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An Evaluation of a Digital Learning Management System In High School Physics Classrooms (Evaluation)

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An Evaluation of a Digital Learning Management System in High School Physics Classrooms

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Abstract

For this study interested parties, engineering university academics and K-12 STEM researchers, have partnered in an attempt to impact high school physics enrollment by evaluating a 21st century teaching and learning tool that can act as an alternative to conventional teaching methods. The Digital Learning Management System (DLMS) has the potential to change the perception of high school physics and, ultimately, to improve student outcomes. This learning tool has been developed by a leading STEM educational not-for-profit Canadian organization. The tool appeals to digital natives (high school 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.

This paper presents the results of the initial evaluation of the DLMS. After providing the details regarding its infrastructure, a critical evaluation of the platform and how it supports both teachers and students in a balanced approach to learning is presented. This evaluation draws upon the Felder-Silverman Learning Style Model (FSLM) in that elements of the DLSM are evaluated within the context of the models four dimensions. The initial results of a pilot project aimed at evaluating its effectiveness in schools is discussed.

Introduction

Consistent with the majority of provinces across Canada, the enrollment in senior level, high school physics in Alberta has significantly lagged in comparison to chemistry and biology. In 2010[1], 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[1]. 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.

Numerous studies such as those in Refs.[2-3] have pointed to an array of factors that contribute to the attrition of these potential engineering students. The most compelling of factor is the perception by these disinterested students that physics is difficult and irrelevant. The impetus behind this disengagement has been attributed to a “one size fits all”, linear model of instruction format that is often adopted in schools. Subjects are often taught independently (i.e. put in silos) with subject specific textbooks to support learning. Theory is often emphasized over practical application. It has been found in studies such as Ref.[4] that this traditional teaching style is ineffectual and does not address the diverse learning styles of students today. Furthermore, it has also been shown[5] that there are differences in engagement between genders that are not addressed by these conventional instruction methods.

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. Enrolment issues may be better 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 in a manner that appeals to their daily instructional needs and to the diverse learning needs of the students. Teachers would then be better prepared to independently deliver content in a manner that appeals to their daily instructional styles and to the diverse learning needs of the students.

Students in today’s K-12 space are digital natives, having been born in a generation that has always had technology integrated into their daily lives. Digital engagement is thus a critical component in making content relevant and ensuring the interest and attention of students in

K-12. As a result, digital learning tools are being integrated at all levels of education, leveraging technology for maximum learning impact. Furthermore, digital tools have the potential of rapid and wide integration into classrooms, and if developed and implemented thoughtfully, may serve to address some mismatches that may exist between teaching methods and learning styles.

For this study, interested parties of engineering university academics and K-12 Science, Technology, Engineering, and Math (STEM) researchers have partnered in an attempt to positively impact high school physics enrollment. Specifically, an evaluation is being conducted of a dynamic tool that can grow as teachers and researchers continue to define best practices in education today. This Digital Learning Management System (DLMS) has been developed by a leading Canadian STEM educational not-for-profit organization. The DLMS is a personalized hypermedia instructional tool developed for K-12 educators and students. The resources within the DLMS have been created in collaboration with subject matter experts from industry and academia; it is a STEM-based digital learning environment informed by curriculum.

This paper presents the results of the initial evaluation of the DLMS. Specifically, a critical investigation of the elements of the platform and how they support both teachers and students in a balanced approach to learning is presented. In the first section, the highlights of the DLSM including some of its key architectural features are described. In the context of the Felder-Silverman Learning Style Model (FSLM)[6] a critical analysis of the platform is conducted. Additionally, the initial results of a pilot project aimed at evaluating its effectiveness in schools will be discussed. Finally, conclusions will be drawn regarding the potential benefits of the use of the DLMS in K-12 classrooms, and outline the ongoing research activities being conducted regarding its evaluation.

The Digital Learning Management System

A group of K-12 science teachers (n=87) were engaged to determine their needs prior to beginning the evaluation of the DLMS. Needs such as "questions that challenge students to think more critically and drive inquiry", "lesson plans that can be adjusted depending on the outcomes of experiments", "project-based lesson plans that are built for hands-on learners", and "a community of practice where teachers can share their experiences teaching science" were identified as critical factors for classrooms today. Students (n=153) were also surveyed about how they could be greater engaged in science learning. These students indicated that activities such as listening to lectures or reading static material was "boring or dull"; a majority of students felt that having more independent learning opportunities would make learning about science more enjoyable. As such, the DLMS was developed with the intents listed below. It is on the basis of these intents that university researchers are providing research support that may help to identify key success criteria, and ultimately promote its market adoption.

