THE NAME OF THE GAME: UTILIZING EXPERIENTIAL LEARNING IN THE CLASSROOM TO ENGAGE, EMPOWER AND REFLECT ON STUDENT LEARNING AND ASSESSMENT

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In the modern post-secondary classroom, there is a push for more experiential and active learning activities for students. A variety of benefits such as engagement, improved learning and self regulated learning have ensued with these different types of learning. Studies regarding these benefits have mostly centered on experiences carefully orchestrated by instructors, rather than experiences that were created by students under the guidance of instructors. Herein is a study of the benefits and efficiency, of the latter type of activity, which requires students to generate chemical puzzles in a large post-secondary classroom. The authors determined that not only is a puzzle generation activity possible, but students' reflections on instructor examples highlights the potential for learning and for a new form of assessment. Going forward, however, the study also shows more support and examples are required in future iterations of the puzzle framework, to help students create a meaningful experience.

This study began with the authors reflecting on experiential and active learning and how to incorporate them into the classroom based on potential career paths a student may take and how students learn. It is hoped that this study provides a foundation in the literature from which a growing gap between the instructor-centered design of experiential learning that develops critical thinking skills and student-centered learning may be addressed. The authors' focus was to create a puzzle-based activity. The questions of interest were: Could one create a puzzle-based activity that is a blend of experiential and active learning for large postsecondary classrooms and what are the benefits of doing so?

WHAT IS EXPERIENTIAL LEARNING?

Experiential learning is commonly defined as learning through doing or learning by experience (Gorghiu & Ancuta Santi, 2016). In Kolb's definition of experiential learning there are four significant elements; experiencing, reflection on the experience, conceptualization and experimentation (Kolb, 1984; Kolb & Kolb, 2005). The senses of touch, sight and sound are utilized to experience learning at each of Kolb's steps. The key element in the learning process is the reflection of the students on their learning. The reflection creates opportunities to generate meaningful discussion between students and instructors. A main driver of experiential learning is engagement (Andres, 2019). It has been observed that traditional methods of instruction to inform and teach students are especially difficult in the current digital age. The difficulty arises from the ease of access to information as well as how the information is delivered. This ranges

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from the challenge of addressing students' attachment to devices in the classroom to the craving for an instant gratification that many apps provide them. Students would rather select their own video on chemistry over listening to an instructor talk through their slides, and without an obligation to engage in discussion. Apart from engagement, experiential learning also provides improved student performance and learning, when the experience is positive it can enhance metacognition (Ng, Chan, Lei, Mok, & Leung, 2019; Prensky, 2002). One way of integrating engagement and learning into the classroom is through the creation of games and escape room type puzzles by instructors (Atunes, Pacheco, & Giovanela, 2012; Kucukkal & Kahveci, 2019; Ruben, 1999). The addition of engagement facilitates the formation of a bridge between instructor's learning objectives and a student learning course content.

Another desire to utilize experiential learning in the classroom stems from the skills that students can develop. Skills such as critical thinking, problem solving, communication and self regulated learning are also developed while students are learning through these games (Ng et al., 2019). Currently the problem with experiential learning activities of this type is that the instructor is in control of designing and constructing the experience of the students. Limited research has been conducted on students building their own experience and what the impact of the experience means for student learning or assessment.

WHY IS EXPERIENTIAL LEARNING ESSENTIAL?

Potential employers promote experiential learning. Graduates of a program are not only expected to have attained knowledge required for their job but, also a set of skills to complete their job. Some of the critical skills that organizations want are communication, problem solving, critical thinking and metacognition (Gorghiu & Ancuta Santi, 2016). The goal of postsecondary is not only to teach these skills to students, but also to ensure that they see the value of these skills. The struggle is that the majority of student grades are still currently determined using assessments that ask students to demonstrate knowledge and understanding over learning skills. Although learning a skill like critical thinking is important for demonstrating knowledge and understanding, how students use their critical thinking skills is not directly assessed as part of examinations. For example, questions are not graded by a rubric that evaluates a student's skill at applying conceptual knowledge as being either strong, satisfactory or limited, but rather focuses on did they follow the "logical" steps shown to them in class to deliver the answer to a problem. When students struggle with learning, they will fall back on memorization techniques when studying for exams. This default study habit is re-enforced when students recognize that they are not being directly assessed on learning a skill. Students are grade centric, meaning that if a skill or piece of knowledge is not being evaluated, they will shift their time and effort to only accomplish the tasks needed to obtain the grade (Hernandez, 2012). This mentality turns learning into set of tasks to be completed rather than an opportunity to learn and grow. The essential need for experiential learning is now evident. Learning skills such as critical thinking are inherently embedded within it, as well as giving students an opportunity to interact with real workforce situations/simulations (Pan, Seow, & Koh, 2018). The integration of experiential learning that focuses on employable skills into the classroom satisfies industry and engages students to apply their knowledge to their careers.

