USING A DIGITAL LEARNING MANAGEMENT SYSTEM IN PRE-ENGINEERING CLASSROOMS

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ABSTRACT

Consistent with the majority of provinces across Canada, the enrollment in senior level high school physics in Alberta has significantly lagged behind enrollment in commensurate chemistry and biology classes. Furthermore, there is significant gender disparity in respect of high school physics students; the majority of students are male. Since engineering faculties depend on these students for their enrollment, to foster diversity in their own student population, engineering outreach programs are often aimed at providing university led in-class presentations / demonstrations in K-12 classrooms. Although met with some anecdotal success, enrolment issues may be more effectively addressed by engineering academics if their efforts were directed toward providing research support in the evaluation of educational tools that may support high school teachers in delivering content themselves in a manner that appeals to their daily instructional needs and to the learning needs of the diverse student population.

An award winning digital learning management system (DLMS) developed by leading Canadian STEM not-for-profit organization is under investigation. This system is a personalized curriculum based hypermedia instructional tool for K-12 educators and students. Being digitally based, it has the potential for rapid integration into classrooms. The tool appeals to digital natives (students), and incorporates: mind mapping (discovery based learning), experts on call, gamification, all integrated through teacher views that produce dynamic project-based lesson plans. The system encourages an interdisciplinary approach that requires students to draw on multiple subject areas simultaneously to solve real world problems.

The global objective of this research program is to improve enrollment and outcomes in high school physics by the further analysis and development of the DLMS. In order to determine the gaps between learning styles and conventional teaching methods, and ultimately to inform physics specific DLMS development, this study will first present the results of attitudinal and learning style surveys that were conducted in local high schools that correlate learning style profiles, gender, and student attitudes towards physics. Some specifics of how the DLMS addresses these gaps is discussed along with the next phase of the research program.

KEYWORDS
Physics, learning styles, engineering, digital learning, gender, Standards 11, 12

INTRODUCTION

The 2013 Report on the Pan-Canadian Assessment of Science, Reading, and Mathematics (Council of Ministers of Education, Canada (CMEC), 2013) states that Alberta leads the nation for science performance among grade 8 students. Unfortunately, the majority of these early scientists are not choosing to take physics in high school; enrollment in senior level, high school physics in Alberta has significantly lagged in comparison to chemistry and biology. In 2010 (NSERC, 2010) the number of diploma exams completed in Alberta in physics was only 21% of the total diploma exams written in the major sciences. Furthermore, the enrollment of women in Alberta senior level physics classes has hovered around 38% between 2005 and 2010 (NSERC, 2010). Since a credit in senior physics is normally required for entrance into engineering programs across the country, it is a concern that engineering programs are losing students as a result of the decrease of students in high school senior level physics. Consequently, the potential for females entering into engineering is also reduced as only a fraction of that 38% will choose the vocation.

Some engineering faculties in Canada are re-evaluating the current entrance requirements and the subsequent ramifications of compromising the high-school physics prerequisite, considering instead to teach the content in university. In a more feasible and collaborative approach, engineering outreach programs aimed at providing supplementary content in K-12 classrooms have become common place in an effort to combat the problem. In such programs, university faculty and students provide curriculum-based demonstrations or career talks in K-12 classrooms. Although these programs are met with some anecdotal success, they do not globally address the daily issues associated with traditional teaching methods in K-12 classrooms.

Thayer School of Engineering at Dartmouth College reported a higher number of female engineering graduates than males in June 2016 (Dartmouth College, 2016). One significant shift in the programming at Thayer was that it started placing an emphasis on group-based projects in introductory classes. These classes were structured to let students understand why they were studying the course materials, which appealed to many of the females in the program. This approach is a departure from the traditionally linear way to teach these materials. Like the Dartmouth College example, enrollment issues may be better addressed by changing how Physics is taught in high school.

Studies have shown that physics is perceived as difficult and irrelevant (Cech, 2013), (Cummings & Bain, 2006), contributing to the attrition of students who choose not to pursue engineering as a field of study. Studies have suggested that the traditional linear model used to teach physics is ineffectual and does not address the diverse learning styles of today's students (Rockland, et al., 2010) or the differences in engagement between genders (Catsambis, 1995). As was indicated at Thayer School of Engineering, a more global approach to understanding the whole problem, relating the theory to the daily lives of most people, can affect an overall increase in the diversity of students pursuing physics and ultimately, engineering.

