Qualitative Proposal - Gamification

Project #2 Dr. Carnahan

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Introduction

Thanks to the many different Science, Technology, Engineering, Mathematics (STEM) professionals and their innovations and inventions, our lives are made easier and more engaging on a daily basis. Have you used an app on your smartphone to play game or order a coffee to collect reward points? This type of engagement with technology know as gamification, impacts almost every aspect of our lives. But are we preparing enough students of all types to pursue STEM professions? It depends. The United States Department of Labor & Statistics Monthly Review (2015) reports that STEM professions are at both a surplus and in crisis depending on the STEM occupation (Yi, 2015). While there are a surplus of tenure-track Ph.D.'s for faculty positions there is a lack of qualified Ph.D.'s for nuclear engineering or jobs like cybersecurity and electrical engineers. The issue, however, is that there is still a lack of diversity, in all STEM professions, specifically for women and underrepresented minorities (Bidwell, 2015; Radu, 2018). According to Pew Research Center *Social & Demographic Trends* (2018) the diversity of the workforce varies widely, specifically for women and minorities. According to a report by U.S. News (2015) the workforce is no more diverse than it was fourteen years ago and while women have made significant gains in STEM occupations they still work primarily in healthcare fields, not in computing or engineering fields. Finally, Black and Hispanic professionals remain underrepresented in STEM fields overall (Radu, 2018). The need to retain underrepresented students who have entered college to pursue STEM fields needs to be addressed.

Statement of the problem

Underrepresented minorities (first-generation college students, college students who have been inadequately prepared (Sagenmüller, 2018), Black and Hispanic students, and women) may need additional support in order to stay at their institution (retention), improve graduation rates of underrepresented STEM students. The addition of gamification elements in STEM courses may be a way to not only engage and (intrinsically) motivate students, but build community among STEM students to improve retention and graduation rates.

Need and value

While college students who enter college and plan to major in a STEM field may be intrinsically motivated and hardworking they may need additional support to succeed at the college level and to graduate. These students may find college-level STEM courses even more challenging in a number of ways. STEM classes are more challenging and deliver a lot of dense, technical material and may be delivered in an unengaging manner. Students may be unaware of the support systems the college offers to support academics as well as help to build a community of like-minded STEM students. Without these supports, students may withdraw from not only their STEM major but from college all together. Academic and social support, when provided consistently, may improve student self-efficacy, motivation, and retention of STEM students (Banfield & Wilkerson, 2014). The Department of Education's report, *STEM 2026: A Vision for Innovation in STEM Education* reports on six areas in which to improve STEM teaching and learning "to ensure the engagement and success of the full diversity of the nation's learners" (p. i) and focuses on six different components:

- Engaged and networked communities of practice (COP)
- Accessible[8] learning activities that invite intentional play and risk
- Educational experiences that include interdisciplinary approaches to solving "grand challenges"
- Flexible and inclusive learning spaces supported by innovative technologies
- Innovative and accessible measures of learning
- Societal and cultural images and environments that promote diversity and opportunity in STEM

This study will focus on the following three aspects of the report as they relate to higher education 1) communities of practice 2) innovative and accessible measure of learning and 3) societal and cultural images and environments that promote diversity and opportunity in STEM. Preparing and supporting higher education students in the pursuit of STEM careers will help to increase retention and graduation in underrepresented populations.

The purpose of this qualitative grounded study (Creswell, 2018) will be to understand the impact of the addition of gamified elements in an introductory *Careers in STEM* course will promote the retention and graduation rate of underrepresented minorities at a diverse, moderate size, urban university in New Jersey. At this stage in the research, gamification will be generally defined as "the application of typical elements of game playing (e.g., point scoring, competition with others, rules of play) to other areas of activity, typically as an online marketing technique to encourage engagement with a product or service" (gamification, 2018).

