Editorial

Charalampos Karagiannidis and Sabine Graf, Co-Editors

Welcome to the Bulletin of the IEEE Technical Committee on Learning Technology, Volume 17, Number 4, December 2015 issue. This issue focuses on topics related to **serious games and gamification for technology enhanced learning** and consists of seven articles discussing cutting-edge research on this topic. Furthermore, one article is included in the regular paper section which focuses on diverse topics on learning technologies.

In the first paper, Theodosiou and Karasavvidis describe a study with students of a Serious Games Design (SGD) course and their development following the IGENAC model, and discuss the complexity of the serious games design, even working with educational experts.

The second paper, written by Mazarakis, presents the results of a series of studies which used feedback mechanisms to increase user participation with different learning tools.

In the third paper, Barbat, Dutra, Adamatti and Werhli describe a serious game-type simulator for teaching high school and university students physics and industrial automation concepts through the development and experimentation of industrial plants.

Subsequently, Broer introduces the gamification inventory, an instrument for structured assessment of gamification in a given system, based on an expert survey which analyses terms related to gamification.

In the fifth paper, Lazem, Bassuony, Gaber, Youssef and Farag present a work-in-progress prototype for an affordable multi-player interactive floor that allows for various game scenarios and tracks the students' performance.

The sixth paper, written by Klock, Gasparini, Pimenta and de Oliveira, explores characteristics (i.e., player type, age, sex, motivation, personality, culture) that influence the gamification success and could be considered to adapt the use of these techniques in an adaptive hypermedia system.

In the seventh paper, Wu, Zhu and Luo discuss gamification in education, and present an application which aims to teach digital circuits through a game.

In the regular paper section, one paper is included. In this paper, Jalil, Beer and Crowther present a case study which investigated the use of a specific application (MOBIlearn2) while attending a one-hour seminar or workshop.

We sincerely hope that the issue will help in keeping you abreast of the current research and developments in Learning Technology. We also would like to take the opportunity to invite you to contribute your own work in this Bulletin, if you are involved in research and/or implementation of any aspect of advanced learning technology. For more details, please refer to the author guidelines at http://www.ieeetclt.org/content/authors-guidelines .

Special theme of the next issue:

Technology-Enhanced Science, Technology, Engineering and Math Education

Deadline for submission of articles:

May 10, 2016

Articles that are not in the area of the special theme are most welcome as well and will be published in the regular article section.

An Exploration of the Role of Feedback on Optimizing Teachers' Game Designs

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Abstract— Engaging learning experts in serious game design is one way of bridging the game design – educational design gap. This engagement is expected to lead to game designs of high educational value. However, conceptualizing how to involve experts in game design is still in very early stages. To address this issue, we examined the educational value of 24 serious game designs made by pre-service teachers. The findings suggest that, even after substantial support, the majority of the designs were found to be insufficient. The paper is concluded with a discussion of the findings and recommendations for further work.

***Index Terms*— Serious games design, Ideal design, Educational value, Learning experts**

I. Introduction

COMPUTER games have become increasingly popular over the past decades and have shown great potential in fostering the development of multiple skills. Serious Games (SGs) have recently emerged as a type of Computer Games that are designed to serve purposes other than pure entertainment [1]. Designing a SG is an interdisciplinary task requiring the cooperation between experts from different areas such as graphic design, product design, programming, animation, interactive design, writing, audio design, and content areas [2]. As [3], [4], [5] argue, the major problem that the Serious Games Design (SGD) field is currently facing concerns the disconnect between traditional game design and educational design. Recent conceptualizations recommend involving educators in the design process. It is being increasingly recognized that, to design effective serious games, the corresponding experts, content and instructional ones, would need to be actively involved in the design process [6]. [7]. Despite recent interest, few studies have focused on engaging teachers in the processes of game design (e.g. [8], [9]). Consequently, there is a knowledge gap regarding teacher engagement in serious game design. The present study aims to address this gap by reporting evidence from a systematic exploration of the content and forms of support that pre-service teachers require when they undertake game design tasks.

