Implementing gamification in engineering bridge programs: A case study exploring the use of the Kahoot! application

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Abstract

This work introduces a case study in which the gamified application *Kahoot!* was implemented in an engineering bridge program. Students' Hexad player type is assessed to gain a better understanding of how their player type relates to their perception of application and the game elements employed. Gamification has shown great potential for improving the learning performance and motivation of students. Nowadays, there exist several gamification applications that facilitate the implementation of game elements in educational environments (e.g., *Kahoot!*). These applications allow educators to implement game elements, like Leaderboards and Points, into their learning activities. However, researchers have shown that a game element that improves the motivation and performance of an individual might not have the same positive effects on another. Moreover, while researchers have studied the effects of gamification in educational environments, they tend to overlook how students' traits confound the effects that game elements have on their motivation. In light of this, the authors present a case study in which the application *Kahoot!* is employed in an educational environment. In addition, students' Hexad player type, their perception of the game elements and the application are assessed. The results reveal that students felt motivated by the application. Students with a Hexad player type of *Socialiser* reported the Team-mode element as the most fun, while *Achievers* reported the element of Points as the most fun. In general, the Leaderboard was rated as the most motivating and the element of Time-pressure as the most frustrating. These results reveal the capability of gamification to improve students' motivation, but also indicate that individuals respond differently to game elements, which support the potential of personalized educational applications. Finally, the lessons learned and the insights gained from the students' feedback are presented to guide educators in the implementation of gamified applications, like *Kahoot!*

Keywords: *Gamification, Player types, Game elements, Personalization, Engineering Education*

1. Introduction

There has been an increased interest in gamification in the last decade[1–4]. Gamification is frequently defined as: "*the use of design elements characteristic for games in non-game contexts*" [5(p14)]. This means that gamification implements game elements (e.g., Leaderboards, Points) to motivate individuals to perform an action or behavior. Depending on the context and the designers' intentions, the objectives of a gamified application can vary widely. For example, the objective of a gamified application in an educational context might be to improve the learning performance of students by motivating them to review different class materials or participate in learning activities[6,7].

Educational gamified applications are an emergent paradigm that researchers and educators are implementing to engage students during the learning process[8–10]. Studies indicate that gamification can help improve students' motivation and performance in a variety of learning environments[11–15]. Nowadays, there exist several applications that facilitate the implementation of game elements in learning environments, such as *Kahoot!* (www.kahoot.com), *Socrative* (www.socrative.com), and *Quizizz* (www.quizizz.com). Figure 1 illustrates some of the functionalities of the *Kahoot!* application. In the gamification community, designers frequently develop applications based on a "*one-size-fits-all*" approach. With this approach, designers make the assumption that individuals are a monolithic group that when presented with a game element will react similarly[16,17]. However, researchers have shown that a game element that improves the motivation and performance of an individual might not have the same positive effects on another individual[7,18–20].

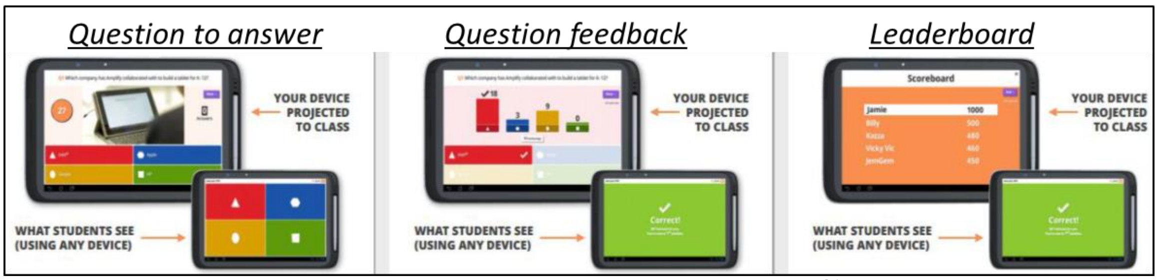

Figure 1. Illustration of Kahoot! extracted from Ref.[21]

Overall, researchers agree on the potential of correctly implementing well-designed game elements to improve students' motivation and performance[8–10]. However, most of the existing studies tend to overlook how students' traits confound the effects that game elements have on their motivation and engagement. Moreover, research shows that the perception and respond to game elements varies between individauls[22,23]. Due to the existing limitations, researchers are exploring the use of player type models to assess individual differences and advance personalized gamification[24–26]. Unfortunately, these studies only captured participants' perception of game elements without allowing them to interact with the elements in an application. Hence, human biases might affect the validity of the findings since before individuals are presented with the stimuli itself, it is challenging for them to be mindful of their preferences[27–29]. Moreover, these studies are not conducted in the context of educational applications. In light of this, the authors present a case study in which a gamified application is employed in an educational environment. Subsequently, students' player types, their perception of the applications and the game elements implemented are captured. This allows the authors to explore how students' player type relates to their perception of the elements implemented in an educational gamified application. A better understanding of this relationship could potentially guide educator and designers towards personalized gamification applications to improve students' learning performance.

