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Example of a micro-adaptive instruction methodology for the improvement of flipped-classrooms and adaptive-learning based on advanced blended-learning tools

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ABSTRACT

Despite the wide spread of modern teaching techniques such as the flipped classroom, adaptive e-learning, and active learning, still most of them provide limited and delayed feedback from the student to the instructor. Something, which could lower their efficiency and limit their applicability. This paper presents a teaching methodology and the development of the related tools. A key aspect, of this methodology, is the collection of students' feedback prior to lecture and additional detailed information on their learning progress. This information is then used to adapt course's content. The methodology has been tested and demonstrated on a module of a Chemical Engineering Fluid Operations course. Three evaluation tools were implemented between modules of the same course and an equivalent control group. The qualitative evaluation showed an improvement on the students' perception, a significant engagement and motivation. The quantitative evaluation showed no clear change between modules of the same course (with and without the proposed approach). On the other hand, an overall improvement was observed against the control group. Finally, significant effort was necessary to upgrade the existing teaching material to the level of the new tools. Something, which might discourage more instructors to adapt fully the proposed tools. Nevertheless, the findings related to the methodology are promising, and the tools development can take place gradually or even be directly adopted by the educational publishers.

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1. Introduction

In principle, adaptive instruction is about addressing the needs of individuals. It is linked with the success of education itself and is practiced by teachers since ancient times (Corno and Snow, 1986). In the ongoing course of instruction and in response to particular students practicing teachers make micro-adaptations all the time (Corno, 2008). There is a number of mechanisms used by teachers to adapt their teaching to the pace of the class. Angelo and Cross (1993) outlined many of these concepts such as the "Background Knowledge Probe", the "Minute Paper" and the "Muddiest Point". Later Mezeske, B.A. and Mezeske, R.J. (2007) compiled some modern ideas on creative assessment e.g. "Exams as Learning Experiences". Although, the implementation of these mechanisms is rewarding, there is always the challenge of managing the finite classroom time (Felder, 1992), the limited number of face-to-face meetings (Hannafin et al., 1997), and student's resistance (Felder, 2011).

Flipped classroom models have attempted to address these challenges with successful outcome most of the times even for quite different topics and audience composition (Danchak

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and Huguet, 2004; Kim et al., 2014). Through this approach, students can prepare at their pace, level of understanding and schedule for the lectures (Davies et al., 2013). Instructors in turn, commit more in-class time to provide adaptive and instant feedback to individual or group of students (Fulton, 2012). However, one of the most critical disadvantages of flipped-classrooms is that the instructor must also develop and include activities to ensure that students are prepared for the class (Day and Foley, 2006; Kellogg, 2009; Mason et al., 2013). It became clear that regardless of the advantages of flipped classrooms this is not enough (Lam et al., 2013; Ronchetti, 2010). More advanced tools need to be employed in order to track students' out-of-class behavior and utilize it to adapt the content of the course (Chen et al., 2014). Lian (2003) observed the difficulty to implement adaptive learning without actual feedback from the students. Therefore, he proposed a methodology to monitor continuously students' performance during and after a lecture. Hughes (2007) presented an online tracking system to monitor students' access to the material as a tool to identify and proactively help "at risk" learners. A step further, Fraij (2010) developed a computer-aided instruction system where students could provide feedback on blended learning material. Then the system provides instructors with the knowledge about learners' challenging topics.

Indeed, the current state of information technology provides a major opportunity in education and especially in engineering education and training. Beyond the simple exchange of lectures and homework, the use of learning technologies such as multimedia provide new tools for instructors and new opportunities for students (Lage et al., 2000). Maximizing the best advantages of face-to-face learning and multiple technologies to deliver learning is called blended learning (Bonk and Graham, 2006). There are examples in the literature where blended learning tools like multimedia and web-platforms have been used to improve and enhance teaching and learning experience. Assael and Kakosimos (2010) developed an interactive course platform on consequences modeling (fires, explosions, and dispersions) based on Macromedia Authorware®. They demonstrated its efficiency in teaching the principles of safety to undergraduate engineering students. Violante and Vezzetti (2013) described the effectiveness of an interactive web-based learning application using a 3D virtual environment for biomedical engineering students. Marepalli et al. (2010) developed a tool called SugarAid to help students monitor their learning progress by providing e-homework to prepare them for in-class examination. Kalinic et al. (2011) designed an application to offer the blended learning material not only to browsers but specifically to mobile devices. Analysis of quantitative data for blended learning indicates improved performance of students in typical courses (Swartz et al., 2013). As well as, in more particular case studies such as vocational training (Pohl et al., 2008) and distance learning (So and Brush, 2008).

In blended learning, computer-based technologies have a central role. It spans from enhancing classroom teaching and learning activities to access control and tracking of individuals records and performance (Bonk and Graham, 2006; Wu et al., 2010). However, more recent studies (Fraij et al., 2012; Kakosimos and Mihailidi, 2010) note that similar platforms are extremely rare in the academic environment though highly praised by both students and instructors. Furthermore, even in the cases where such platforms are employed, they are merely used as passive tools. In other words, they only support the one-way transfer of knowledge; from the instructor to the students.

This study demonstrates a micro-adaptive instruction (mAI) methodology for the improvement of flipped-classrooms and adaptive-learning. mAI focuses on the collection of information and student's feedback prior to lecture and off class-time. Then the instructor can use this information on designing the flipped-classroom or simply adapting the content of the next lecture. mAI is based on the development and deployment of advanced blended learning tools. The present study also illustrates the methodology to develop such tools and how to design the context of the course. In brief, the blended learning material of the course is provided through a multimedia platform, which students are using for reading and practice prior to the lectures. The platform tracks detailed information on students' "behavior" such as time spent on each slide and section, answers and attempts of quizzes, individual comments, access date and time, and self-assessment/evaluation. Thus, transfer of feedback takes place both directions – student to instructor and vice versa. The instructor can carry out the flipped classroom more efficiently because (s)he is aware of the specific topics that need to be addressed and clarified. In other words, mAI deploys some of the known classroom assessment techniques (minute paper, muddiest point, etc.) during the off-class time to use the in-class time more efficiently e.g. for active learning. Therefore, next section presents a brief background and more details on the concept of the proposed methodology.

2. Development and tools

2.1. *Background*

"Education as Usual" (EaU) is a well-established process that involves two parties the students, and the instructor. The latter party formulates the syllabus of the course and the content of each lecture; primarily based on the context and experience. An experience that is mainly personal, through teaching the same context multiple times. Fig. 1 illustrates the most common teaching approach where the instructor just prepares printed or electronic material (e.g. videos, notes) and distributes it to the students. Depending on the style of the classroom (normal or flipped), during the in-class time the instructor interacts with the students to explain concepts, describe examples and, in general, convey knowledge. In other words, EaU develops and supports a one-way feedback. The instructor can only collect this scattered feedback, solely based on his/her limited "multi-tasking" abilities; according to extensive studies (Watson and Strayer, 2010) most of us are not real "multi-taskers". There are techniques to develop and enhance the feedback from the student to the instructor. For example, the online-homework (Fraij et al., 2012), "clickers" (Caldwell, 2007) and others (Felder, 1992). Most of these refer to the time-scales during or after the lecture. So it seems that little are available to support a pre-lecture feedback, which could be the most critical factor (Corno, 2008) to implement real micro-adaptive instruction.

The author's concept of micro-adaptive instruction (mAI) is illustrated in Fig. 2. Many things are of course similar to the EaU approach. Such as the sources for preparation of the

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