Research Questions

1. How do the addition of gamified elements in a ten-week *Careers in STEM* class affect the retention rates of underrepresented STEM students at a selective, diverse, mid-size university?
    a. How do the of the use of gamified elements in a ten-week *Careers in STEM* course impact the self-efficacy and motivation of underrepresented STEM students at a selective, diverse, mid-size university?
    b. How does gamification in a ten-week *Careers in STEM* course build a supportive community among underrepresented students of underrepresented STEM students at a selective, diverse, mid-size university?

Literature Review

The retention of STEM majors, especially underrepresented students, at the undergraduate level is paramount not only to diversify the workforce in years to come, but to fill STEM professions that will be lacking qualified professionals (Pew Research, 2018). Educational pedagogy in pre-K the middle school has seen increased student engagement and active learning through problem-based lessons, focusing on the attainment of 21st-century skills throughout all disciplines, as well as fostering individualized learning. However, high school and higher education have been slow to follow suit. Incorporating these methods into STEM courses at the higher education level pose a particular challenge.

One of the ways that might help to improve and maintain interest and support success in these challenging courses might be to incorporate gamified elements in STEM courses. The revision of such courses by adding gamification throughout these classes would serve to engage, motivates, and build a community of practice and peer support that may help to retain STEM college students. According to Pew Research Internet and technology (2018) only six percent of people aged nineteen to twenty-nine do not own a smartphone but one hundred percent own a mobile phone. Students use their phones as their primary form of communication (Biomed Central, 2017) Games not only create engagement but offer opportunities to engage with others in an enjoyable situation.

Gamified elements, or gamification, incorporate active learning (Pellas, N., 2014) 2), motivational situations while helping students identify and improve self-efficacy (Banfield & Wilkerson, 2017; Mah, D. 2016; Tan, J. & Sockalingam, 2015) and build peer-relationships along with social engagement. The creation of communities of practice (COP) further support this engagement (Gilliam et al., 2017; Lave & Wenger, 1991; Pallas, N., 2014). The combination of these gamified elements help to engage students both academically and socially all of which are important in the increased retention and graduation rates of students who are prepared to fill STEM professions upon graduation.

Active Learning

Active learning is not a new concept and can be traced to early educational pedagogical theorists like Dewey, Piaget, Vygotsky, and Papert. It involves students in self-directed learning which allows for students to construct their own meaning from their experiences. Constructionism, or learning through play is student-centered and self-directed as students seek to do what supports what they want to learn. Different from didactic instruction active learning often occurs through play (Banfield & Wilkerson, 2014)

A humans baby's first experiences with the world are filled with interactions between them and their mothers. Growing involves learning about the world around them and occurs as they are filled with wonder about their surroundings. On their own, and with the guidance of their caregivers, they explore the world around them (Machajewski, 2017). As students enter the formal education system in preschool or kindergarten students in engage in learning. Students are engaged and busy in creating their own learning as they make meaning from their surroundings (Ackerman, 2001). This does not stop when they leave the classroom they continue to explore and experiment to learn more about the world. As students grow older and move into higher grades and into a more traditional class, they do less "playing" and become less engaged in their own learning. There is a "lack of engagement in traditional courses, especially in introductory college courses" (Machajewski, 2017)

The ability to construct meaning while engaged in active learning experiences through play can best be explained using Kolb's *Experiential Learning Theory* (Banfield & Wilkerson,

2014) as *Figure 1* shows, this theory shows how the learners go through dynamic steps in which they are assessing their learning (metacognition) in order for them to proceed through the game.

This dynamic process of participating is what makes using game-playing or gamification of classes interesting. Gamification is active learning, which is student centered, involves play, has self-directed opportunities that allow for students to learn through their experiences (Arnold, 2014; Banfield & Wilkerson, 2014; Tan & Sockalingham, 2015). Additionally, active learning has shown to significantly improve academic results and student engagement (Machajewski, 2017).