2. Literature Review

Gamification has shown to improve students' engagement, motivation, and performance in wide varieties of educational settings. For example, Stavljanin et al.[30] indicates that their gamified online course helped improve motivation and learning outcomes of students. Likewise, the studies of Kim et al.[7,31] reveal that gamification of engineering activities can have a positive effect on students' motivation, engagement, and performance. Repanovici et al.[32] implements the

Kahoot! application to engage students with copyright literacy homework. Their students reported that the application was a good pedagogical method and adapted to their generation. Similarly, Cutri et al.[21] indicates that students had a positive attitude towards the application *Kahoot!* Furthermore, Tan and Saucerman[13] study of Student Response Systems (SRS) reveals that the gamified application *Kahoot!* improved students' motivation and enjoyment, compared to a non-gamified SRS application. With the *Kahoot!* application students collaborated more than with the non-gamified application. However, their likelihood to complete a problem or provide the correct answer did not increase. As stated by Dicheva et al. "*gamification has the potential to improve learning if it is well designed and used correctly*" [8(p83)]. In their literature review, Dicheva et al.[8] conclude that while most of the papers reviewed supported the value of gamification in educational contexts, more empirical studies are needed to better understand the effects of gamification on students' motivation. Similarly, both the literature reviews of Looyestyn et al.[9] and Khalil et al.[10] found that most of the studies to date support the value of gamification in online educational environments. However, they also reveal that more empirical studies are needed to better understand how gamification can sustain students' engagement.

Designers frequently develop gamified applications based on a "*one-size-fits-all*" approach. In this approach it is assumed that individuals are a monolithic group that when presented with a game element will react similarly[16,17]. However, research reveals that treating users as a monolithic group is not an optimal design approach [33,34]. Researchers identify this as a reason why studies that implement a "*one-size-fits-all*" design approach often reveal mixed findings regarding the effectiveness of their gamified applications[1,35,36]. For example, Fitz-Water et al.[37] reveals that students' behavior in the experimental group (i.e., gamified application) was not significantly different from the control group. Furthermore, their results show that students tended to enjoy different elements of the applications. Multiples studies indicate that students perceived and enjoyed game elements differently[7,18,19]. For example, the results of Kim et al.[7] reveal that 80% of students reported being motivated by the game elements of *Ranking* and *Score*, while only 50% reported the elements of *Badges*, *Feedback*, and *Avatar* as fun. Similarly, while Bullon and Martinez[14] reported that in general students had a positive perception of the gamified application used, some of the students did not enjoy the *Competition* element implemented. These findings are supported by one of the most frequently used theories within gamification research, the Self-Determination Theory (SDT)[38,39]. SDT states that humans are motivated if their psychological needs for (i) *autonomy*, (ii) *competence* and (iii) *relatedness* are satisfied. Though, the fulfillment of these psychological needs does not rely on objective judgment. Instead, it depends on individuals perception[40].

The SDT theory is in line with multiple studies that reveal the value of personalized learning systems in improving students' performance[41–43]. However, the development of personalized learning systems is one of the grand engineering challenges of the 21st century, according to the National Academy of Engineering[44]. Due to individuals' heterogeneity and the advantages of personalized applications, researchers are starting to explore how individuals with common player type attributes perceive and interact with gamified applications in order to advance personalized gamification[25,26,45]. Player type models are intended to capture individual traits that could help explain the differences between individuals' attitudes toward game elements and game applications[46]. Marczewski[47] introduces the "*Gamification User Types Hexad Framework*" to assess individuals' preferences for game elements in the context of gamification. The framework introduces six player types, as shown in Table 1. Tondello et al.[33] presents a questionnaire to assess individuals' preferences based on the Hexad player type framework. In a recent study, Tondello et al.[48] validated the questionnaire with data from 1,681 participants from different backgrounds and nationalities. Their results support the validity of the questionnaire and indicate that *Philanthropies*, *Free Spirit*, and *Achiever* are the most prominent player types. Orji et al.[49] employs storyboards to explore how individuals with different Hexad player types perceived different game elements of a health and wellness application. In a similar study, Tondello et al.[18] explores how individuals with different Hexad player types perceived commonly used game elements. While these studies provide value guidelines to advance personalized gamification, they captured participants' perception of game elements without allowing them to interact with the elements in a gamified application. Hence, human biases might affect the validity of these results since before individuals are presented with the stimuli itself (e.g., game element), it is challenging for them to be mindful of their preferences[27–29]. Furthermore, studies indicate that the effects of a game element may differ if implemented in an application[20,50]. Finally, none of the previous studies have focused on educational applications, even though it is one of the areas in which gamification is most widely used[10,51,52]. In light of this, the authors present a case study in which the gamified application *Kahoot!* is implemented in an engineering summer bridge program. Students' feedback and perception of the application and the game elements implemented are analyzed. Students' Hexad player type is also assessed to gain a better understanding of the relationship between students' player type and their perception of the game elements and the application. A better understanding of these relationships could help designers advance personalized educational gamification and improve students' learning performance.

