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TEACHING INNOVATIONS IN THE INTRODUCTORY TO ENGINEERING AND DESIGN COURSES

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ABSTRACT

The educational objectives of the College of Arts and Sciences includes the need of the students to possess an ability to apply, study skills and life-long learning, function effectively in teams, and demonstrate creativity. The main objective of the below mentioned innovative pedagogy is to help the students to reach their maximum potential by providing new insights and to enhance the student thinking skills. With this in place, Introduction to Engineering (ENGR 100s) and Strategies for Team Based Engineering Problem Solving (STEPS) classes have been equipped with innovative teaching methodology to enhance the student learning experience. There are three aspects that are looked into with the ENGR 100s and STEPS classes including embedding visualization, injecting technology in classroom, and applying active learning. The three pieces of innovations are put in place to enrich the student learning experience with the proper directions and the tools that are used in such classes. The tools that are used in the classroom may vary by instructors, for example, The ENGR 100s classes provide a transitional bridge that carries the student from a state of observation of science into a state of applying and engineering. At this stage, the students are slowly liberating them from being dependent on the instructors and begin to select proper tools to find solutions. Traditional teaching methodologies may still help but will hinder the skills development keeping the students waiting for the instructions instead of taking lead. Efforts that are considered to enhance the student's maturity in engineering pedagogy brings the students into thinking outside of the box when applying spatial visual teaching techniques using augmented learning methods. The abilities and skills to visualize the concepts leads to better ability to transfer knowledge and to grasp the problem. Embedding the latest classroom technologies puts the world of possibilities in the hands of our students opening doors for swift understanding when correct simulations and intelligent props are used. More advance classroom environment is proposed in this study referred to as Active Learning Problem Solving classrooms (ALPS). Exploiting the ALPs rooms provides the proper environment for such innovation making it easier to secure the students' attention when all the class notes are saved and effectively shared. Taking it a step farther, classroom technology is optimized when implementing students' laptops in class giving them power to search, design and share without wasting papers, hence, seeding the meaning of sustainability in their belief. Needless to say, significant improvement targets the students' personality; thus, the students are driven into leadership through cooperative learning. Employing cooperative learning puts the students in charge of teaching each other which is proved effective to elevate the student's confidence and reinforce their knowledge. Each project in ENGR and STEPS classes reflects one of the best ways to get the students thinking, talking and sharing information in the classroom.

INTRODUCTION

Well-developed spatial visualization skills are necessary for success in engineering programs (Wai, J., Lubinski, D., & Benbow, C. P., 2009; Hsi, S. et al., 1997; Alias, M. et al., 2002). The ability to imagine and visualize the transformation of spatial information is crucial for developing innovative engineering designs. Spatial skills are essential in engineering graphics in particular in order to understand and create isometric and orthographic drawings, which are the tools used by engineers to communicate information about a component's exact shape and dimensions. Reaction time to mental rotation tasks has been shown to predict performance on an isometric and orthographic drawing assessment given at the end of a semester (Sorby, S. A. 2001).

Studies have also addressed the difference between innate ability and spatial skills that may be enhanced through education. Although differences have been found on a mental rotation task in children as young as primary school age (Orion, N. et al., 1997; Sorby, S. A., 2000), a number of factors has been attributed to the development of spatial skills, including prior experience playing with construction toys such as Legos, experience with sketching and drawing, and playing 3-D video games (Sorby, S. A., Veurink, N. L., 2012).

As research has been predominantly conducted in Western industrialized countries, the generalization of results to non-Western developing regions is increasingly being questioned by scholars as a normative fallacy. A study spanning 16 years compared the spatial skills of American students and students from the Middle East studying at an American university on a test of mental rotations. Scores on the Purdue Spatial Visualization Test- Rotations (PSVT-R) indicated that students from the Middle East had lower spatial skills than the American students (Sorby, S. A., Veurink, N. L., 2012). Another study compared PSVT-R scores of male students in the previous study with the PSVT-R scores of male's students at the Petroleum Institute. Although the targeted students scored better on the PSVT-R than the students from the same region who were studying engineering in the US, these students still scored lower than the American students on the assessment (Sorby, S. A., Veurink, N. L., 2012). A meta-analysis of spatial training programs indicates that visualization skills are malleable and can be enhanced through spatially-enriched educational programs (Uttal, D. H., et al., 2012). However, many universities are reducing their emphasis on engineering graphics (Sorby, S. A., 2000).

While a certain level of visualization ability may be innate, performance is also based on experience and exposure, making it a learnable skill. Bertoline suggests that providing a spatially-enriched learning environment can contribute to the experiences required to improve visualization ability (Bertoline, G. R., 1988). Although mere exposure to computer-aided design can have positive outcomes for students with low levels of spatial ability, a curriculum that utilizes a variety of learning modalities would be even more beneficial to improve the skills needed by engineers in the industry. As students at the PI have been shown to have lower spatial skills than their peers in the United States (Sorby, S. A., 2000), high quality experiences with visualization tasks may improve their ability and confidence.