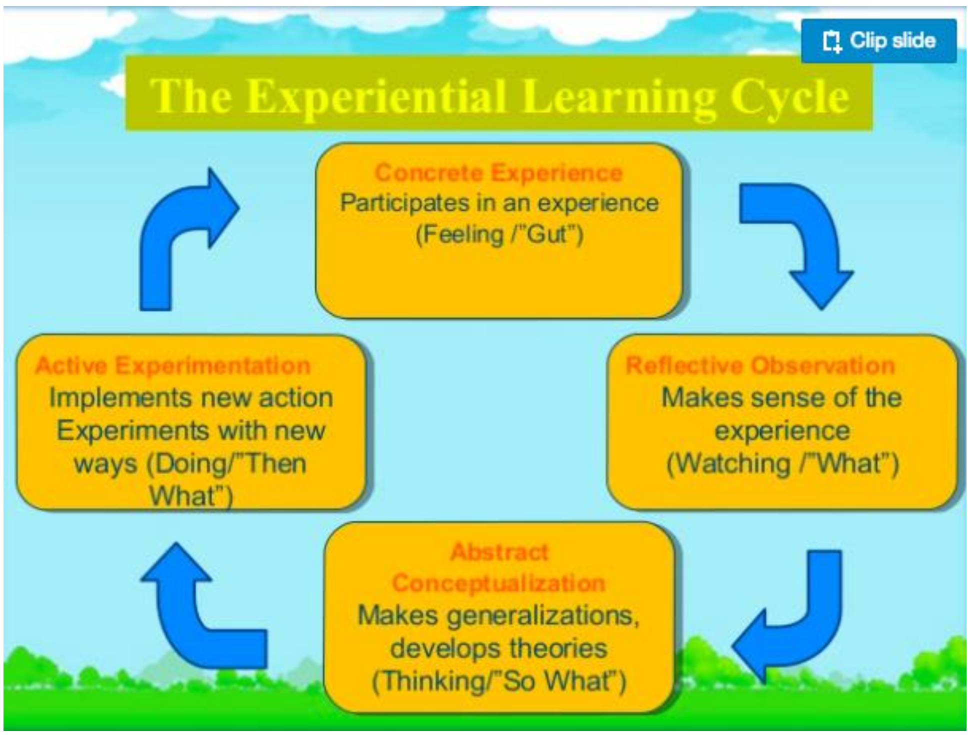

Figure 1. Kolb's Experiential Learning theory

Motivation and self-efficacy

Students who are able to construct their own learning are not only engaging in 21st-century skill building (collaboration, creative-thinking, communication, critical thinking) but tend to have tend to have higher intrinsic motivation, higher self-efficacy and are more apt to engage in lifelong learning (Arnold, 2014; Lee, et al., 2016; Machajewski, 2017). While motivation is a complex issue of motivational theories, learning theories, and emotion theories extrinsic rewards offered within games (such as digital badges, points, position on a leaderboard) incentivize learners to engage in positive behaviors (Chugh & Shields, 2017). Not only are students motivated by having fun playing the game, but the promise of rewards and the interaction with others in a virtual world can be a catalyst for continued engagement and learning.

Many different game elements support educational pedagogy. Design principles that encourage continued participation in games incorporate techniques that hold the players attention, offer relevance to the player, build confidence in a situation where it is ok to fail, and give players satisfaction. These characteristics encourage student persistence which is a trait that is especially important when participating in challenging STEM courses (Mah, 2016). These processes help the player to gain insight during the learning process as they optimize learning as supported by Kolb's Experiential Learning Theory. Many of the strategies that help to reinforce motivation and self-efficacy in education include (but are not limited to) immediate feedback, scaffolding, mastery, social connection, player control, and progress indicators. These not only engage students in active learning but serve to improve motivation and self-efficacy while creating supportive peer relationships (Lee et al.,2016; Mah, 2016; Shields & Chugh, 2017).