SHIFTING EXPERIENTIAL LEARNING FROM INSTRUCTOR-CENTERED FACILITATION TO STUDENT-CENTERED LEARNING

Instructor-designed activities that give students limited control over the experience are done altruistically, integrated to enhance traditional teaching methods. However, these activities designed by instructors lacked the engagement and the focus the students crave (Prensky, 2008). The reason for the disconnect is suggested to arise from instructors and students having different perspectives on course outcomes. How does one coalesce the two perspectives? Empower students through the incorporation of active learning strategies (Akınoğlu & Tandoğan, 2006). Akınoğlu & Tandoğan explained that within an instructor centric classroom, students are passive as they are told the information. An instructor-designed experiential activity suffers from the same short-coming. Active learning or student-centered learning requires students to engage with their own learning and develop a sense of responsibility for it. The sense of responsibility develops skills such as problem solving, critical thinking and metacognition.

As postsecondary graduates move into the workforce the majority struggle to judge and classify what they created at work (Thompson et al., 2017). Active learning offers an opportunity to practice judgement and classification. In utilizing an active learning approach, students are engaged and their ability for life long learning is strengthened. Students also experience greater success in their classes leading to subsequent job satisfaction (Wright, 2011).

MERGING EXPERIENTIAL AND ACTIVE LEARNING

A growing trend within the literature is the implementation of escape-room based puzzles and games within the classroom (Banister, 2017; Nicholson, 2018). The authors were drawn to how designing puzzles promotes deeper learning within students (Vos, Meijden & Denessen, 2011). This suggested that designing puzzles would be a viable experiential, active learning strategy. However, few studies were found in the literature that examined the relationship between student learning and student puzzle design. The majority that focused on games and escape room puzzles, were conducted at the high school level or in smaller postsecondary classrooms (Antunes, Pacheco, & Giovanela, 2012; Franco-Mariscal, Oliva-Martínez, & Almoraima Gil, 2015). It was also noted that implementing puzzles as an experiential learning activity with a student-centered focus does not come without a variety of diverse challenges.

The challenges include the design of games that are specifically aimed at meeting course learning objectives, cost of supplies and the long times associated with the set-up and presentation of the games (Mora, Riera, González, & Arnedo-Moreno, 2017; O'Donovan, Gain, & Marais, 2013; Prensky, 2008). The challenges become exponentially more difficult to carry out for postsecondary classrooms of 200-400 students. The main design challenge stems from providing effective guidelines to help the students create puzzles. While frameworks exist in the literature to help instructors design new assessments, very few exist to help students generate their own material. The desire to utilize digital technology to generate games for student engagement limits the number of frameworks developed for games. Due to the diversity in classroom conditions and cohort's reproducibility becomes a barrier in developing new frameworks for game design (Mora et al., 2017). With these challenges in mind the authors developed a framework to explore an experiential learning activity that put student-centered learning as the focus.

OUTLINE OF PUZZLE ACTIVITY AND FRAMEWORK

Over the course of the semester, 100+ groups of 3-4 students were tasked with designing and building two chemistry themed puzzles, which a group of their peers would then be asked to solve. Through the process of generating their puzzles students should demonstrate conceptual understanding as they troubleshoot how their peers would be solving the puzzles. They would also be co-developing employable skills such as communication, problem solving, critical thinking and meaningful learning. As a bonus, students would be actively involved in assessment, both as they created and engaged with solving other student's puzzles.

An important goal of the project was to devise a framework that provides students with support to create puzzles that effectively communicate learning objectives to their peers. The framework began with an opportunity for a cohort of 80 students, to experience two instructor-generated puzzles in a 50-minute tutorial session (Supporting Information (SI) Figures 1-4). The purpose of the first tutorial was to give the students ideas on what a puzzle contains and begin brainstorming about how the puzzles are centered around learning objectives. During the next tutorial students were placed in groups of three to four and given the task to begin to design two chemistry puzzles of their own, based on the course's learning objectives. To help with their design, time was given for the tutorial instructor to go through the framework of an instructor-generated puzzle, and for students to discuss their ideas with the instructor if desired (SI Figures 5-7). Half-way through the semester each group was then required to submit a written description or proposal for their puzzles. Additional resources to help students craft their puzzles and proposal included a puzzle proposal guideline and puzzle planning questions (SI Figures 8-10). The proposal gave everyone an opportunity to receive meaningful instructor feedback on their puzzle designs (SI Figure 11).