Implementing laptops in classrooms improve the student's communication skills and increases their confidence making them more independent learners (Tubaishat, A. and Bataineh, E., 2009). Technology in the classroom allows more focus on the learners where teachers usually take the students seat and the tasks is performed with multimedia not only text (Bergman, J. and Sams, A., 2012). Efaw et al. signify that the need to leave the classroom for library visits is reduced with laptops in the classrooms, thus, there is no isolation between the immediate research and recourse exploitation. Using laptops allows for documentation and data to be always stored and shared. Learning is easier to flip as class preparation tasks can be multi-mode (video, audio, text) and the teacher is often giving the students the lead in collaborative learning (Efaw, J. et al. 2004).

Interference of technical issues can sometimes hinder the learning process and should always be considered. Issues like projectors not functioning properly, Wi-Fi failing, power outage and others. The overloading of servers is obviously a much higher risk when there is more demand as in laptop heavy environments. In some instances this can cause the network to freeze and immobilize the class (Hu, W., 2007). Some intrinsic issues may also arise such as software rights and computer crashing (Kraushaar, J.M., & Novak, D.C. 2010).

METHODOLOGY

The objectives of the newly adapted methodologies of teaching of ENGR100s and STEPS classes can be endorsed with four important capabilities that help students' maturity as future engineers. The first objective is to inspire the students to feel the liveliness of engineering works through providing proper visualization technique that keeps them at the edge of their seats. The second objective is to engage the students with applied learning and team work so that the learning will be built on stronger pedagogical and psychological bases. The third objective is using technology to enlighten the students' perception by broadening the spectrum of resources and opening windows to the world while sitting in the classrooms. Finally this work aims to enable the students to put their knowledge to work and take lead in managing, teaching and producing solutions based in practical scenarios. Showing in Figure 1, the three pieces of innovation are put in place to enrich the student learning experience with the proper directions and the tools that are used in such classes.

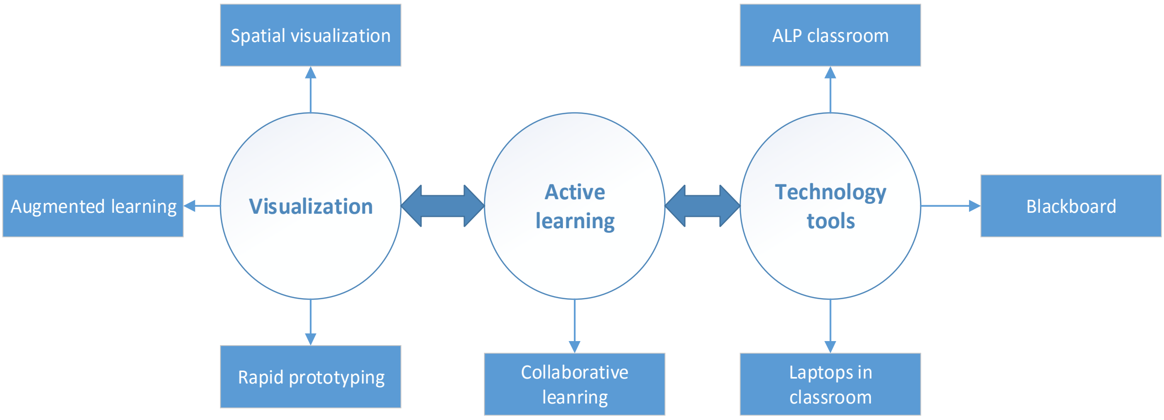

Figure 1: Tools used in ENGR100s/STEPS

VISUALIZATION METHODOLOGIES

This study examines engineering graphics as a part of the engineering design known as STEPS. Students take the sequence of STEPS courses in their freshman and sophomore years after they have completed two Communications courses and one Physics course as prerequisites. The STEPS program requires teams of students to respond to client requirements by designing, managing and presenting technically feasible solutions to real-world problems. In the first STEPS course (STEPS 201), students are introduced to the engineering design process and the terminology required for communication. As the STEPS 201 classes consist of a variety of engineering majors, team members often represent multiple disciplines. Students are introduced to engineering graphics using SolidWorks, a computer-aided design (CAD) software which enables them to develop professional graphics to support their designs. However, there is minimal instruction in sketching with only one class period used to review the terminology needed for understanding graphical models and views. Visualization instruction is not directly provided, but rather infused into the CAD component of the course. Students are given homework each week to practice the SolidWorks software. A CAD assessment is given at the end of the semester where students are asked to reproduce a 3-D figure and its related top, front, and side views.

