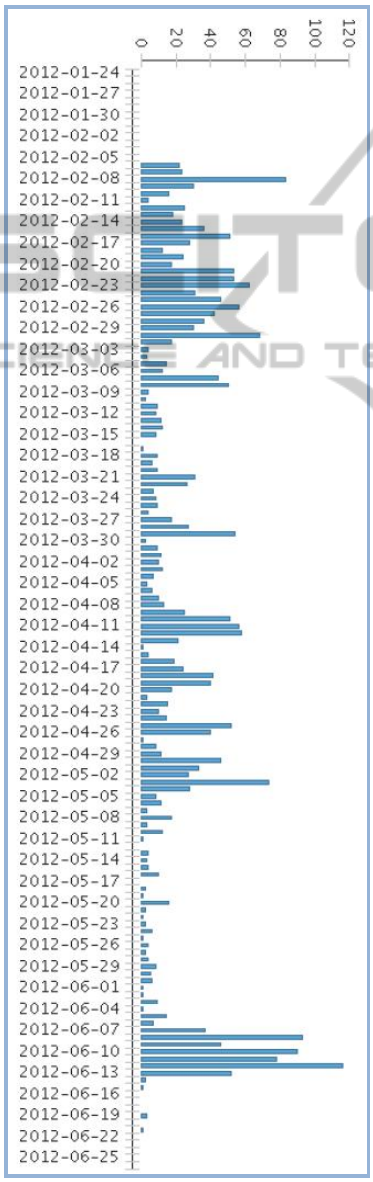


Figure 3: Number of student views of the pencasts during the semester. (Data from the English class).

# 6 DISCUSSION

## 6.1 Learning Options before Class

There were three main learning options for the students to work with before class: pencasts, lecture notes and the textbook. Figure 2 gives a very clear indication that while the pencasts and the lecture notes were found to be very useful and efficient, the textbook was found to be one of the learning options with poorest efficiency of them all. Presumably for this reason, the students did not use the book very often. This view on textbook and lecture notes reading was stressed by students' comments on the essay questions:

*'Reading in books is just naturally so slow and boring.'*

*'Personally, I can't learn properly in a book. Some texts are too strange and difficult to read.'*

*'I read every week the lecture notes - they are really good because they have a nice overview and structure.'*

The online lecture notes were found to be very popular among the students. This can be explained, at least partly, by the lecture notes being much easier read compared to the textbook. It is important though, in order to create the optimal learning, that focus is put on the lecture notes being a tool helping the students to benefit from studying the textbook rather than being an alternative to the book. A study by Fitzpatrick *et al*. (2010) indicates that students regard a good set of notes a requirement for a well-taught module, but in general the students are not convinced that this is sufficient. Hence, providing such lecture notes is not seen as an alternative to the textbook in this context. Since most careers in engineering in the future will be based on life-long learning, it is crucial that the students are provided with the skill to benefit from reading a traditional textbook.

Next to lecture notes specially produced video films have been suggested to help to prepare students for studying a textbook (Markvorsen and Schmidt, 2012). Since video production is a rather expensive solution, in this work it was chosen to make use of the pencast technology. Easily and inexpensively created with a digital pen with a build-in audio recorder, pencasts are very useful not at least for a course topic of mathematical nature. The pencasts made for this course was meant as 'appetizers' before reading the textbook but also to achieve direct learning, mainly in the sense of

creating an overview of the subject. Figure 2 shows that the students found the pencasts very efficient. Some students' comments on pencasts were:

*'The pencasts are very great. They are short and precise - and the best thing: you can repeat every explanation until you've got it all!'*

*'Pencasts were new to me. It's a cool idea.'*

*'Pencasts work well for me because of the "listen-to-anywhere-anytime" function. Repeat. Repeat. Repeat!'*

In addition, the pencasts might also enhance the students' motivation to read the textbook:

*'The pencasts I also think was a good idea to help me kickstart on new theory and made reading the book easier.'*

A similar observation has been made for the video introductions by Markvorsen and Schmidt (2012).

