Integration of gamification elements in the generation of visual representation of a mathematical function using digital technology: A case study

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This study explores the experience of students while using an in-house developed, gamified activity that encourages the use of the graphical representation of mathematical functions. The main objective is to explore and describe student use experience in the activity and to comprehend if a relationship between the graphical representation and the real problem context —sustainable development— is achieved. A web-based activity was developed so that different devices could access and carry out the activity. Student behavior was observed to identify different categories which describe the experience and how this type of activities with digital materials is composed. The results allow identifying lessons learned about the benefits and limitations in the design and development of gamified activities for mathematics and sustainability education.

Keywords Gamification, gamified learning materials, educational technology, learning-design.

Introduction
The integration of technologies in the classroom derives from reasons that go beyond education and are based on the current socio-economic environment. For Andreas Schleicher (OECD, 2015), digital technology plays a central role in the social and daily life of students, characteristic that should not be ignored by educational institutions. Technology provides a platform for collaboration and allows to focus on new educational strategies in which the learner is an active participant during the learning process. Currently, different strategies which include technology in educational processes are being examined. One of these strategies is gamification, a recent trend that has been used in the development of the activity for this research.

The main purpose of this study is to understand and construct meanings from the experiences of participants of a gamified activity for the generation of understandings and knowledge in the design and development of educational technology. The research question is: What is the student's experience in generating a visual representation of a mathematical function using gamified technology in a sustainability situation?

The research’s general objectives fall into three areas: Mathematics, Sustainability, and Gamified Technology. We asked secondary questions to approach each theme. For Mathematics, the secondary question was: How is the interpretation of the graphics given by students in the gamified activity? For Sustainability the secondary question was: How is the student’s thinking regarding the sustainable development introduced through the gamified activity? Finally, for Gamified Technology the secondary question was: What are the advantages and limitations that arise while using gamified technology during the activity? This study is exploratory and descriptive, allowing in-depth analysis about integrating gamified technology focusing mainly on the graphic representation of mathematical functions.

Theoretical Framework

Gamification
To understand the concept of gamification a historical review of its definition is needed. These definitions come
across different perspectives that range from psychology to game design. Gamification has its origin in the use of game elements as a tool to achieve different goals. It’s necessary to consider that the use of games has been studied in many different contexts and stages. Huizinga (1950) considered the game as an intrinsic part of human nature that shapes culture. Caillois (1961) considered games as a biological part of a human being to achieve full development through play. From a Human-Computer Interaction stance, gamification is reviewed as a strategy that modifies user’s behavior by using game elements in tasks that are not necessarily a game (Deterding & Dixon, 2011).

From a behavioral perspective, gamification has been associated with psychology concepts such as the Theory of Goal and Achievement (TGA) (Nicholls, 1984); the Self-Determination Theory (SDT) (Ryan & Deci, 2000); and, the Experiential Learning Theory (ELT) (Kolb & Kolb, 2012). Other researches like Aguilar, Holman and Fishman (2015), Banfield and Wilkerson (2014), Eleftheria, Charikleia, Iason, Athanasios and Dimitrios, (2013), Kalinauskas (2014), and Songer and Miyata (2014) explored these relations between psychological perspectives and the use of gamification to influence education. This is because gamification can be aligned with learning objectives. For example, Barata, Gama, Fonseca, Gonçalves and Jorge (2013), Eleftheria et al. (2013), Krawse, Mogalle, Pohl and Williams (2015), Villagrana and Duran (2013) consider gamification as a technique within the educational context that can shape the learning process.

From a programming and design point of view, gamification should be seen from a different perspective. Hamari and Koivisto (2013) present gamification as the use of elements in the design of games which provide the user with game-like experiences to influence their behavior. Gamification focuses more on the motivation than on the behavior of participants. Motivation is achieved by adding visual playfulness and through interacting with characteristics proper of games. Zichermann and Cunningham (2011) and Zichermann and Linder (2010, 2013) define gamification as a process in which game-thinking and game mechanics are included in a task. Game mechanics are the rules, goals, and challenges which define what the player can do in a game (Winn, 2008). Finally, Kapp (2012) considers gamification as the use of game mechanics, aesthetics and game-thinking to encourage the user to participate.