- Multiple entry points for both students and educators to allow for varied learning styles as well as 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)[7] educational approach to lessons in which students are first engaged or "hooked", then asked to explore-explain-elaborate-evaluate.
- Mastery learning[8] in which students 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 infrastructure of the DLMS supports both teachers and learners; access of the platform is personalized based on user type. The teacher has the ability to access inquiry-based lesson plans from a peer-reviewed repository, can use these lessons as-is or customize any aspect of the plan, and can also create unique lesson plans of their own to share within the community. These lessons can further be disseminated to the teacher's students, and then track both student progress and achievement on the activities. In conjunction with the repository of lesson plans, the platform contains both formative and summative assessment tasks, which teachers again can use as-is or customize. Teachers can also leverage the digital tool to create their own assessment tasks to assign to students and share with the community.

In the student area of the DLMS, gamification is incorporated into the student experience through use of various game mechanics such as achievements (badges, avatars), experience and leader boards implemented both on a global level and on a resource level. Globally, a student can earn badges and unlock avatars through their progression through the lesson plans and activities. A class specific leaderboard tracks student experience relative to their classmates. There are also many digital games by learning area where students can create immersive experiences.

Depending on their preference, students can gain access to the content through two modes. In the first mode, content is accessed through a conventional more linear front. A student uses the search functionality and based on grade level, will access content on a hierarchical basis. Figure 1 is an illustration of the highest level of content that provides a gateway to all associated or sublevel content. The second mode provides access to a mindmap. Students access a topic, and the map provides links to all interdisciplinary content associated with the topic. Figure 2 is an illustration of the mindmap functionality of the DLMS. Each mode accesses the same content which includes computer games, animations and videos, self-assessments such as quizzes and interactive worksheets, and descriptions of hands-on experiments that can be performed in class or at home.