An unexpected use of the pencasts can be deduced from figure 3 exploiting the number of students' views on the pencasts during the semester. Right from the beginning of the semester, the pencasts had quite a lot of hits. The decrease in students' views in a part of March was due to cancellation of lectures and a spring break. When the teaching period ended in the beginning of May the students did not access the pencasts very much anymore, but approximately one week before examination (starting June 12) there was a lot of activity again. Hence, even though the pencasts were made in order to be an option to be used before reading the textbook, the students used them quite a lot in preparation for examination.

## 6.2 Learning Options at Class

All three main elements when the students met at class: the teacher going through theory, voting tests and discussion of examples received high scores in efficiency, well above 4 on the 5-point scale. That a majority of students finds the teacher lecturing beneficial to their learning is in accordance with Fitzpatrick *et al.* (2010), who conclude that students require lectures as well. A lot of effort was put in to lecture on theory and applications in close connection to what the students had seen in the pencasts, in the lecture notes and in the textbook, but always so that the lectures added something new, a new idea, a new point of view etc. to give a further perspective to the subject. According to Fitzpatrick et al. (2010) these are very important factors regarding the students' perception of the efficiency of a lecture. This was supported by students' comments in the present study:

*'I think the exercises we did in class and the explanations are very good. I like to work with examples. Then it is easier to remember.'*

*'Lectures and exercises at class build well upon the lecture notes as they both teach and challenge students. Personally, I appreciate the teaching style because it shows me how to visualize and approach physics problems effectively without tiring me by overloading me with grey theory that has long lost connection to the "real" world. The classes help me to apply theory flexibly with a fair understanding of what is actually going on.'*

The voting test sessions at class were considered very efficient by the students, too. Previous work (Schmidt, 2011) has shown that using clickers to stimulate peer instruction can improve the learning outcome and student satisfaction in courses like engineering dynamics. In addition, the present case study indicates that the students themselves assess the efficiency to be quite high. Comments from the students on the voting tests gave credit to this teaching style to enhance satisfaction and motivation as well as to expose students' insight into the core of the learning process:

*'Voting tests have satisfied me tremendously as they put the learned theory to test right away and helped me widening the view of physical implication around us.'*

*'Voting tests inspire students to use each others' knowledge of a given subject, and sometimes their way of seeing a problem differs from the teacher's.'*

Facilitating peer instruction is one way to engage the students at class and stimulating active learning. To actively involve the students in the classroom is an important parameter to improve the lecture, according to students' opinions (Fitzpatrick et al., 2010). Findings in the present study indicate that implementing voting tests and peer instruction at class should be considered a recommendable teaching style. In general, the essay answers from students show that the blended environment was quite appreciated by the students:

*'Good mix of learning strategies can be the most useful way to learn new things and understand them!'*

## 6.3 Learning Options after Class

Following the suggested learning strategy the main activity for the students after class was to work on

the recommended exercises, either on their own or in study groups if preferred. As experienced by the teacher during the semester, the vast majority of students did work on these exercises and this work was seen as important by the students. To the students' disposal, in order to stimulate their work on problem solving, the web-page offered some hints and answers to all these exercises, but the questionnaire reveals that these materials were not accessed very much with an average score of approximately 3 (corresponding to the answer 'now and then'). Some students stated that they learned more from discussing and helping each other than from consulting the 'hints and answers' since they were found to be either too much or too little. Some student comments indicated that it could improve this learning option if it could be given a more interactive form:

*'The hints the teacher gave for the exercises could be more like, one hint, second hint, third hint and then if you can't solve it, use the forum...'*

A similar result seems to be the case for the 'discussion forum' established for each of three compulsory assignments. The discussion forums were not used very much, and since the benefits in a discussion forum totally depends on the input from the users the forums were not perceived efficient either. Even though the use of discussion forums has been reported very useful in teaching engineering (Brodie, 2009) it was not the case in the course structure described here. Most likely, the reason was that the student volume was too small to create a real need for a discussion forum because most of the students met at different classes every day anyway.