Mathematics visual representation

Duval (2008) states that there are three representations by which the student can deal with mathematical content. These are the numerical, algebraic and graphic representations, and there are learning problems related to each one of them and their flexibility to transfer information from one to other. All three of these representations are symbols; one can’t experience a mathematical object without a symbolic representation. For this research, we named the graphical representation of mathematics as a visual representation. Digital technology makes it possible to take advantage of the visual representations of mathematics since, as opposed to traditional media, it is possible to make dynamic representations that allow the student to experience mathematics in a different and meaningful way seeing the mathematical concepts. For example, students can experience the visual construction of these objects like in the construction of a graph through time. For Moreno-Armella and Hegedus (2009), the resulting learning from the mediation of technology in mathematical teaching is epistemologically different (Moreno-Armella & Sriraman, 2005).

Development

For this research, an educational activity should be designed and developed using the visual representation of mathematics and gamification within digital technologies. There are two main reasons to go deeper into this field, first to address the intrinsic interest of some researchers in the use of digital technologies in mathematical teaching (Hegedus & Moreno-Armella, 2009, 2014; Hegedus & Roschelle, 2012; Moreno-Armella & Hegedus, 2009, 2013; Moreno-Armella & Sriraman, 2005). The second criterion was the use of the visual representation of mathematics as the best way to allow students to generate a connection between the mathematical content and everyday life situations. It should also promote dialogue through the interaction with digital technology and the work of students (Salinas, Quintero, Sánchez & Mendivil, 2015; Salinas, Quintero & Fernández-Cárdenas, 2016).

An everyday life situation through which it is possible to contextualize the activity is a sustainability issue in the natural systems. In this scenario, it is possible to design a function between the consumption of a resource about time, making possible a connection between the graphs involved in the activity and the actions performed by the participants. This situation was selected in the form of a board game developed by The Cloud Institute for Sustainability Education (2015) with a Creative Commons Attribution-Noncommercial-Share Alike 3.0 License. An adaptation from the board-game to a digital technology activity was then developed.

![Figure 1. The Fish Game in mobile devices](https://www.riege.mx/index.php/riege)
A match starts with five players joining a room. An avatar is assigned to each of the players. The avatar shows a marine species and a label with its name in a specific color to make it easier to identify. Initially, players do not know who the rest of the teammates are. Short texts and illustrations were used to make the participants aware of the rules and controls in the game, as well to explain the background story. During each turn, players can choose between 0, 1, 2 or 3 fishes. The initial number of fishes available is 36, after each turn, they get coins per unit caught. When all players complete a round, 25% of the remaining shoal is regenerated. The game includes two modalities: the first in silence, without communicating with teammates; and in the second they can talk to each other to organize. It is to be expected that in the first mode after some rounds the fish will be depleted creating a sense of doubt about the true purpose of the game, a non-zero-sum game where there is not only one winner. In the second modality, participants work together to come up with a solution.

The relation between the mathematical content and the game is embedded within the behavior of the graphs from the resource consumed. The upper graph represents the individual consumption while the lower graph represents the fish population (Figure 2). No labels or identifiers are allocated to promote an interpretation of the graphs in the students. The graphs show the behavior of the number of resources that changes as consumption occurs without restrictions. The graphical representation of this quantity, as a time-dependent mathematical function, allows visualizing the variation of fish population as time passes. In this way, the effect of consumption can be perceived, and its consequences can be predicted. Students must solve this issue by searching for a sustainable solution (Figure 2).

Instrument

A qualitative research method was selected because it is an appropriate approach when it is necessary to understand the context in which a phenomenon occurs, or when the experience of the participant is to be analyzed (Creswell, 2012). The qualitative approach selected is a case study as an intensive and holistic description of a phenomenon (Merriam, 1998). Due to the lack of participants, a mixed study with a quantitative analysis of statistical significance was not possible.