The students were advised to wait for their proposal feedback before constructing their puzzles, in case there were issues with the puzzles. Some of the issues that arose with students' puzzles were conceptual misconceptions, puzzles that could be solved without understanding concepts, and conceptual defects. Once the feedback on their proposal was received, students had 4 weeks to build their puzzles. In the final week of term students brought their puzzles to tutorial to be solved by another group of students. As students engaged in solving each other's puzzles, two worksheets were given out to try to assess students' understanding of the relationship between a learning objective of a puzzle and its solution. One worksheet involved students individually self-reporting on the design process of their puzzle. The second involved a group self-report as they solved another group's puzzles. In addition to the self-reported assessments, instructors also assessed each puzzle for a relationship between the understanding of a learning objective and its solution (SI Figure 12). With the above framework over 400 puzzles were constructed, solved, and assessed over the course of the Fall and Winter terms in the 2018-2019 school year. The assessments were conducted with approval from the University of Calgary Conjoint Faculties Research Ethics Board (REB13-0724).

FEEDBACK ON THE PUZZLE FRAMEWORK DEVELOPED

Using the framework outlined above, a large numbers of students at the postsecondary level were able to effectively create two chemistry themed puzzles based on course learning objectives for an introductory, postsecondary course. We believe the success was due to finding a balance between the degree of support (e.g. tutorial check-ins and proposal) offered to students and the workload on the instructors as they both supported and then assessed student work. The focal point for this balance in the project design was the large number of students. Of concern for the future is how to maintain this balance to adopt the changes highlighted by this study in future iterations of this framework.

Changes were informed by both instructors and students reflecting on the puzzles and the framework. From an instructor point of view, the framework appeared to have provided students with the basic criteria for the project as well as promoting the students' creativity. It also allowed for student-centered learning to take place. The main weakness identified in the framework was the instructors' assessment of a student puzzle to effectively communicate a course learning objective. Due to the diversity of topics as well as students' creativity in designing the puzzles, it was difficult to devise one rubric to accommodate all the important criteria. A rubric was developed that focused on the effectiveness of a puzzle to communicate a learning objective and its level of interactivity. The assessment was limited as it did not involve the instructors taking the time to actually solve the puzzles. Instructors had only twenty minutes to evaluate twelve different puzzles as well as take pictures for later reference. Overall, instructors found that an experiential and active learning activity can be comfortably conducted at the introductory postsecondary level, but the intensity of assessment to evaluate student learning is high, and further modification is required.

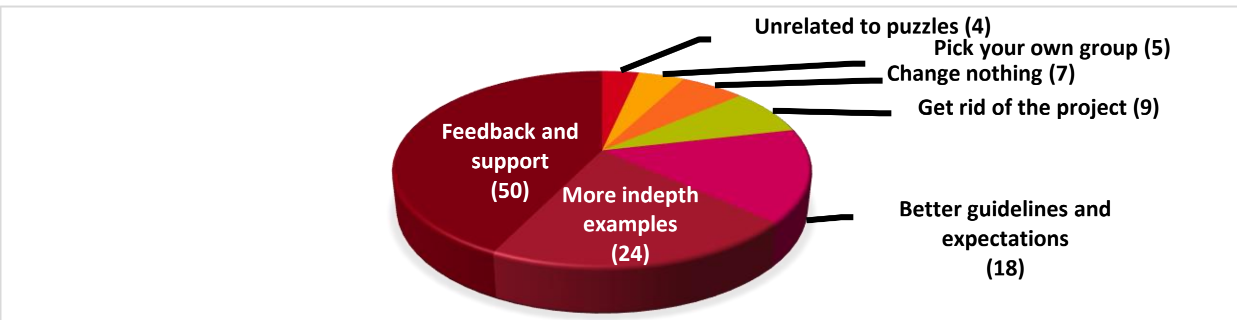

Figure 1. Summary of students' written response reflections on the puzzle project. The question asked to the students was: What other resources/feedback opportunities would have been helpful to design your puzzle proposal? Each number indicates the number of times students mentioned a concern in their specific responses. These categories were created using grounded theory based on students' responses.