The second STEPS course (STEPS 251) is designed to provide more in-depth technical knowledge related to the different majors offered for the engineering students. Thus, STEPS 251 courses are divided by major and the projects that students complete are representative of their field. At times, the mechanical and electrical engineering departments may offer a multidisciplinary section that combines students from both these majors, focusing in this case on a project that requires knowledge of both disciplines. Advanced applications of the SolidWorks software is used in the mechanical engineering section of STEPS 251.

Based on the current studies of male and female engineering students involved in this study, it would seem that an improvement in graphics instruction would be particularly beneficial for the women. A hybrid model of instruction that consists of traditional content (such as free hand sketching, orthographic projection-views, and pictorial views) and interactive curriculum including computer modeling and visualization can provide students with a deeper understanding of how to mentally manipulate spatial information. Spatial skills are now introduced along with the CAD component to improve the student skills in order to be a successful engineer.

AUGMENTED LEARNING METHODS

Augmented learning technology superimposes a computer generated image to user's view of the real world in real time. Augmented reality engineering helps students learning 3D visualization skills by combining virtual 3D models with real time video. The Augmented technology would be very attractive to the students and can enhance their self-education process. The educators try to exploit the entertaining features of technology (laptops, tablets, smart boards) into the classroom to investigate how the application of those technologies effects on students ability of three-dimensional visualization and free manipulation of geometrical shapes. At the same time, the investigators can see how the advanced technologies could help from the beginning of the student's academic learning, to improve their performance in the spatial comprehension process and graphic representation skills. Students will also work in teams to learn the material.

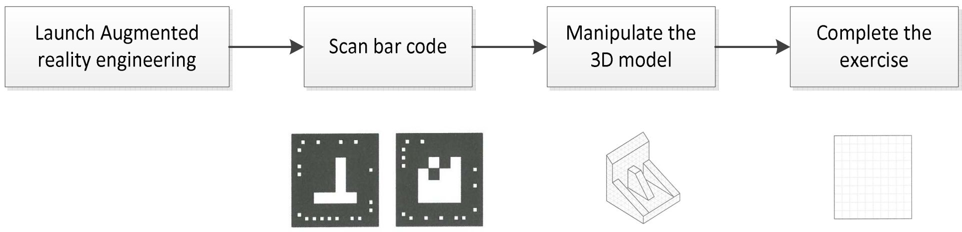

Figure 2: Process for augmented learning

ACTIVE LEARNING

Active learning refer to a critical shift in mission and purpose of education aiming to move from an lecturing state in which knowledge is delivered from faculty to students to a Learning state where learning is produced through student discovery and application (Huba, M. E., & Freed, J. E., 2000). Cooperative learning is considered in engineering classes where students are engaged an active roles rather than sitting passively behind students disks. One method encourages students to be the instructors and lecture a comfortable part of the class. Second method involves roundtable discussions and brain storming particularly in the engineering design application. Technology in the classrooms help to provide students immediate feedback on their preparation for problem based tasks and case studies. Projects and reports are not new to the engineering education but still effective; hence, Projects and reports are regularly assigned engaging the students in self exploration of learning material and solutions to engineering problems. These and more peer-led team learning strategies keeping students in cooperative learning mode to take lead exploring solving and communicating effectively.

TECHNOLOGY IN CLASSROOMS

Many argue that technology in the classroom is a hindrance on the student's attention and can be a cause for student's dependency on the technology rather than putting their brain to work faster and more effectively. This may be the case in recollection based classes that requires the students to perceive and build new concepts, however, at a certain stage, the students are encouraged to hone resource exploitation as a valuable tool. In fact, exams and tests are now being conducted with open books, open notes and lately, open internet. ENGR 100s classes provide the proper training grounds for the engineering students to start taking responsibilities and learn how to look for good resources and find answers. The students are then encouraged to take the driver seat in the STEPS classes and the instructors observe and monitor the students mature. Technology in the classroom showed great improvement on the students' adaptation to resource exploitation. Though many freshmen were not familiar with Microsoft Office, they managed to create and interpret their first Well Logging activity, an important tool for petroleum drilling, using graphs and other tools provided by Excel. Figure 3 shows a sample homework that was submitted by a freshman student after generating a Well log and explaining the findings and potential oil/gas reservoirs.

In the STEPS class, the students were challenged to create their own Gantt chart using Microsoft Project, another piece of technology that should enhance the students' maturity and elevates their acquaintance with available design management techniques. Technology in the classroom provided a vigorous yet robust means for introducing new technical concepts. For example, correct simulations and smart props were put to work for clarifying the picture for the student when the course introduced robotics functions and programming. The idea behind the computer logic is difficult to demonstrate using computer coding, but with the help of technology, LEGO Mindstorms robot program makes it easier to explain and teach the robot/computer interface using graphical blocks as showing in Figure 4.