Site and Participants

A non-probabilistic sample is appropriate in a qualitative case study due to the fact that “in qualitative studies the size of the sample is not important from a probabilistic perspective, since the researcher's interest is not to generalize the results of his study to a wider population” (Hernández, Fernández & Baptista, 2010, p. 392). For this reason, a purposeful sample was chosen. The participants in this study were selected from the Mathematics I course, in the first semesters of the engineering career in a private university in northern Mexico. Choosing students from that course was relevant since it covers graphical representations of single real-variable functions. A total of 50 students participated throughout the research: 25 students during the prototype stage and 25 during the field study in summer 2016. Each session lasted around 45 minutes (Figure 3).
Results

Valenzuela and Flores (2011) recognize data analysis as the systematic organization of data collected in a way that allows the researcher to achieve findings. This research opted to use the construction of categories with the Atlas.ti software. This tool is capable of using different types of files, text transcriptions, audio, video, and images to systematically organize them and allow the researcher to perform the analysis.

The outcome of the observation analysis shows that the disposition of the students to participate was high, although initially there was some uncertainty about what they were supposed to do. As time passed, the attitude of the participants was transformed and relaxed, resembling a game environment. In the end, the students were capable of establishing a relationship between what was happening with the graphics and their actions in the game, fostering a reflection on sustainability. In the same way, the participants could make a direct interpretation of the meaning of the graphics in a mathematical sense, although this required the activity to reach the last instances.

Additionally, the document analysis focused on thoughts, ideas and solution proposals that each of the students wrote individually. Something that caught the attention of the researchers was that only one of the students chose to make a calculation using equations (Figure 4), while the rest usually wrote their proposals, which consisted for example for establishing periods of closure or that during certain rounds certain players would not catch fish, and then make a rotation in the fishing turns. This could mean that the majority of the students prefer the use of verbal expression than to use algebraic representations to express their thoughts. Additionally, the interpretations given during the initial stages of the game were different, but in the final stages, they agreed on the real objective: to form a sustainable model of consumption.

Figure 4. Solution proposed by one a student using equations instead of written ideas.