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II. Serious Games Design

A. Teachers and Game Design

While the design of a SG is an inherently interdisciplinary endeavour, it is only lately that the importance of cooperation between game designers and instructional designers has been consistently stressed [10], [11]. This cooperation premises the development of a common language, so that experts from various fields can communicate on the same grounds [10], [11], [3], [12].

The induction of educators to game design is a completely uncharted territory. The difficulties teachers might experience when they embark on game design are not known. Additionally, the content and form of the support that might be required to address these difficulties is also unknown. Although there is little published research on the topic, we will briefly review two studies the findings of which clearly illustrate the potential difficulties educators might face in designing games.

In the seminal [13] study, the game designs of 16 pre-service teachers were investigated. The authors reported that designing fraction games turned out to be very challenging for the teachers. As the initial designs lacked intrinsic integration and proper focus on user thinking, [13] introduced specific conceptual design tools to facilitate the improvement of the designs. The study concluded that the conceptual design tools provided were pivotal for making good game designs: it was only after the introduction of such tools that the game designs improved in a number of dimensions. In a more recent study involving a group of 9 university educators, [7] attempted to bridge the game development process and the story-writing process. The authors examined the uptake of a narrative tool built on the top of an educational game authoring platform (e-Adventure). The study findings indicate that, to understand the narrative tool and design games, the participants needed a particular form of scaffolding such as specific examples.

These findings suggest that, regardless of the subject matter, instructional, and learning expertise that teachers possess, facing difficulties in the course of game design is very likely. Documenting these difficulties and addressing them through support is essential for ensuring game design success. Both the content and the form of this support needs to be systematically researched, as it might eventually be critical for successful game design. To facilitate teachers' encounters with the world of game design, two main components are required: (a) relevant conceptualizations, such as game design models, and (b) appropriate scaffolds such as worked out examples, structured guidance, and feedback.

In the remainder of this paper we report data from an on-going research project which aims to systematically investigate the content and form of support that educators might require when designing serious games. The paper is organized as follows. First, the design conceptualization (serious game design model) that was used in the study is briefly introduced. Second, the specific study context is described and the feedback scheme adopted is outlined. Finally, the paper is concluded with a discussion of the main study findings.

B. *A model for Serious Game Design*

In an attempt to bridge the gap between game design and educational design, a few SGD models have been advanced in recent years [5], [11], [3]. Depending on the perspective they take, these models fall along the traditional game design and educational design continuum. The authors have put forward, IGENAC, a holistic model for SG design [14], [15]. This model combines conventional game design elements (goal, obstacles, rules, mechanics) with narrative elements (characters, challenge, spatial environment, temporal environment) and academic content (intrinsic integration). The model is based on a specific conceptualization of learning that is derived from sociocultural theory. Drawing on the concept of mediation, the model enables the explicit association between game mechanics and learning mechanics. The model is comprised of 10 interrelated game elements (see Fig. 1).

The main idea behind IGENAC is that the player is bound to learn the embeded academic content by using appropriate resources to overcome specific obstacles. In terms of relations between game elements, an ideal game design will need to meet three main conditions simultaneously:

(a) the direct association among *Mechanics – Resources – Obstacles*. This relation is critical as it is through game mechanics that the player utilizes the resources provided to overcome the obstacles. In principle, the outcome of this utilization should be learning.

(b) the indirect association among *Resources – Learning Content*. Resolving the problems will require the player to use the resources appropriately. Again, it is through the game mechanics that the player accesses the resources, employing them as instruments. Consequently, the resources need to be instrumental for resolving the challenges and associated with the learning content.

(c) the indirect association among *Obstacles – Learning Content*. This indirect association describes the fact that to resolve the problem, the player will need to develop a body of concepts which, typically, coincide with the academic content ones.