## 6.4 Limitations

There is a range of limitations in this study appropriate to be mentioned. The small number of students in the sample is reducing the strength of data, even though the response rate was relatively high. The novelty of the pencasts may have produced a Hawthorne effect, which would have had an influence on the students' perception regarding these. On the contrary, this is assumed not to be the case for the voting tests using clickers, since this teaching style was used with the same cohort of students in the previous semester. The students assessing the efficiency of a certain learning option is a very subjective measurement and in some cases it could be misleading. For instance, the students might feel that listening to the lecturer is efficient because they feel safe in that situation, where they are not challenged personally on their learning outcome. Some learning options may be efficient, but may also require a certain level of use. Hence, it is possible that students failed to acknowledge their efficiency, because they abandoned them early. It would be pertinent to include a comparison with the students' learning outcome directly, but it has not been considered within the scope of this work.

# 7 CONCLUSIONS

The aim of the study reported here was to present a teaching strategy for an engineering dynamics course based on several learning options and resources supporting different learning styles in a blended environment. The students' perception of the use and the efficiency of the different learning options offered were measured in order to optimize the strategy for future courses. In general, students were found to be positive to the blend, and they perceived the chosen elements to be effective regarding their learning outcome. Especially, the students value the variation in teaching style and indicate a positive influence in their motivation and engagement in the course topics.

It was found that pencasts, being an inexpensive and easy-to-adopt technology, can be a very fruitful tool and enhance the outcome and motivation when students are reading a traditional textbook. In addition, the pencasts were found to be useful to the students in their preparation for examination. The online lecture notes were considered efficient by the students too, and the students appreciated the close connection between the notes and the topics discussed at class.

The students found traditional lecturing very efficient, but it is stressed that in this context lecturing took up only a minor part of the time spent at class. Voting tests using clickers as a means to encourage peer discussion were implemented consequently at class, and the students rated the efficiency of such a teaching style high. A vast majority of students valued the alternation between the teacher lecturing, active learning through the voting tests and problem solving through class discussions.

In the present course setup the option of offering hints and answers to exercises and discussion boards on the course web-page were not used very much by the students. The efficiencies of these tools were relatively low, too. To increase these efficiencies it will be considered to create more interactive

instruments for the future in order to meet the students' demands.

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## REFERENCES

Bourne, J., Harris, D. and Mayadas, F., 2005. Online engineering education: learning anywhere, anytime. *Journal of Engineering Education*, 94 (1), pp. 131-146

Boyle, T., 2005. A dynamic systematic method for developing blended learning. *Education, Communication & Information*, 5 (3), pp. 221-232.

Brodie, L.M., 2009. eProblem-based learning: problem-based learning using virtuel teams, *European Journal of Engineering Education*, 34 (6), pp. 497-509.

Cortizo, J.L., et al., 2010. Blended learning applied to the study of Mechanical Couplings in engineering. *Computers & Education*, 54 (4), pp. 1006-1019.

Dzakiria, H., Che, S. M. and Bakar, H. A., 2006. Moving forward with blended learning as a pedagogical alternative to traditional classroom learning, *Malaysian Online Journal of Intsructional Technology*, 3 (1), pp. 11-18.

El-Zein, A., Langrish, T., Ballam, N., 2009. Blended Teaching and Learning of Computer Programming Skills in Engineering Curricula, *Advances in Engineering Education*, 1 (3), pp. 1-18.

Fang, N., 2009. Electronic classroom response system for an engineering dynamics course: student satisfaction and learning outcomes. *International Journal of Engineering Education*, 25 (5), pp. 1059-1067.

Felder, R.M. and Brent, R., 2005. Understanding student differences. *Journal of Engineering*, 94 (1), pp. 57-72

Fies, C. and Marshall, J., 2006. Classroom response system: a review of the literature. *Journal of Science Education and Technology*, 15, pp. 101-109.