On the other hand, interviews allowed to explore deeper in certain topics that emerged during the observation. They allowed to delve into greater detail about the impressions, opinions and experiences of the students after their involvement in the activity. Table 2 shows which categories are contained in each theme. Certain quotations will be included to capture the essence of the most relevant categories.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Category</th>
<th>Count</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics #1</td>
<td>Strategy</td>
<td>54</td>
<td>Proposal of the participants’ strategy to resolve the activity</td>
</tr>
<tr>
<td></td>
<td>Numerical thinking</td>
<td>99</td>
<td>Use of numbers and calculations in the activity.</td>
</tr>
<tr>
<td></td>
<td>Graphical thinking</td>
<td>66</td>
<td>Use of graphical representation of mathematics, including sign language.</td>
</tr>
<tr>
<td>Sustainability #2</td>
<td>Consume</td>
<td>80</td>
<td>Reference to the fish consumption of the participants.</td>
</tr>
<tr>
<td></td>
<td>Gains</td>
<td>52</td>
<td>Reference to an increase in wealth or resources.</td>
</tr>
<tr>
<td></td>
<td>Reposition</td>
<td>89</td>
<td>Reference to the replenishment of the consumed resource.</td>
</tr>
<tr>
<td></td>
<td>Reflection</td>
<td>76</td>
<td>Reflection about sustainability.</td>
</tr>
<tr>
<td></td>
<td>Point of balance</td>
<td>46</td>
<td>The balance between consumption and replenishment of resources.</td>
</tr>
<tr>
<td></td>
<td>Equality</td>
<td>60</td>
<td>Proposed equity between the group.</td>
</tr>
<tr>
<td>Gamified Technology #3</td>
<td>User Experience</td>
<td>53</td>
<td>Aspects of Usability in the interface.</td>
</tr>
<tr>
<td></td>
<td>Game Mechanics</td>
<td>103</td>
<td>Reference to the game mechanics, rules, instructions, etc.</td>
</tr>
<tr>
<td></td>
<td>Digital Skills</td>
<td>56</td>
<td>Reference to the Digital Skills of the participants.</td>
</tr>
<tr>
<td></td>
<td>Activity Amenity</td>
<td>88</td>
<td>Reference to a pleasant environment among the participants.</td>
</tr>
<tr>
<td></td>
<td>Activity Appreciation</td>
<td>89</td>
<td>Appreciation on the activity by the participant.</td>
</tr>
<tr>
<td></td>
<td>Activity Exploration</td>
<td>43</td>
<td>Exploration of the activity.</td>
</tr>
<tr>
<td></td>
<td>Activity Interpretation</td>
<td>129</td>
<td>Interpretation about the purpose of the game.</td>
</tr>
<tr>
<td></td>
<td>Motivation</td>
<td>19</td>
<td>Interest, attraction or involvement for participating in the activity.</td>
</tr>
<tr>
<td>Communication #4</td>
<td>Collaboration</td>
<td>81</td>
<td>Collaboration in agreement within the team.</td>
</tr>
</tbody>
</table>
Theme #1 - Mathematics
In the activity, participants must propose strategies in which all players are interdependent. The main difference in this theme is between Numerical Thinking and Graphical Thinking. Participants considered the replenishment percentage (25% of the remaining fish) or used the graph as an instrument to interpret and solve the activity. The complexity of the arithmetic operations was quite low; addition, subtraction, multiplication and percentage calculation. Participants usually decide what calculations to do after a few trials in the game. The graphs worked as indicators or instruments that players used to find a limit and then determine the number of fish they could consume without harming their team, the fish population and therefore their income. The graphs allow the player to visualize the behavior of consumption and replenishment and promote thinking on their individual and group actions, as they construct the plots over time (rounds). This allows participants to connect their individual experience in the gamified activity with other topics, such as sustainability or boosting a stance on this issue. The next quote was selected because it shares a participant impression of how he used the graphs and his thoughts at the end of the gamified activity.

Quote #1 Category - Graphical Thinking:
In the beginning, we were a little confused. We did not pay much attention to graphs. But later they helped a lot to increase the amount of fish and to continue to increase our profits [...] At first, I barely used the graphs, like ‘okay fish are going down, my money is going up.’ But then the graphs were mostly like, ‘okay we reduced the fish, but then we kept them steady, then we raised them, just like our money’ (Student Interview, 2016).

This quote expresses how the activity generated uncertainty, but with the development of the activity, the participant started to consider the graphs as a tool. This helped him to understand the relation between the creation of the graph with the progress of the activity and the impact of the group actions.

Theme #2 - Sustainability
Different mental models appeared in the activity. Some of these focus on the consumption of resources by the player's attempt to maximize their profits, or to obtain as many fish as in a zero-sum game in which there can only be a single winner. Mental models declared as sustainable were also present. Students understood the interdependence of the natural systems. For instance, two important sustainable models appeared in the activity, the first is that natural systems have limits and the second is that it was everyone’s responsibility to keep the ecosystem healthy. Likewise, it was possible to observe how the participants went through different players’ profiles (Bartle, 2004; Marczewski, 2013) initially looking to maximize individual profit and win individually, to one in which the resources were equally distributed, and players collaborate with each other to achieve the real objective: develop a sustainable solution of consumption. The next quote reflects the opinion of one of the participants regarding the change in his mindset after participating in the gamified activity.

Quote #2 Category – Reflection:
The system used for making us play without communication, then playing once, and then asking us questions is excellent. This is how you first make us confused. Later, more or less we start to understand and work as a team to achieve a goal. And then you explained what we have to understand and wonder: ‘it’s true, why do we deplete all the fish if we can sustain an infinite resource?’ (Student Interview, 2016).