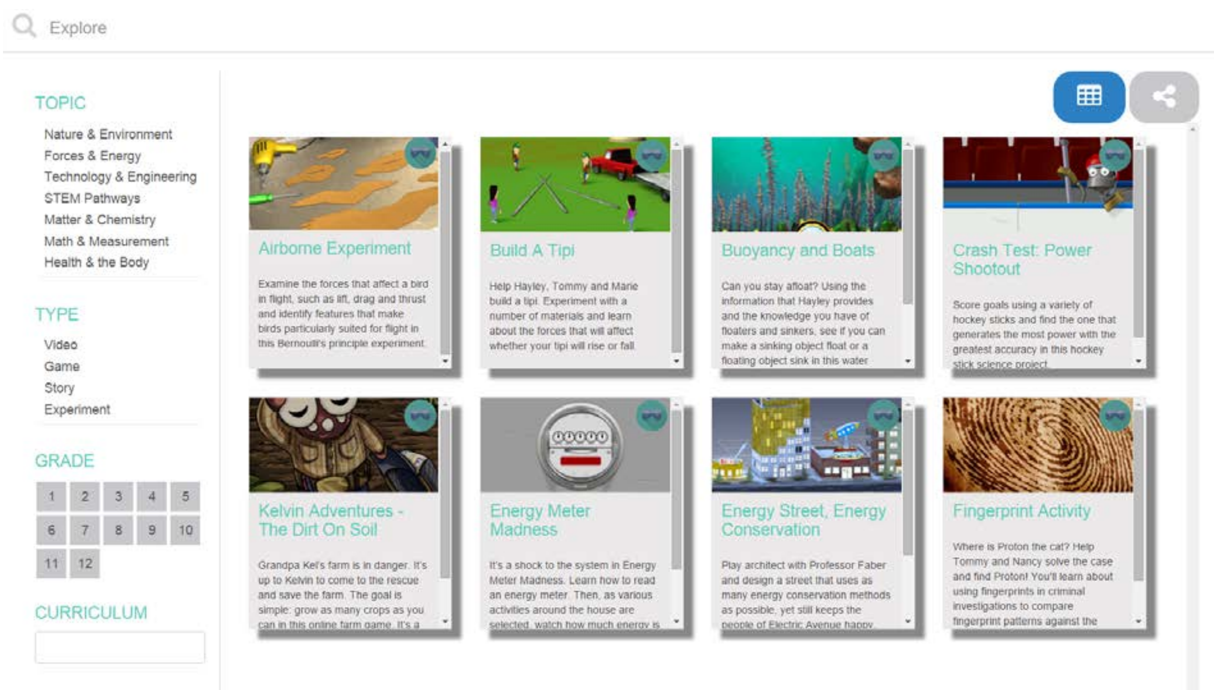

Figure 1. The “Search” functionality of the DLMS

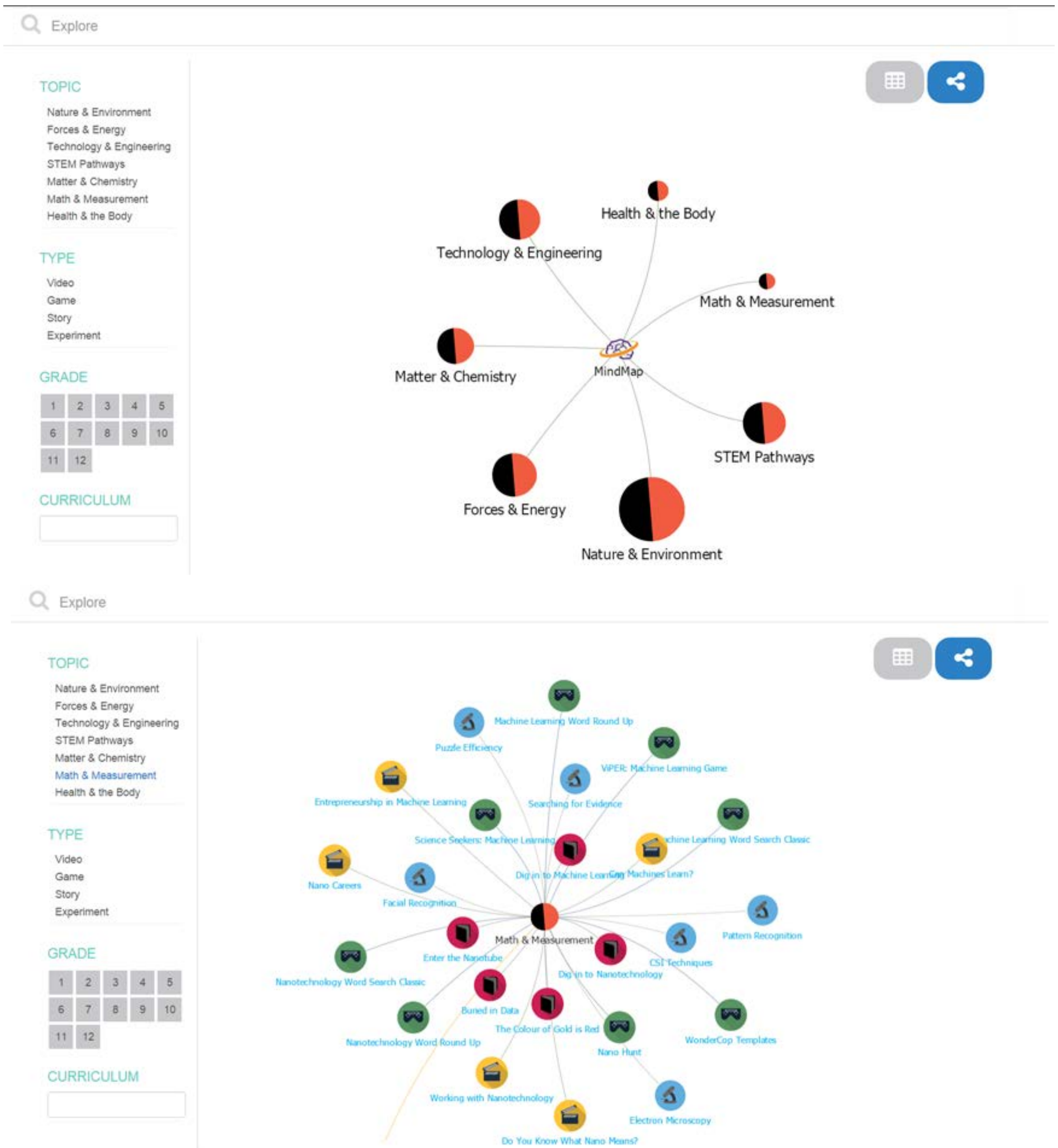

Figure 2: The Mindmap

The DLMS also has functionality for both teachers and students to engage in real-time conversations with experts in STEM. Collaborative learning occurs both between classrooms and these experts as well as among student groups that use social media during these live events to further explore the content being discussed. The live event functionality and its interactive nature was listed in our preliminary evaluation as one of the top four features of the DLMS.