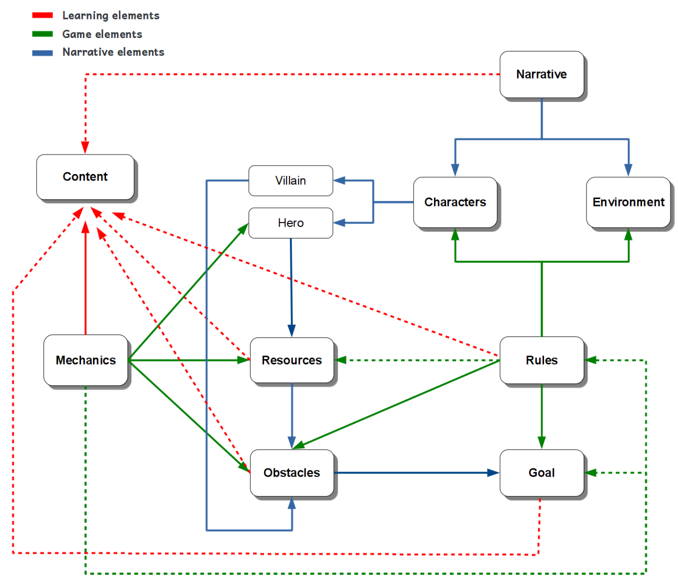

Fig. 1. The IGENAC model

The main premise of the present work is that good learning follows from good design [16]. Undoubtedly, a player can learn from a poorly designed SG, much like a player can learn from entertainment games [8]. However, such learning will be circumstantial at best, largely uncontrollable and unpredictable. Ensuring optimal learning from SGs through design requires leaving nothing to chance: the learning outcome should naturally follow from good design, being fully controllable and largely predictable.

Given a game design model such as IGENAC, one measure of game design quality is the extent to which it includes all elements and exhaustive relations amongst them. We will refer to such a complete design as an "ideal" one. In principle, such a high quality design would have the greatest educational value, namely the most potential for supporting learning. Conversely, the more a design diverges from the ideal one (i.e. it fails to include all game elements and encompasses only some associations between elements), the less educational value it has, considering that learning might occur but circumstantially, not necessarily as a consequence of systematic design. We argue that an ideal SG design includes all three types of aforementioned relations.

In the study reported in this paper we examine the designs novice game designers made after attending an undergraduate course on SGD. The aim of this course was to introduce pre-service teachers to the game design processes. Our intervention involved (a) the aforementioned IGENAC model as the main conceptual artifact, and (b) comprehensive feedback on the initial game designs. This feedback constituted an important part of the course and was meant to support student teachers in improving their initial designs. Our objective in this paper is to determine the quality of their revised designs by examining their nature and deviations from an ideal comprehensive design. The following question is addressed: *What is the quality of the revised game designs using "ideal designs" as a frame of reference*?

III. Method

A. Participants and Context

Seventy-five students participated in an undergraduate course on Serious Games Design and Development, offered at a preschool education department in a Greek state University. The course, that lasted 13 weeks, consisted of lectures and lab sessions. The students were introduced to the IGENAC model and, working in small teams of 2-3 members, (a) designed a SG and (b) developed a playable prototype. The 35 teams that were formed were asked to submit their initial designs in the form of a design document (DD). The idea was to provide feedback to the initial designs, finalize the designs and then proceed to the development of the prototype. After submission, the course teaching assistant (TA) (first author) reviewed all DDs and provided feedback via email to all teams. This feedback consisted of detailed comments and questions on the submitted designs. The feedback aimed to help students clarify or resolve potential ambiguities and/or misperceptions in their designs. In addition to annotated comments, optional face to face feedback sessions with the TA were also offered. In these sessions the TA and the team had the opportunity to discuss existing issues and students' new ideas for their design improvement. While such meetings were optional, they were highly recommended. Thirty four teams submitted valid initial DDs and 29 teams requested additional face to face meetings. Following the feedback phase, the students revised their DDs, and submitted their final designs along with a working game prototype. As 10 teams failed to submit a revised DD, the main data source of this study are the 24 revised DDs.

B. Measures and Analysis

The initial DDs have been analysed in a previous work [15] using the presence of game elements and the relations between them as criteria. The findings suggested that the students experienced major difficulties in associating mechanics to content, while various other connections (e.g. resources – obstacles, resources – learning content) between game elements were also missing. In this work we draw on the revised DDs in order to identify the quality of their designs.