This quote shows how the traditional mental model of a player is from a zero-sum game where there can be only one winner. This is expected because the majority of the traditional games use this model. The participant was able to reflect ranging from uncertainty to the interpretation of the objectives and teamwork to achieve the real purpose of the activity making him understand and think about renewable resources.

Theme #3 – Gamified Technology
The category of User Experience was predicted since “gamification is an umbrella term that encompasses the use of games elements in a system that is not a game” (Deterding, Sicart, Nacke, O’Hara & Dixon, 2011, p. 2). Students had some initial complications with the interface, which is natural with any new system. However, it has a very short learning curve, so in a short time, it was possible to control the game. The Game Mechanics were difficult to assimilate in the very first attempt, but within the following rounds, students showed a mastery of the rules and controls in the game. Inexperience with the devices during the activity was not a problem. Students showed different digital skills to cope with the technology involved. During the sessions, it was possible to perceive an environment of amenity. This is important because part of the objective of the development of these digital materials is to create a more appealing educational resource. Piaget (1962) considers play as an intrinsically rewarding activity by itself. This playfulness in conjunction with the use of design elements to provide an experience similar to a game like Hamari and Koivisto (2013) state, afforded a positive appreciation for the students. About the Activity Exploration

<table>
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<th>Theme</th>
<th>Category</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Dialogue</td>
<td>118</td>
<td>The dialogue between participants presenting points of view to reach an agreement.</td>
<td></td>
</tr>
<tr>
<td>Gestural</td>
<td>42</td>
<td>Non-verbal expression through body language.</td>
<td></td>
</tr>
</tbody>
</table>
category, students had the chance to observe the behavior of the graphs by experimenting and exploring their behavior. Banfield and Wilkerson (2014) state that a “learning by doing” approach fosters an understanding of what is being studied. Hence, they made the connection between the outcomes in the graph and what they experimented, also matching the proposals of Bogost (2007) and Ferrara (2013), which state that a characteristic of games is to allow self-directed discovery, that is, to appropriate the knowledge discovered while playing. The next quote reveals a student’s appreciation regarding his experience with the gamified activity.

Quote #3 Category - Activity Appreciation:
It’s unlike any other activity I’ve experienced. I’ve never been involved in anything similar. The first stage was a bit complicated because I did not understand the objective or what the application was looking for, and because we were not able to share ideas with other teammates. But when we received an explanation and we were allowed to communicate with the other teammates it was easier [...] then you can develop a better idea or a way to reach the requirement with the application. I found it to be innovative. It’s something I’ve never done before. And I liked the idea of trying to apply mathematics in a game, but that is not an easy game, well, that is a game that requires you to think and also involve other teammates (Student Interview, 2016).

The student shares his appreciation towards the gamified activity. He states that it’s unlike any other activity previously experienced. Also, although it was confusing at the beginning, he found it innovative in the way that it required the application of math in a game that is not easy, and that it requires to think of a solution in conjunction with the other teammates.

Finally, although the use of design elements and game mechanics does affect the motivation of the users, it does not ensure it in all participants at the same level. The next quote captures the opinion of one of the students that took part in the activity. Although at the end most of the players got engaged, it took a while to make them participate in the activity.

Quote #4 Category - Activity Motivation:
In the beginning, I saw just one of the classmates motivated. It seems like he was looking to understand the meaning of the game. I saw him, but the other four teammates including myself were not very interested in the first phase. However, in the second phase when we could talk and catch the idea of the game, it was like everyone, well at least the other two classmates besides the one that was already engaged, showed interest (Student Interview, 2016).

The last quote reflects how despite all the planning and efforts considered to design an engaging activity with the introduction of gamification elements, sometimes it is not possible to capture the motivation of participants at a first try. Even worse, gamification effectiveness tends to dilute with the pass of time or the loss of novelty for the participant.