Fitzpatrick, J., Cronin, K. and Byrne, E., 2010. Is attending lectures still relevant in engineering education?, *European Journal of Engineering Education*, 36 (3), pp. 301-312.

Graham, C.R, Allen, S. and Ure, D., 2005. Benefits and challenges of blended learning environments. *Encyclopedia of information science and technology*, M. Khosrow-Pour, ed., Hershey, PA: Idea Group, pp. 263-259.

Granic, A., Mifsud, C. and Cukusic, M., 2009. Design, implementation and validation of a Europe-wide pedagogical framework for e-learning. *Computers & Education*, 53 (4), pp. 1052-1081.

Groen, L. and Carmody, G., 2005. Blended learning in a first year mathematics subject. *Proceedings of UniServe Science Blended Learning Symposium,* pp. 50-55.

Kerres, M., de Witt, C., 2003. A didactical framework for the design of blended learning arrangements. *Journal of Educational Media*, 28 (2-3), pp. 101-113.

Limniou, M. and Smith, M., 2010. Teachers' and students' perspectives on teaching and learning through virtual learning environments, *European Journal of Engineering Education*, 35 (6), pp. 645-653.

Lux, J.R. and Davidson, B.D., 2003. Guidelines for the development of computer-based instruction modules for science and engineering. *Educational Technology & Society*, 6 (4), pp. 124-133.

Marino, T.A., 2000. Learning online: a view from both sides. *The National Teaching & Learning Forum*, 9 (4), pp. 4-6.

Markvorsen, S. and Schmidt, K., 2012. Online Mathematics Education - E-Math for First Year Engineering Students. *International Conference on Computer Supported Education (CSEDU 2012)*, Porto, Portugal.

Martínez-Caro, E. and Campuzano-Bolarín, F., 2011. Factors affecting students' satisfaction in engineering disciplines: traditional vs. blended approaches. *European Journal of Engineering Education*, 36 (5), pp. 473-483.

Mazur, E., 1997. *Peer-Instruction: A user's manual*, Upper Saddle River, NJ, Prentice Hall

Meriam, J.L. and Craige, L.G., 2008. *Engineering Mechanics, Dynamics*, 6.th edn., Hoboken, NJ: Wiley & Sons.

Moebs, S., Weibelzahl, S., 2006. Towards a good mix in blended learning for small and medium sized enterprises - Outline of a Delphi Study. *Proceedings of the Workshop on Blended Learning and SMEs, 1st European Conference on Technology Enhanced Learning Crete*, Greece.

Nagy-Shadman, E. and Desrochers, C., 2008. Student response technology: empirically grounded or just a gimmick? *International Journal of Science Education*, 30 , pp. 2023-2066.

Oliver, M. and Trigwel, K. (2005). Can 'Blended Learning' be redeemed? *E-learning*, 2 (1), pp. 17-26

Osguthorpe, R.T. and Graham, C.R., 2003. Blended learning environments: definitions and directions. *The Quarterly Review of Distance Education*, 4 (3), pp. 227-233.

Peercy, P.S. and Cramer, S.M, 2011. Redefining Quality in Engineering Education Through Hybrid Instruction. *Journal of Engineering Education*, 100 (4), pp. 625-629.

Schmidt, B., 2011. Teaching engineering dynamics by use of peer instruction supported by an audience response system, *European Journal of Engineering Education*, 36 (5), pp. 413-423.

Schmidt, B., 2012. Skip lecturing - Let the students talk!, Proceedings of the *12th International Conference on Engineering and Technology Education (INTERTECH 2012)*, ed. by Claudio da Rocha Brito and Melany M. Ciampi, ISBN 978-85-89120-89-0.

Wan Ahmad, W.F., Shafie, A., Janier, J.B., 2008, Students' perceptions towards blended learning in teaching and learning mathematics: Application of integration, *Proccedings of the 13th Asian technology Conference in Mathematics.*