Communities of Practice

Working actively with other students within a specific STEM course whether it is completing a class assignment together, working collaboratively to come up with the solution to a problem or connecting socially outside of class offer opportunities for STEM students to help place value on their new STEM community. Students who come together because of similar interest, proven STEM talent, and similar context find peer support in this kind of social community (Ackerman, 2001; Gilliam et al., 2017; Lave & Wenger, 1991). The nature of games as described by Arnold's paper on Gamification in Higher Education (2014) not only create engagement, are enjoyable, attribute to strengthening skills and changing behavior, but can be engaging socially, especially when the game is collaborative. The ability to connect in an experiential event an allows students to think more deeply, learn from their peers, and relate to real-life experiences or situations. This social connection through collaborative gamified class material will have an overall positive impact on students, and the beginnings of a community as they share experiences (Lave & Wenger, 1991; Tan & Sockalingham, 2015)

The use of gamification or gamified elements in college STEM courses have the potential for this group of STEM students to have a community in which they can rely on an use to support each other throughout their process of learning at the college level. The difference of didactic instruction versus active learning with peers fosters real life relevance for students (Arnold, 2014; Lave & Wenger, 1991; Pellas, 2014) offering a social connection that motivates student learning.

The retention of STEM majors, especially underrepresented students at the undergraduate level is needed to fill STEM fields that will lack qualified professionals. The gamification of college level STEM courses may the perfect opportunity to help improve student engagement, motivation, self-efficacy as well as create and sustain a supportive community of practice. While the consistent practice of appropriate pedagogical methodologies in gamification of STEM courses has not been firmly established at the higher educational level, the benefits and positive impact of this practice is supported with growing research. The use of this active learning strategy looks hopeful in the retention of undergraduate STEM students .

Methodology

This qualitative grounded study seeks to understand the nature in which undergraduate STEM students engage in active learning, are motivated to learn, participate in social interactions through the gamification of an introductory STEM course, and how the gamification may impact their retention as STEM students. The theoretical framework of constructionism through active learning, the development of motivation, and the support through the creation of a community of practice (Creswell & Creswell, 2018). Grounded theory not only offers the ability to conduct data collection and analysis simultaneously but will allow for the evaluation of how (the addition of) gamification might work to improve the retention rates of STEM students by drawing on narrations and descriptions from students that may help deepen the understanding of this intervention (Patton, 2015). Grounded theory supports a constructivists worldview which aligns with the three frameworks; Barron's Learning Ecology framework which emphasizes transferring learning from one context to another (as with gamification of a course); Lave and Wenger Social Community (Community of Practice) and the direct engagement and practice within a social community; Chang's Socio-contextual framework that fosters real-world relevance, includes hands-on activities, and interfaces with technology (Gilliam et al., 2017).

Population & Sample

A convenience sample of STEM undergraduates enrolled in the Summer STEM Academy will be contacted as potential participants in the study to understand the impact of gamification of a *Careers in STEM* ten-week summer class may have on their retention in the University STEM program. Approximately sixty students are projected to be enrolled in the 2019 summer program as of the writing of this paper. Students will be invited to participate in study of the impact of gamification during the gamified orientation activity in May of 2019.

Procedures

1. Work with appropriate faculty to gamify parts of the *Careers in STEM* ten-week summer course and obtain IRB approval for research study.
2. At the gamified orientation in mid-late May 2019, students who be introduced to the research project and asked to voluntarily participate. The consent form will be read aloud and all questions answered and then students will be asked to participate in the research study. Students who consent to the study will make up the sample population for the ten-week research study. Students may drop out at any time without penalty.
3. Once the orientation day is over, any necessary communication related to the study will subsequently be conducted through their preferred method, as needed, throughout the duration of the study. These methods may include (but are not limited to) any combination of 1) email to their school address 2) notification text(s) 3) reminders through the school's LMS and 4) other notifications that may be requested by student participants. Expectations as to the extent of participation will also be indicated (See below)
4. Potential instruments may include
    a. An initial closed-ended STEM interest and career survey (to be determined and permission to be obtained, in writing, once instruments have been identified)
    b. A close-ended survey on demographic characteristics (to be determined)
    c. Open-ended survey within student course evaluations
        i. created with the professor and given after each gamified element is implemented
    d. In-depth interviews (7-10 interview questions)

i. Describe how the use of gamification impacted your learning in this class.
ii. Share a time when you were persistent in getting something done.
iii. What qualifications might support someone pursuing a STEM career?
iv. Describe your strengths and supports that help you when you are struggling.
v. Describe a time when you decided not to attempt to solve a problem. What where your thoughts about why you did not pursue it?
vi. Describe your strengths and weaknesses when faced with a situation in which you must make an important decision.