For this study, interested parties of engineering university academics, K-12 Science, Technology, Engineering, and Math (STEM) researchers have partnered in an attempt to positively impact high school physics enrollment and outcomes. Specifically, an evaluation of the correlations between learning style, gender and attitude towards physics is investigated in detail. The results of this study will be used to help develop physics modules for a Digital

Learning Management System (DLMS) (MindFuel, 2017) and to explore its efficacy in increasing student outcomes in, and affinity towards physics. The DLMS is a hypermedia instructional tool developed for K-12 educators and students that will continue to evolve to meet the growing needs of educators as they, along with researchers, continue to pursue best practices in teaching and learning. It has been developed by a leading Canadian STEM educational not-for-profit organization.

This paper first presents the results of attitudinal and learning style surveys that were conducted in local high schools. The researchers used the Felder-Silverman Index of Learning Styles (ILS) survey (Felder & Soloman, 2001), widely used in understanding the learning styles of engineering students at the post-secondary level. The analysis of the results will focus on correlating students learning styles with gender and attitude towards physics. The DLMS will then be presented and evaluated as a tool that has the potential to overcome some of the barriers students face in enrolling in and succeeding in physics. Conclusions will be drawn regarding the potential benefits of the use of the DLMS in K-12 classrooms. Finally, the ongoing research activities being conducted will be presented.

GENDER-BASED ATTITUDINAL INSIGHTS INTO PHYSICS

A group of high school students in grades 10–12 (n=186) were engaged to determine what correlations exist between their interest in physics, learning style, and gender. The students were given a multi-part survey to self-report on gender, respond to attitudinal questions towards physics and complete the ILS survey. The attitudinal survey included questions such as "physics is hard", "physics is interesting", "I see physics in my everyday life" and "physics leads to rewarding career choices". Students responded on a five-point scale, ranging from Strongly Agree to Strongly Disagree.

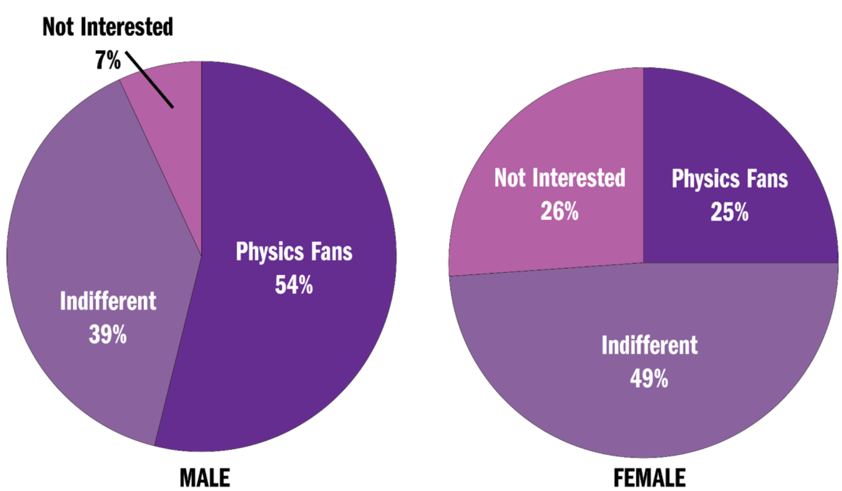

Figure 1- High school students' attitudes towards physics, segmented by gender

As shown in Figure 1, three distinct segments emerged from the attitudinal survey – physics fans, those indifferent towards physics and those not interested in physics. Gender disparity was evident between the physics fans and not interested group.

- Aproximately 2:1 male to female ratio for pro-physics
- Approximately 4:1 female to male ratio were not interested in physics
- Moderately higher female to male ratio indifferent to physics

LEARNING STYLE RESULTS

Apart from the Felder-Silverman learning model (FSLM) (Felder & Silverman, 1988), numerous learning style models have been proposed (Kolb D. , 1984), (Dunn & Dunn, 1978), (Myers I. , 1962). All models classify students according to scales that are defined based on the way learners receive and process information. The FSLM incorporates some elements of the Myers-Briggs model and Kolb's experiential learning model. The main reasoning for its selection in the DLMS evaluation is that it focuses on aspects of learning that are significant in engineering education.

The FSLM consists of four dimensions, each with two contrasting learning styles: Processing (Active/Reflective); Perception (Sensing/Intuitive); Input (Visual/Verbal); and Understanding (Sequential/Global). A summary of the learning styles is as follows:

- Active learners are those who learn by trying things out, enjoy working in groups. Reflective students learn by thinking things through, prefer working alone or with a single familiar partner.
- Sensing students are concrete thinkers, practical, oriented toward facts and procedures. Intuitive students are abstract thinkers, innovative, oriented toward theories and underlying meanings.
- Visual learners prefer visual representations of presented material, such as pictures, diagrams and flow charts. Verbal students prefer written and spoken explanations.
- Sequential learners demonstrate a linear thinking process, learning in small incremental steps. Global learners use a holistic thinking process, learn in large leaps.