Evaluation of the DLMS in the Context of Student Learning Styles

Apart from the FSLM, numerous learning style models have been proposed, including Kolb[9,10], Dunn and Dunn[11], and Meyers-Briggs[12]. 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 the Kolb's 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). The details of the dimensions can be found in Ref.[6]. In order to determine an individual's specific learning style, Felder and Soloman[13]developed the Index of Learning Style (ILS) survey. Each of the 44 questions within the 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, such as Refs.[14,15] that have aimed at validating the survey, and there is also a great deal of published data such as that in Refs.[15-17] 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[15] learning. This is in contrast to the conventional instructional methods within engineering departments that tend to be more reflective (little room for active participation in lectures), intuitive (abstract theory delivered in symbols), and verbal (lecture delivery medium). Although lectures address sequential learners, the lack of the big-picture emphasis often completely loses global learners. Research has also shown[18] that learning styles are different between females and males. 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[15,19]. 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..

The DLMS can be used in a variety of ways, both online and off-line, independently and in groups. As such, it supports a multitude of learners and diverse needs of both students and educators. The online activities in the DLMS typically support a reflective style; the DLMS is a platform for delivering digital learning resources that students consume as individuals and progress through at a personalized pace that permits time and space for processing. When e-learning is positioned as videos with follow-up questions for reflection, it engages those students who may tend towards the reflective style of learning. However, active learning is also promoted through the DLMS. Specifically, suggested activities within the platform provide support to active learners; the DLMS prompts students to work collaboratively in real-world activities to experiment towards finding solutions to suggested science-based problems. Teachers can guide the class to these activities to supplement the on-line reflective learning.

The DLMS engages both sensing learners who may inherently be drawn to math, science, and engineering subject matter and intuitive learners who prefer a less structured, open-ended, innovative learning environment. Specifically, DLMS combines multiple types of activities that are grounded in real-world scenarios so as to mimic both the logic-oriented, detailed nature of some work as well as the possibilities presented in multifaceted unique problems. Depending on the activities accessed, learners can strategically gravitate toward information presented in either a sensing or an intuitive manner.

The third dimension of learning style differentiates between visual and verbal (or auditory) learners. One of the great advantages of the DLMS and its digital delivery of curriculum content is that with multimedia, visual and auditory learners can be simultaneously engaged. Games, videos, and other digital interactives seamlessly integrate music, sound, narration, images, and written text in order to maximize the modalities in which students may be best captured with the material.

The fourth dimension of learning style as defined in the FSLM contrasts sequential and global learners. One of the defining elements of the DLMS is the aforementioned architecture regarding how digital resources can be browsed and viewed; users can select two fundamentally different methods for exploring the platform that are presented in parallel. The first is a sequential, linear "browse" capability that presents information in a progressively narrowed fashion (filtering results to gain greater specificity). The second is termed the "mindmap" and visually illustrates a holistic overview of the platform content that students can navigate based on category or keyword, honing in for specificity or zooming out to see all the connections amongst the various topics. The DLMS responds to the needs of both sequential and global learners in its framework, by addressing differing needs for seeing "big picture" versus a need to have information presented in a progressive sequence.

Although the DLMS addresses all of the diverse learning preferences discussed in the FSLM model, it does not directly provide any guidance to students regarding choices of learning modules. Advocates of adaptive digital learning tools such as in Ref.[20] have shown that students do not necessarily choose to engage in modules that are consistent with their learning styles. In the context of the DLMS, a sequential learner may end up in the mind map platform because something independent of their learning style draws them to it. If that is the case, the student may become discouraged, as they do in traditional classrooms, with their lack of knowledge assimilation. This easily implementable approach may be investigated for integration in the DLSM.

Summary and Current Research

The DLMS is currently in its piloting stage and for this purpose, classrooms within Canada and the United States (n=87) have been provided with the software for the purpose of its evaluation. After having used the platform to deliver certain content, they were given a survey to fill out. Initial 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, mindmap 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 addresses all of the diverse learning preferences discussed in the FSLM. 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 interdisciplinary nature of the DLMS additionally 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.

From the authors’ viewpoint, a balanced approach to learning physics in a multidisciplinary environment will definitely promote interest in physics in K-12 classrooms and thus, any research efforts aligned with its adoption will be of benefit to enrollment statistics. For this purpose, research aimed at a more quantitative evaluation of the DLMS is ongoing. Firstly, a survey that is aimed at determining relationships between learning styles, how they differ between grades, gender, and if they can be correlated with attitudes toward physics is currently being conducted at local junior and senior high schools. It is projected that the results of this study will provide needed insight into the connections among learning style, gender, and physics engagement and identify student needs for greater engagement (and subsequent enrollment) in physics classes. 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. 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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