Following previous work [15], we operationalized the educational value of each design in terms of the sequential connections that were present between game elements. The presence of a specific connection was defined in terms of its identifiable, discrete, and explicit appearance in each design. According to this operationalization, a game design is of high quality if the DD deviates minimally from the "ideal" design, i.e. no game design elements are missing and comprehensive associations between the elements are evident. Conversely, low design quality suggests omitted game elements and insufficient relation completeness.

IV. Results

Firstly, the sequential relations that appeared in the DDs were determined. As shown in Table I below, more than two thirds of the designs included appropriate connections between Mechanics – Resources – Obstacles. This means that in 7 of the designs either the obstacles were not associated with the resources provided or that the game mechanics were only indirectly related with the resources. Well over two thirds of the designs incorporated a proper connection between Resources – Learning content of the game. The remaining 7 designs, however, failed to associate the game resources with the learning of the academic content, thereby failing to meet one of the most critical objectives of SGs, i.e. learning. Finally, in the majority of the designs the obstacles were unrelated to the learning content, which suggests a fundamental flaw in most designs, as overcoming the obstacles was expected to lead to learning. Overall, these findings suggest that some of the designs were insufficient.

TABLE I
Groups of relations in designs

Relation(s)	Present	Not Present	Totals
Mechanics – Resources – Obstacles (A)	17	7	24
Resources – Learning Content (B)	17	7	24
Obstacles – Learning Content (C)	9	15	24

Furthermore, we identified the designs in which multiple sequential relations appeared simultaneously. The outcomes of this analysis are presented in Table II below.

TABLE II
Relations completeness

Relation(s)	Present	Not Present	Totals
(A) AND (B)	7	9	24
(A) AND (C)	0		
(B) AND (C)	0		
Ideal design: (A AND B) AND (A AND C) AND (B AND C)	8		

As table II suggests, only one third of the DDs corresponded to an ideal design, while almost one third only included two of the critical connections between game elements. Even though relations between two game element nodes were present in the students' designs, only a few designs were characterized by the simultaneous presence of all the requisite relations. The students faced difficulties in forming all appropriate relations to the learning content of their designs which means that the resulting designs were not optimal in terms of educational value.

V. Discussion

To maximize the potential of SGs in the field of education, the focus needs to shift to their design. Traditional game design and educational design need to co-exist [3], [4], [5]. As designing SGs is an interdisciplinary task [2], to produce games with educational value, instructional designers' involvement is of essence [10], [11]. In the study reported in this paper instructional design experts were furnished with (a) a conceptual artifact (serious game design model) and (b) extensive feedback on their initial game designs. Overall, the study findings suggest that despite systematic support in terms of the IGENAC model and comprehensive feedback, only one third of the student teams managed to make game designs which would qualify as ideal.

It should be noted that our findings are consistent with contemporary research, confirming the inherent difficulties in designing SGs, such as combining the game design and the educational design approaches [3], [4], [5] and translating academic content into gaming tasks [17]. Furthermore, our findings are also in line with evidence from other studies (e.g. [13], [7]) which suggest that involving teachers into SGD might not be effective without support. While some of the pre-service teachers in our study made high quality designs, still the outcome cannot be considered satisfactory as two thirds of the student groups created suboptimal designs.

The contribution of the present study is that it sheds light on the SG design complexities that surfaced when the designers are educational experts, even if they (a) have a comprehensive conceptual design tool available, and (b) have received elaborate support through asynchronous and live feedback. Many sources [10], [11] advocate the importance of teacher participation in game design to bridge the traditional game design with educational design. However, the findings of this study suggest that (a) such participation is unlikely to be without challenges and (b) the content and form of the requisite support for resolving these challenges might be intricate.

Future research needs to be directed towards more systematic forms of both instruction and support in order to ensure game designs of sufficient quality.