Each of the 44 questions within the associated ILS survey is designed to place the learner's preference within each of the four dimensions. Depending on the answers to the questions relating to a given dimension, the learner can be described as one with a strong, moderate, or mild preference for one learning style over the other within a given dimension.
There have been extensive studies (Zywno, 2003) (Felder & Spurlin, 2005) that have aimed at validating the survey, and there is also a great deal of published data (Felder & Spurlin, 2005) (Mansor & Ismail, 2012) (Kolmos & Egelund, 2008) from test studies done in universities. Results of studies have shown that learning preferences vary among students in different fields of study. Within the four dimensions, engineering students tend to have preferences for Active, Sensing, Visual, and Sequential learning styles (Felder & Spurlin, 2005).

Results of the physics fans' and physics foes learning style profiles are compared to baseline engineering students' data in Figure 2. The baseline engineering student data (Felder & Spurlin, 2005) is a compilation of the results from ILS surveys conducted by engineering students at ten different North American universities. It is interesting to note that results of the physics fans segment (n=71) demonstrated a strong correlation in all four dimensions to this Felder profile for engineering students. More significant differences exist between physics foes and engineering students. Of note, physics foes tend to be more active, more intuitive, and more sequential learners than physics fans or engineering students.

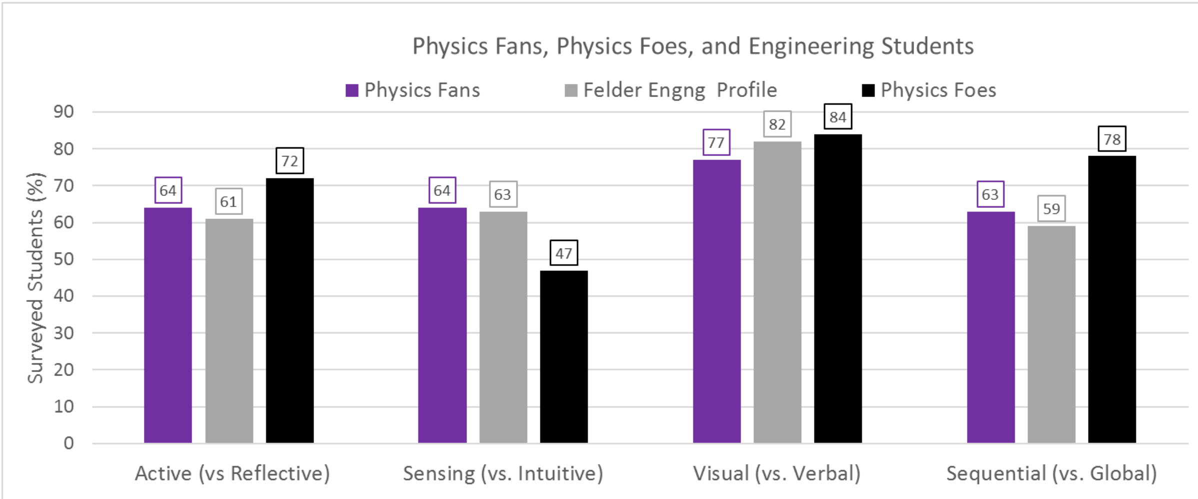

Figure 2 - Comparison of Felder's baseline profile for post-secondary engineering students to high school physics fans

The learning styles of the physics fans are broken down by gender and compared to the baseline Felder data in Figure 3. The chart suggests that on the whole the differences between the learning style profiles of male, female, and engineering students are not significant among physics fans. The largest difference in the profiles is that the female fans lean more towards sequential learning styles (as opposed to global) than the engineering students or male physics fans.

The learning styles of the physics foes are broken down by gender and compared to the baseline Felder data in Figure 4. Female physics foes are more Active, Visual, and Sequential than male counterparts and engineering students. Moreover, on the whole, female students tend to be more sequential learners than the male and engineering students, regardless of their preferences in physics.