e. Focus groups - students would be asked open ended questions (initial baseline data) (in an anonymous Google Form):
   i. Describe your favorite college class. What makes it your favorite?
   ii. Describe your least favorite college class. What make is your least favorite?
   iii. What have you done in other learning situations (this can be in or out of a school environment) that made you want to keep working?
f. Artifacts from the summer program
   i. Any notes, handwritten, computer or other interaction with the course material that resulted from gamified activities

Collection of data from all of these instruments will allow for the collection of data to the point of saturation as well as having enough data to triangulate the findings (Creswell & Creswell, 2018; Patton, 2017).

Equipment

Equipment needed for the gamification of the course is dependent on the nature of the gamified elements that will be designed and implemented. Students should have access to any materials in class and will be provided by the college. They will be able to use their own personal mobile devices when not in class.

Potential risks for failure

When implementing new techniques or educational designs, especially where technology is involved there is the risk for something to go wrong. If at all possible a pilot study of any of the gamified elements during a spring STEM course might help to refine the addition of these elements. Something as basic as not having enough equipment, the right kind of equipment, could all risk failure of the implementation of the gamification. Student participation may be inconsistent. Ideally all students would be able to participate in the initial questionnaires, the individual interviews and the focus groups but each student has a number of different variables that would affect their participation at any given time. Another issue that might arise is being able to connect the demographics with any anonymous survey. This would not allow for the ability to understand the relationship of the experience within certain demographics.

Study execution

Research Questions, Literature review	→	1. IRB approval
		↓
2. Initial Convenience Sampling of STEM SSA students (n=) Permissions obtained 3.communication preference obtained		
↓		↓

4a Initial closed-ended STEM questionnaire (from consent sample) (all students who give consent)	Compile data	4b Collection of closed-ended demographics (from consent sample)
4c Initial Open-ended written questions (all students who give consent)		4ci Initial (in-class) game evaluation
Data Analysis: identify themes, coding, memo writing		
Modifications and resubmission of IRB approvals if needed		
Theoretical Sampling		
4d In-depth interviews of all students (all students who give consent) (n=) Student1: -- Student 2: -- (etc)	Code themes	Note taking and memo writing from videotaped interviews for each student
4f collection of artifacts as available by participants	Code	Review images Memos about artifacts
4d In-depth interviews of all students (mid-course) (n=) Student1: -- Student 2: -- (etc)	Code themes	Note taking and memo writing from videotaped interviews for each student

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4d In-depth interviews of all students (end course) (n=) Student1: -- Student 2: -- (etc)	Code themes	Note taking and memo writing from videotaped interviews for each student
Final mapping of concepts, triangulation of data, further refinement of codes and themes		

Figure 2. - Illustration (map) of design study execution (Sbarini et al., 2011)

Timeline

January 2019 - April 2019	Gamification of STEM course - working with the professor of the course the addition of some gamified elements into the curriculum would be developed
End May 2019	Gamified Orientation - This is the third year new STEM transfer and current STEM students (admitted into the SSA program) will attend and participate in an orientation using gamified social scavenger app
June - August 2019 Beginning (June) Mid course (July) Final course (August)	Over the ten-week course researcher will conduct interviews, collect data 3 times - at the beginning of the program, at the 5 week mark, and at the conclusion of the course. Survey students after each new gamified elements is implemented (Google Form or Survey Monkey). Gather artifacts that relate to the students engagement as it relates to the gamified course material (screen images, student drawing, etc.)
August - September 2019	Analysis of Data

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