Table 1. Summary of Hexad player types extracted from Ref.[50]

Hexad Player type	Description
(i) Philanthropists	These players are motivated by purpose and meaning. They show altruistic behavior and are willing to give without expecting a reward.
(ii) Disruptors	These players are motivated by change. They have a tendency to disrupt and challenge the system. They often test the limitations of the system and try to push it further.
(iii) Socialisers	These players are motivated by relatedness. These players want to interact with other players and create social connections.
(iv) Free Spirits	These players are motivated by autonomy and self-expression. They like to have a meaning, freedom, act without external control, and explore within a system.
(v) Achievers	These players are motivated by competence and mastery. They seek to progress within a system by completing tasks or prove themselves by tackling difficult challenges.
(vi) Players	These players are motivated by extrinsic rewards. They will do what is needed to earn a reward within a system, independently of the type of activity.

3. Engineering Bridge Program Case Study

Summer bridge programs are frequently intensive multi-week experiences developed with the objective to improve the academic success and retention of an at-risk student population in postsecondary education[53,54]. Multiple studies have shown that this type of program helps improve the academic success of students[55–58]. Moreover, due to the growing research supporting the value of active-learning[59,60], researchers are starting to increasingly implement active learning activities into bridge programs[53]. However, studies also reveal resistance from students in regards to active learning[61,62]. In this work, the authors implement the gamified application *Kahoot!* as a Student Response System (e.g., clicker) with the objective to engage and motivate students with the course material and active learning exercises.

In summer 2018, the Center of Engineering Outreach and Inclusion from the Pennsylvania State University supported the *Jump Start* summer bridge program. This was a four-week program designed to support the academic success of current students who are in entrance-to-major classes for any engineering major. Participants attended math and physics classes Monday through Friday and lived on the University Park campus through the duration of the program. The results presented in this work are from the General Physics Mechanic section in which the gamified application *Kahoot!* was implemented. The section was composed of 18 students. However, the data of only 15 students that completed all the questionnaires are analyzed in this work.

During the first day of class, students were asked to complete the Hexad player type questionnaire presented by Tondello et al.[33] During each class, the *Kahoot!* application was used as a Student Response System to gather students' responses to the problems given as homework or as part of the different in-class activities. The in-class activities involved both solving problems in teams and individually. For the team activities, the *Team-mode* element of Kahoot! was used. This allows students to respond as a team while competing with other teams. The other game elements implemented were (i) *Points*: students were given a score based on the time it took them to select the right response, (ii) *Leaderboard*: allowed the students to see their raking score compared to other students, (iii) *Reward:* rewarded the top 3 scoring students with a "medal", and (iv) *Time-pressure*: students were given 20 secs to select their responses.

At the end of the program, students' perception of the *Kahoot*! application and the game elements implement was assessed via a series of questionnaires. The first questionnaire focused on assessing students' perception of the application. Using a 7-point Likert scale, students were asked to rate how strongly they agree or disagree (1: strongly disagree - 7: strongly agree) with the statements ***S1*:** "*I would like to continue using Kahoot! in the futur*e", ***S2***: "*Kahoot! motivated me to work in teams to solve the different problems*", and ***S3***: "*Kahoot! motivated me to learn physics.*" The second questionnaire focused on assessing students' perception of the different game elements. They were asked to select the game elements they perceived as the most and least (i) motivational, (ii) fun, and (iii) frustrating. The order in which the questions and the game elements (i.e., *Points, Leaderboard, Rewards, Team-mode, Time-pressure*) were shown to the students was randomized to reduce any possible order effects. Also, at the end of each class, students were asked: (i) "*What did you like most about today's class?*" and (ii) "*What did you like least about today's class?"*

4. Results and Discussion

The results indicate that students would like to continue using the application in the future, and felt motivated by the application to work in teams and learn physics (***S1***: M=5.87, Mdn=6, SD=1.13; ***S2***: M=6, Mdn=6, SD=0.37; ***S3****:* M=5.53, Mdn=6, SD=0.92). The results of the non-parametric Mann-Whitney U-test indicates that students' responses were significantly greater than the neutral response of "*undecided*" (i.e., M=4 in the 7-point Likert scale, p-value<0.001).