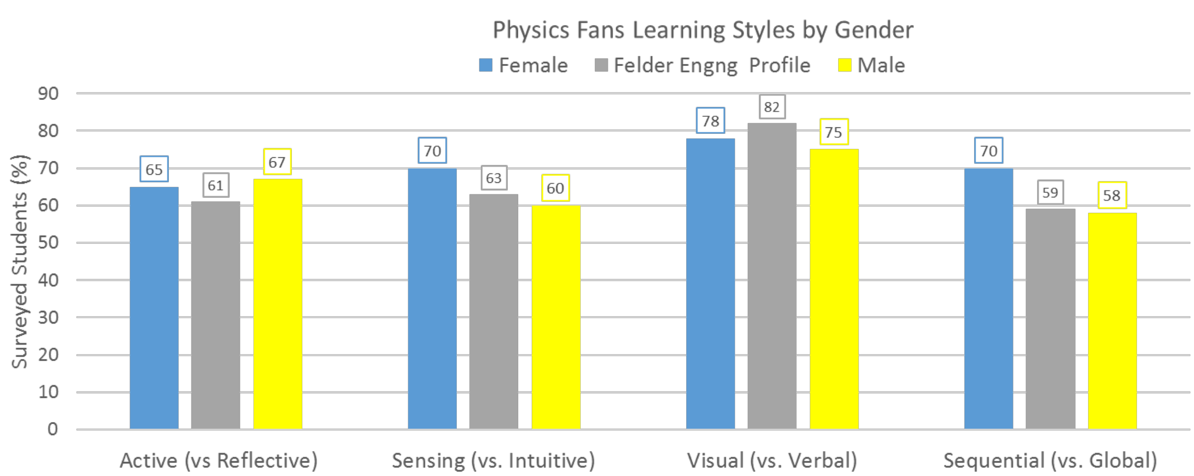

Figure 3 – Learning Styles of Physics Fans by Gender

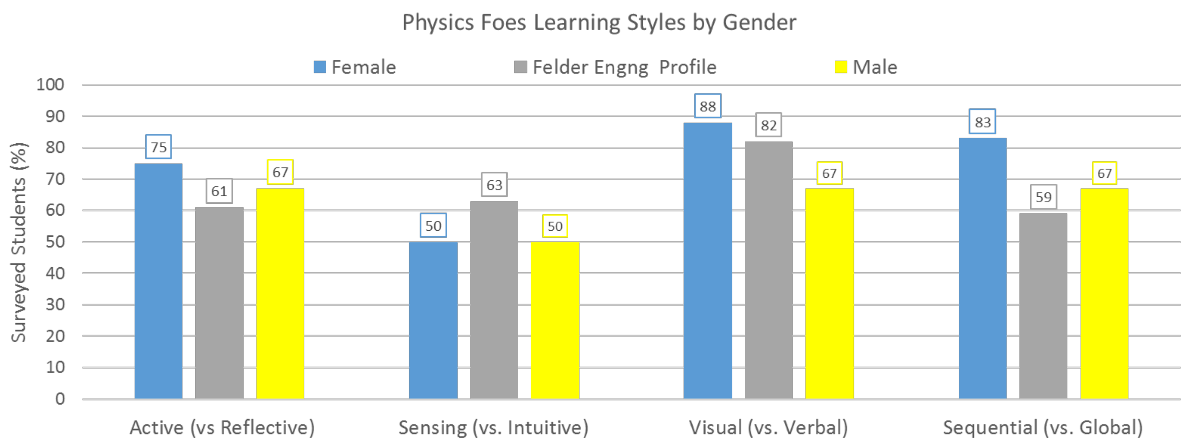

Figure 4 – Learning Styles of Physics Foes by Gender

Within the four dimensions, engineering students and physics fans tend to have preferences for Active, Sensing, Visual, and Sequential learning. This is in contrast to conventional instructional methods that tend to be more reflective (little room for active participation in lectures), intuitive (abstract theory delivered in symbols), and verbal (lecture delivery medium). These conventional instructional methods may not be addressing female learners that are less interested in physics who have an even stronger preference for active and visual learning than the others. This gap between the instructional methods and learning style preference in female students may be a contributing factor to the greater lack of interest in physics among female students than male students.

Although conventional instructional methods do address sequential learners, the lack of the big-picture emphasis often completely loses global learners. In order to address the mismatch between teaching methods and learning styles in university environments, Felder advocates a balanced approach to engineering education that incorporates experiential, active, collaborative, and student-centered learning (Felder & Spurlin, 2005) (Prince & Felder, R.M., 2006). This balanced approach to learning is of particular importance in the K-12 environment where students with diverse learning styles work together in classroom situations.