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Using Gamification for Technology Enhanced Learning: The Case of Feedback Mechanisms

Athanasios Mazarakis

Abstract — **Motivation of students is crucial for effective usage of technology enhanced learning. Still, many approaches fall short in supporting long-term motivation. This paper presents the results of six studies using feedback mechanisms to increase user participation with different learning tools. Additionally a new feedback is introduced, called Social Ranking Feedback.**

Index Terms — **Feedback, Motivation, Experiment, Learning**

I. Introduction and Related Work

CONTRIBUTING to a knowledge management tool like a wiki needs commitment from all participants because usually they are responsible for the integration and enlargement of the knowledge base. This knowledge creation is comparable to the concept of communities of practice [1]. Unfortunately these communities and knowledge management in general suffer from the free rider problem [2], which is also knows as social dilemma [3]. Usually monetary incentives are used to increase participation and motivation but these incentives often don't take into account the measurement of objective and individual effort [4]. Also extrinsic motivators like monetary incentives can lower significantly the attitude to share knowledge [5]. Finally the psychological phenomenon of reactance can demotivate individuals to share their knowledge because they might fear a restriction of their perceived individual freedom [6]. Therefore non-monetary incentives are considered superior to achieve long lasting participation [7], or a mix of monetary and non-monetary incentives [8]. According to Cheshire some possible alternatives are altruism, selective incentives, to prevent anonymity of participants inputs, or reputation [9]. Additionally some empirical results suggest that perceived uniqueness, goal setting, social approval, or the perception of cooperative behavior can help to increase motivation [10], [11].

Gamification is already part of an ongoing scientific investigation to analyze the possibilities for user motivation [12], [13]. There are many different game elements which can contribute significantly to motivation, like badges or barnstars, which are an application of badges to Wikipedia [14], [15]. Also other studies suggest that ranking is another game element which can help to increase participation [16]. However feedback has been identified as one key element of gamification [17] and is being recently investigated in social media systems [18]. According to Antin and Churchill feedback can be seen as goal setting (see also [19]–[21]), that is a hint to guide participation in a desired direction, to get reputation, for the verification of an achieved goal as a kind of status, or as some part of identification in an online community [14]. One possible way to make use of feedback for technology enhanced learning are feedback mechanisms, which have been introduced first by Cheshire and Antin with three experimental studies [11]. This paper extends the knowledge about feedback mechanisms and summarizes the results of six studies in two different settings: course wikis and a game to support learning analytics [22], [23]. Besides that the combination of the results is novel, [22] has not been put into the context of gamification and [23] is unpublished work, only presented at a workshop.

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II. Methods

A. Course Wikis

Cheshire and Antin [11] used for their studies three different feedback mechanisms: gratitude, historical reminder, and relative ranking. These feedback mechanisms have been adapted to support five different course wikis for the present paper. 620 participants registered in total for five studies with remaining 436 participants who have at least one edit. Because feedback is only shown if someone makes an edit, users with zero edits can not be considered for the statistical analysis. The aim of the experiments was to investigate if feedback leads to an increase of contributions in a course wiki.

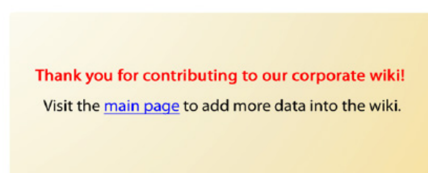

Fig. 1. Gratitude Feedback.

Figure 1 shows a very basic form of feedback, which is gratitude. This feedback expresses thankfulness without any further information.

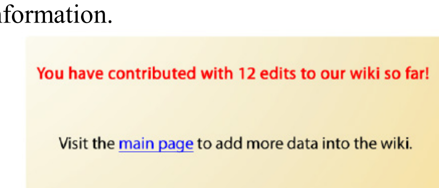

Fig. 2. Historical Reminder Feedback.

The historical reminder feedback shown in Figure 2 gives information about how many edits a user has done so far.

Fig. 3. Relative Ranking Feedback.

Relative Ranking Feedback as displayed in Figure 3 abandons the individual aspect of feedback and takes into account that a wiki takes place in a virtual social community.

These three feedbacks are the ones which has been used already successfully by Cheshire and Antin to increase participation [11].

Fig. 4. Social Ranking Feedback.

Additionally in Figure 4 the Social Ranking Feedback is introduced. This feedback is novel and was not part of the studies of Cheshire and Antin.

Social Ranking Feedback aims to provide more information and additionally has a competitive gamification element which is implemented as a ranking. Interestingly, only 2 positions above and below the own position are displayed, which distinguishes the social ranking from a regular ranking.