When evaluating their perception of the different game elements, the χ-square test reveals that students identified the game element of *Leaderboard* as the most motivating (7 out of 15, χ-square=10, p-value=0.04), and the game element of *Time-pressure* as the least fun (12 out of 15, χ-square=34.67, p-value<0.001) and most frustrating (11 out of 15, χ-square=30.67, p-value<0.001). While there was not enough evidence to indicate a statistical significance at an alpha level of 0.05, students also reported the game element of *Time-pressure* as the least motivational, *Points* as the most fun, and *Team-mode* as the least frustrating.

When assessing students' Hexad player type, the distribution of students was: *Philanthropist*=7, *Free Spirit*=4, *Achiever*=2, and *Socialiser*=2. This distribution is similar to the one found in recent studies[48]. The results indicate there was no statistically significant relationship between students' player type and their perception of the application. That is, independently of their Hexad player type, students reported they would like to continue using the application in the future, and felt motivated by the application to work in teams and learn physics. However, when looking at their perception of the different game elements, the χ-square test results reveal that there was a significant relationship between students' player type and the game elements they perceived as the most fun (χ-square=25.25, p-value=0.014) and as the least motivational (χ-square=20.36, p-value=0.016). The results indicate that *Achievers* tended to report the game element of *Points* as the most fun, and the *Rewards* element as the least motivational more frequently than any other students. Similarly, *Socialiser* reported the *Team-mode* as the most fun, and the *Leaderboard* as the least motivational. These results are in line with the Hexad player type model since *Socialisers* are motivated by relatedness and social connections, while *Achievers* by competence and mastery (see Table 1).

From the open-ended questions, it is clear that students enjoyed using the gamified application Kahoot! Out of all the responses for the question (i) "*What did you like most about today's class?*", the word "Kahoot" was mentioned in 24.5% of them, while for the responses to the question of (ii) "*What did you like least about today's class?*" the word "Kahoot" was only mentioned twice and it was to emphasize that the application should be used more often. The results also reveal that the most frequently used words in these open-ended questions was "Kahoot" (freq.: 31) and the word "problems" (freq.31). Similarly, the semantic network analysis of the responses to the question of what they liked the most, indicates that the most used word bigram was (i)"Kahoot"→"game". The semantic network analysis also shows that the node for the word "Kahoot" had more direct and indirect connections than any other nodes (i.e., direct=9 and indirect=17, from an average of 1.4 and 7.7 connections respectably), indicating that participants commented about the *Kahoot!* application more than any other topic.

Overall, the results of this study support the value of using gamified applications, like *Kahoot!*, to engage and motivate students in educational environments. However, the results reveal that students can perceive the game elements of an application differently depending on individuals attributes. Hence, in order to optimize students' engagement and motivation, designers should personalize their gamified educational applications as much as possible. Furthermore, while the bridge program was an intensive four-week experience for students, the application Kahoot! helped engage students while serving as a practical and free Student Response System. Moreover, the real-time analysis of responses helped assess the progress of the students and their knowledge of the different concepts taught during class on a daily basis.

5. Conclusion

While researchers agree on the potential of employing well-designed game elements to improve students' motivation and performance, some caveats exist. For example, several studies indicate that a game element can positively impact an individual's performance and motivation, while at the same time have a negative impact on the performance and motivation of another individual. Hence, the importance of understanding the relationship between students' attributes and their perception of the game elements implemented in gamified educational applications. In light of this, the authors present a case study in which the application *Kahoot*! is employed in a summer bridge program. In this case study, students' player type, their perception of the application, and game elements employed were assessed.

The results reveal the benefits of gamified applications, like *Kahoot*!, to engage and motivate students. This type of application can also serve as a valuable Student Response System for educators to evaluate the progress of their students. While in general students indicate that they would like to continue using the application in the future and felt motivated by the application to work in teams and learn physics, some caveats exist. Mainly, that students' perception of the game elements of the application was associated with their player type. This indicates that personalized gamification could potentially improve students' engagement. Overall, the students reported to enjoy the *Team-mode* and felt frustrated by the *Time-pressure* element. Hence, when implementing this application in their class environments, educators should take advantage of the *Team-mode* element, and adapt the time to submit a response based on the difficulty of the questions presented to students and their understanding of the concepts evaluated.

This study provides valuable insights into the relationship between students' player type and their perception of different game elements, which could potentially help researchers advance personalized educational gamification. However, there are still many possible areas for future research to help advance the field of educational gamification. For example, one limitation of this study was that a control group was not employed to test the effects of gamification on students' performance. Moreover, future studies should focus on conducting similar experiments with a larger student population. Nonetheless, this work reveals the value of gamification on intensive bridge programs to engage students while serving as a practical, low-cost Student Response System for educators.

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