Unanticipated Theme 04 - Communication
The last emerging theme derives from the importance that participants gave to communication during the activity. Because this was not anticipated, it is named as an unanticipated theme composed by the categories of Collaboration, Dialogue, and Gestural. Conway (2014) considers relevant the use of games in the creation of Constructivist Learning Environments (CLE), environments where people can make sense of a problem and build meaningful solutions through the use of creative resources. Hence, this could apply as a Collaboration category. Additionally, games offer students an area of freedom in which they can make decisions and watch the consequences of their choices without them becoming negative or severe (Sanchez, Young & Jouneau-Sion, 2017). Further, the Dialogue category fits regarding Crawford (2011) suggestion that making a sharp distinction between play and other areas of social life, like a negotiation, is myopic. In this case, students were able to approach a real-world problem through the metaphor of a game to overcome a real sustainability problem finding the outcomes of the game as a moral. This idea of a space in which different ideas can be explored in an agreeable tone, a dialog, concurs with other authors, either as a Magic Circle (Huizinga, 1950), as a Protective Framework (Apter, 1986) or as a Reflexive Space (Sanchez, 2014). Furthermore, students could visualize the representation of a mathematical behavior as an aid. Hegedus and Moreno-Armella (2014) define communication as a combination of different modalities of human expression through writing, speaking or gesturing. This is where the Gestural category resides because students can describe the graph behavior with gestures to share ideas and their interpretation of the plots (Figure 5). The next quote enclosures the feelings of a student regarding the collaboration developed within the gamified activity.

Quote #5 Category – Collaboration:
Teamwork is very important, as it is to analyze what we are doing before acting. In fact, I really did not expect anything, but it was a very satisfying feeling to be able to work as a team and make the link (Student Interview, 2016).

Although the participant was not expecting anything by participating, he developed a feeling of satisfaction after being able to achieve the objective of the activity and create a bond or link between the teammates. This is a dimension that usually players develop when achieved the objective, understood the graphs and created a reflection about the sustainability issues of everyday life.

Usually, one or two players took the lead over the rest of the group, but with the progress of the activity, the thoughts and share of ideas flourished providing a dialogue with the
teammates. The next quote presents the importance that participants gave to dialogue.

Quote #6 Category – Dialogue:
Well, the first thing I thought was that we had to talk before we started, to get an idea of what we were going to do. Because from the moment someone did something wrong we were going to struggle more (Student Interview, 2016).

Although it was until the second round with communication that players could talk, each player got a different interpretation of the objectives and the goals they had to achieve. Only by stating a plan or strategy that is aligned with the ideas of the rest of the participants the outcome of the teamwork could be successful.

![Figure 5. Students discussing and collaborating in a proposal to achieve a sustainable outcome considering the graphs](image)

![Figure 6. A sustainable outcome, with a profit increase and a constant fish population.](image)

**Discussion**

To begin the discussion, it is necessary to summarize the main findings of the study by addressing the research question: How is the student's experience in the generation of the visual representation of a mathematical function using gamified technology in a sustainability situation? This question was approached from three main themes that are Mathematics, Sustainability, and Gamified Technology, and an unanticipated theme emerged corresponding to Communication. Each theme is constituted by different categories (Table 2) which emerged from the analysis of the information provided by the instruments. The following discussion derives from the interpretations, insights, and lessons learned during the investigation.

Regarding the use of the visual representation of mathematics as a better option to achieve a connection between the mathematical objects and the real world, it can be said that initially participants did not find a relationship nor made use of the graphics as planned. However, it wasn’t until the activity reached an advanced stage that the meaning between what they were experiencing and what they were watching in the graphics made sense to them, achieving the desired connection. From that moment, the students used the graphs as guides of the team's performance and formulated strategies that would allow a sustainable solution. This addresses the secondary question **How is the interpretation of the graphics given by students in the gamified activity?** It can be established that in the end they did manage to make a right interpretation allowing a connection, but only after the activity was in a very advanced stage as Quote #1 presents. This could be understood as students not used to interpret graphs and to seek for meaning in the information that graphs are providing.