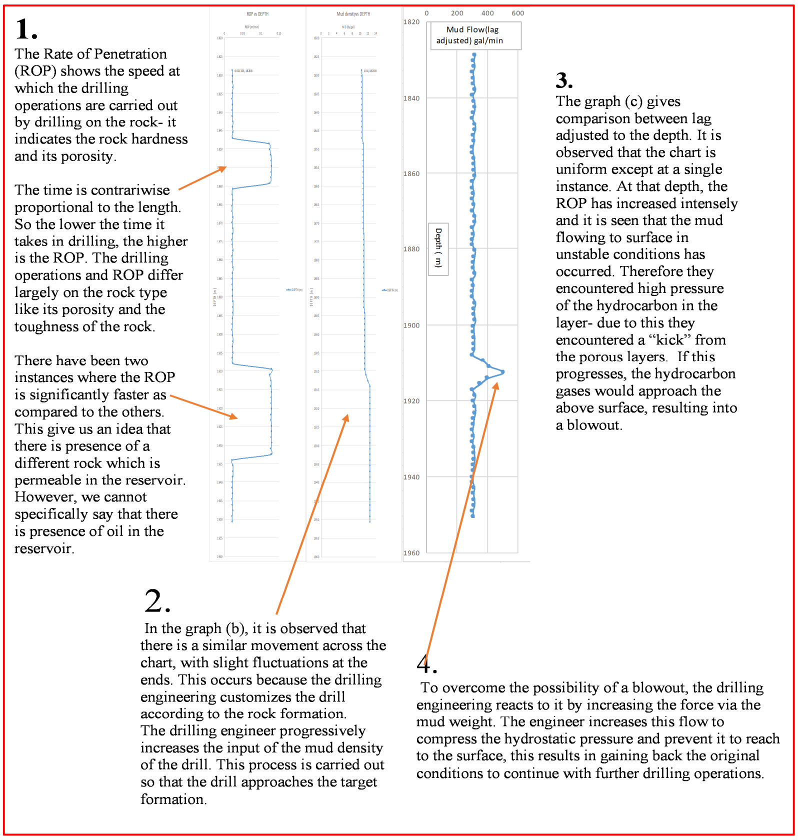

Figure 3: Freshman student outcomes of Well Logging activity using Excel

Embedding technology in the classrooms was optimized when the freshmen students were provided with end of line laptops. The initiative aimed to improve the availability and accessibility multiple resources for undergraduate students and provide key applications such as MS Office, TrendMicro, Matlab and SolidWorks. Research methodologies are significantly engaged with laptops in the classrooms putting the World Wide Web in the students' disposal during the class time. This is carried out with team efforts and with monitoring the process by the instructors, students showed better use of the internet during the conceptual design stages to find proper techniques, tools, parts and industrial terminologies. Needed to reach such vision, a suitable environment is considered for the engineering classes. The Active Leaning Programs (ALPs) initiated by the Center of Excellence in Learning and Teaching provide suitable environments for technology in the classrooms. ALPs were very well exploited in the ENGR 100s and STEPS classes to engage the student's roles in team work. ALPs permit the teachers and the students work comfortably and with higher rate of interaction.

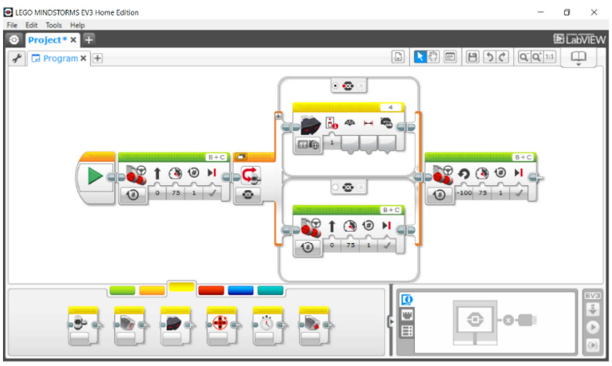

Figure 4: Robotic programming made easy

CONCLUSION

Engineering students go through stages of maturity to gradually build competent professionals who take the lead and provide solutions to the society. Maturity of engineering students depend on how the students are prepared for real world problems. The goal of this work is to propose innovative approaches the guarantees students' transformation from passive roles into active and leading roles. The first skill that this work focused on is enhancing the capability to visualize various setups and interpret them properly. In order to keep the students active, active learning methods are implemented giving the student leading roles by taking over part of the lecture, roundtable discussion, project presentations, report writing, case studies and more. The embedment of technology in the classrooms is essential due to dependence or today's world solutions on such technologies. Using laptops in the classroom proved to be helpful or the students as well as for the instructors by facilitating solutions, research and communication.

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