EVALUATION OF THE DLMS IN THE CONTEXT OF STUDENT LEARNING STYLES

Today's K-12 students are digital natives, never having known a time where technology was not integrated as a key component of their daily lives. It is therefore imperative that digital engagement forms a part of students' educational experiences, using its full capabilities to make content relevant and engaging. K-12 educational institutions are beginning to integrate such content and technologies into the classroom to achieve maximum learning impact. As technology enters the classroom in a more pervasive and consistent manner, digital tools have the potential for rapid integration. If developed and implemented thoughtfully such widespread adoption may serve to address some mismatches that may exist between teaching methods and learning styles.

The DLMS has been studied extensively, engaging a group of K-12 science teachers (n=87) to determine their needs and ensuring those needs were met throughout the development phases. In addition, students (n=153) were surveyed to determine what barriers existed, that if removed could more fully engage them in science learning. The students reported that traditional teaching methods such as lectures and reading static materials was considered dull or boring and that conversely, the ability to participate in independent learning opportunities would be more engaging. In response to these studies, the DLMS was developed on the basis of the following intents:

- Multiple entry points for both students and educators to allow for varied learning styles and differing abilities to achieve success on the platform.
- Create meaningful learning spaces both in the digital realm as well as in hands-on, design based activities based on the constructivist (BSCS 5E Instructional Model) (BSCS, 2007) educational approach to lessons in which students are first engaged or "hooked", then asked to explore-explain-elaborate-evaluate.
- Mastery learning (Kulik, Kulik, & Bangert-Drowns, 1990) in which student's approach and progress through the material at an individualized pace that supports meaningful engagement in curricular concepts.
- Build the opportunity for collaborative group work involving multiple perspectives; virtually connect subject matter experts working in STEM careers with students in the classroom to foster engagement.
- Leverage social media to allow for STEM learning beyond the classroom environment and foster dialogue around STEM topics
- Usage of digital platform to create community and connect users in remote areas
- Position real-world problems to students for them to develop innovative solutions

The DLMS was evaluated by 87 teachers and their students throughout Canada and the United States. Participants were provided access to the platform and asked to deliver certain content, after which, they were asked to complete a survey. Feedback from the first phase of the DLMS has been positive. Teachers interacting with the DLMS have indicated that "[it] provided [teachers] with new ideas and ways to teach science content", and that it "offered…students exposure to more career and real-life applications". The customizable lesson plans, interactive live events, mind map exploration, and videos and games that comprise the DLMS were all identified as key benefits to using the DLMS for heightened student engagement. One teacher said that, with the DLMS, "students are learning about science through interaction on multiple levels, not just listening and taking notes". Another teacher spoke to the value of the DLMS to engage students in immersive self-directed learning.

Ultimately, the DLMS provides a balanced approach to learning and addresses all of the diverse learning preferences discussed in the Felder-Silverman ILS. As a result, it has the ability to create an environment where science (and specifically, physics) concepts can be absorbed and made relevant to K-12 students who are in the progression toward their career choices. The DLMS is based on a foundation of interdisciplinary learning and provides opportunities for students who are engaged in chemistry or biology to encounter physics concepts when engaging in the open-ended Project-Based Learning modules. (Singh, Sun, & Weber, 2016).

SUMMARY AND CURRENT RESEARCH

The Attitude, Gender and Learning Style study demonstrates multiple distinct issues. First, gender plays a difference in attitude towards physics with 54% of male respondents indicating a preference for physics while, conversely, only 25% of female participants indicated the same. Only 7% of males were not interested in physics and the remaining 39% indicated indifference toward the subject. For females, only 26% showed a lack of interest in physics, while 49% indicated an indifference.

Second, although using a small sample size, students within the physics fans, or pro-physics group (n=71), correlated significantly to the learning style profile of engineering students as represented by Felder. Finally, a significant difference between engagement and learning style is evident in the Sensing / Intuitive and Sequential / Global dimensions. This provides an opportunity for the DLMS to provide learning experiences that address these two dimensions.

Ongoing quantitative evaluations of the DLMS and how it may support diverse student needs at the K-12 level to foster interest in physics are moving forward. Currently, this includes creation of activities and lesson plans for the grade 10 physics module that incorporate the balanced approach advocated by Felder. These activities, in conjunction with the Attitude, Gender and Learning Style study are being introduced to a larger student body in the fall of 2017-18. The research findings from these evaluations will help to build understanding among students, teachers, and academics, and it is the authors' aim to support and inform current best practices in education.

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BIOGRAPHICAL INFORMATION

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