The interpretations derived from the Mathematics theme are also connected to the second theme, Sustainability. This theme is addressed by the secondary question: **How is the student's thinking process regarding the sustainable development presented through the gamified activity?** It is possible to state that all the participants confirmed that the purpose of the activity was to achieve a point of balance. Quote #2 exemplifies how students emerge with a new meaning for the activity, realizing that they can create an equilibrium between the consumption of a resource and its replenishment (Figure 6). This could mean that by presenting a real-world problem in a gamified activity, it can provide insights or a reflection for these situations that are happening in real life. Making students more aware of these issues around their daily life.

Considering Gamified Technology theme with the secondary question: **What are the advantages and limitations that arise in the use of gamified technology during the activity?** It was possible to understand that the influence it exerted on the participants was mainly due to two actions, the use of elements in game design (Hamari & Koivisto, 2013) and the use of game mechanics to rethink activities as a game (Winn, 2008). Quote #3 states the appreciation that a participant experienced, qualifying the activity as "innovative," he also states his preference for the use of games and math that challenge the student to think...
and cooperate among other participants. On the other hand, although the motivation and interest of the participants themselves were influenced, it was not possible to establish that the motivation was at the same level in all the participants, as quote #4 suggests.

The unanticipated theme of Communication emerged during the analysis of the other more obvious themes. The lack of consideration of this theme could be a limitation of the study, but at the same time, it brings the opportunity to enhance the research for future stages. Although the gamified technology is the infrastructure in which the students interacted, the atmosphere created by the use of game elements allowed a more easy-going exchange of ideas among participants. Dialogue and collaboration, as described in Quote #5 and Quote #6, were considered important outcomes of the participants’ experience. It seems that students cleared their mind an enriched their opinions while listening and reviewing other teammates ideas. The game’s “atmosphere” can be considered responsible of this in the activity, just as in Huizinga’s (1950) Magic Circle or Sanchez (2014) Reflective Space suggests. These authors pointed out the ability of games to create an atmosphere where communication can be made by providing a creative horizon to explore meaningful solutions to problems and also to aboard them in different ways. In this case, students were able to share their understanding, strategies and their objectives, to be agreed by the team and bring up a solution. All these reflect the kind of experiences that gamified technology creates in the motivation of the students, or as one of the students quoted, “unlike any other activity” experiences.

Future recommendations for this study would be to consider a higher level of complexity in the tasks presented due to the low proficiency of the mathematical problems involved. It would be recommended to try this kind of gamified technologies in other representations of the mathematics such as the algebraic or numerical representation and compare if the experience of the students is similarly good to the ones presented in this activity. This could also apply in another field beside mathematics, like chemistry or biology. Also, one of the flaws noticed in this activity was that that once a player completed it, the activity started to lose novelty and freshness. The challenge then is to achieve a balance between the quantity and quality of the content and the level of motivation required from the student to keep using the activity as a learning resource.

Conclusions
The lessons learned from this study does not lay in the technology by itself but in a possible value that it can provide to education through the use of gamification as a way to create learning environments in which communication is possible. This matches with those spaces of communication that Salinas et al. (2015) and Salinas, Quintero, and Fernández-Cárdenas (2016) explore. The mix between game, a communication space and the environment to learn new things can appeal the students’ preferences in the actual hyperconnected world.

Despite that the learning objectives from the activity seem to remain short in scope, the planned objectives were accomplished. Students could interpret the graphs correctly, not only predicting and understanding its meaning but making a relation between them and the sustainability issue that the game presented with consuming resources. Also, the chance to interact and work with their teammates in a digital environment affords communication about the purpose of the activity creating teamwork in a solution. Finally, students showed their likeness for this kind of environments that provides unique experiences to learn and have fun.

Knowing how to create these experiences should then allow teachers and instructional designers to make better choices when aligning learning objectives with technology and games. Presently, several tools provide elements of gamification for any subject. The problem is that, although they are a great enhancement for teachers, these tools usually constrain the user to the available options. Leaving the chance to customize learning experiences relegated. A most favorable horizon for the creation of gamified activities would be that teachers, designers, and developers work together as a multidisciplinary team to create new content with a balance between the learning requirements and the game experience as tested in this research.

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