Students' reflections on the project helped reveal the benefits of running this type of activity. The results above were collected as a written response question on a survey. Students were not unhappy about the project itself and it was considered engaging. The strong message from the students was that more feedback and support regarding puzzle design is required (Figure 1). Going forward, to address student concerns regarding feedback, more opportunity (15 minutes biweekly for three more weeks) to work on and discuss their puzzle design will be added to the framework. To increase support for students during puzzle design, more varied and in-depth puzzle examples will be available as guides. There is a cautionary note however; though it is simple to come up with more instructor puzzles, it was observed that students copy the style of the instructor puzzles. For example, one of the instructor puzzles on the topic of kinetics involved using coloured blocks for clues (SI Figure 7). Students were required to match the clues to reactions then place the reactions in increasing kinetic order. The students did not repeat the learning objective but 30% of the groups incorporated coloured blocks into their own puzzle design. More specifically, students used the clues on blocks to identify the acidity of products for a reaction then required that these reactions be ranked for increasing acidity. To be faithful to the concern voiced earlier in this paper (that assessments do not ask students to demonstrate learning skills) students will be directed to see a critical thinking pattern behind how varied styles of puzzles were crafted. This direction will ensure in future iterations that students are directed toward understanding over copying instructors' puzzle designs.

CONNECTION BETWEEN STUDENT LEARNING AND PUZZLES

There were two opportunities to look for benefits related to student learning during the term. The first opportunity was during the first week of the semester, when students solved instructor-generated puzzles. The second opportunity was at the end of the semester, when the student-generated puzzles were being solved. Due to the complexities of having 200 student puzzles based on 43 different learning objectives, trying to examine the benefits related to instructor puzzles was much easier. Students were asked to identify the learning objective of the first puzzle they solved. There were two different ones, which focused on the high school concepts of buoyancy and density. Figure 2 shows 97% of students were able to identify the learning objective and solve the puzzle. Students were moved to different groups on the day of the activity when their group members were missing. The shuffling of group members is attributed to the 7% difference between the two learning objectives presented to students.

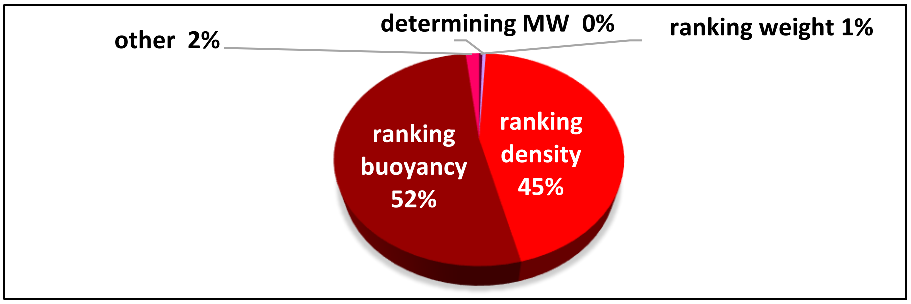

Figure 2. Identification of instructor puzzle learning objectives (n = 221). Survey was given to students immediately after experiencing the instructor puzzles based on either buoyancy or density.

CONCLUSION

Early in this project the authors believed that students should have a different learning experiences during puzzle designing and solving. This belief arose from instructors' comparing their experience in crafting the example puzzles with their observations of how students solved those puzzles. Support for this observation came from a study where students' design of a computer game had a larger impact on learning over students who just played (Vos et al., 2011). Students' reflections on the design experience of the puzzles described action words that were associated with skills higher up in the levels of Bloom's taxonomy (Wood, 2004). Student's solving other students' puzzles described action words that were lower on Bloom's taxonomy. The difference in actions suggest that using puzzle design supports a deeper level of learning while solving puzzles relates to more surface learning. This is currently being studied in much greater depth.

So at the end of this study where do we end up? Implementing experiential learning within the classroom is beneficial, however, not all experiences are created equal. With instructors dictating the focus of an experiential learning activity, students are more passive in their learning because they are not actively involved in designing the activity. When experiential learning is combined with active learning, students engage with an activity as well as taking responsibility for their own learning. The project described here gives students a choice on what learning objectives to focus on and how to effectively communicate these to themselves and their classmates in the form of puzzles. The developed framework shows that a blended experiential and active learning activity dealing with puzzle design can be conducted efficiently in a large introductory course. Due to the intensity of assessment involved in evaluating student learning further modification is required. The reflections of the students make it clear that further support and examples are needed to increase student understanding of the relationship of puzzle design to course learning objectives. There is a self-reported level of student engagement, and suggestion that the students are directed to a deeper level of learning. Based on these results, implementing student-generated puzzles is perhaps a path forward not only for stronger student learning but a chance to renew and re-tailor current assessment methods.

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