The reason behind this procedure is that displaying the complete ranking might demotivate individuals which join later the wiki and therefore might become frustrated because the top places are out of reach. Instead the display of users which are in range of ones own so far done participation might encourage for more edits. The comparison with others has related to feedback a huge potential for motivation [24], [25]. One big difference of the Social Ranking Feedback in comparison to other studies, like e.g. the studies of Kuhnen and Tymula [16], is that not the complete ranking is shown and that it is not anonymous. An increase of participation is anticipated by showing real names and excerpts of the ranking.

The use of different feedback is suggested by Fischer, because there is no perfect feedback for everyone but individual preferences can be important [26]. Each feedback was shown only once immediately after an individual conducted an edit in the course wiki. This was due to the fact that the uniqueness of the feedback should not be spoiled by showing it excessively [10].

The sample of 620 subjects consisted 72% male and 28% female students with a mean age of 23.61 years and a standard deviation of 3.75 years. The total number of edits for all five studies is 10.974.

The students had to answer and discuss various questions regarding the topics of the courses they took at the Karlsruhe Institute for Technology. Bonus points for correct answers were awarded. They were no bonus points for quantity but just for quality. More information about the analysis can be found in the corresponding article [23].

B. *Game to Support Learning Analytics*

A different approach was taken for the sixth study. The previous empirical results about the beneficial provision of feedback are subject to different pedagogical limitations, e.g. by providing extra course credit for participation and therefore possibly damaging the ceteris paribus rule [27].

The sixth study conducts an altered approach to avoid such limitations. The aim is to investigate if the provision of feedback leads to continued playing of a game composed as a standard test with multiple choice questions. There was no incentive offered to the subjects and thus participation was voluntarily. The task for each subject was to play the game as long as they want. For example, they could play only one question and leave the experiment without any penalty. The maximum number of available questions was 75.

A student assistant at a public place at the campus asked each subject in person, if they want to participate in a research study. If they agreed, they got an internet link on paper and could easily access the experiment from any place. At the beginning of the experiment, the instructions made clear that each subject could play the game as long as they want. In addition, the subjects need to enter a nickname at the beginning of the experiment. If they wanted to quit the game and the experiment, they just needed to push a ‘quit’ button at any time of the experiment. Ceteris paribus, three different visualizations of feedback and one control condition have been used: no feedback at all (control condition), right/wrong, social ranking, and a combination of right/wrong and social ranking feedback.

55 students took part in this study (69% male and 31% female). Nineteen subjects answered all 75 questions. Each participant was randomly assigned to a condition, three with feedback and one without any feedback. There was no switching possible between the different conditions, each subject stayed the whole time in the same condition. More details can be found in the corresponding article [22].

III. Results

A. *Course Wikis*

TABLE I
MULTIPLE REGRESSION RESULTS

Experimental Condition	N	M	SD	β
Gratitude	83	28.42	24.67	0.14*
Historical Reminder	70	24.09	27.67	0.07
Relative Ranking	66	29.06	26.71	0.14*
Social Ranking	90	24.42	27.44	0.17**
Random	18	7.67	8.77	0.01
Control Group	109	14.88	15.32	-
Summary	436	22.75	24.42	-

* $p < 0.05$; ** $p < 0.01$

The inferential analysis gives support to the usefulness of feedback. In particular, gratitude, relative ranking and social ranking prove to be very valuable to motivate students. Table I shows the results of the multiple regression analysis.

A random condition was used in one study showing random feedback. Because the participants perceived this condition as irritating, it has been removed from the remaining four studies.

Gratitude Feedback, Relative Ranking Feedback and Social Ranking Feedback are statistically significant. Additionally the Social Ranking Feedback has the highest beta-coefficient and thus is the most effective feedback mechanism. The multiple regression takes into account that the five studies did not have all the identical characteristics. According to Field dummy coding for the regression is necessary and was performed with the control group and the biggest study serving as control groups for the analysis, with the goal to level the different studies even [28]. The explained variance is $R^2 = .11$, with $F = 6.10$, $df = 426$, $p = 0.00$.

B. Game to Support Learning Analytics

Table II gives an overview of the results regarding the different feedbacks for the sixth study and if subjects in the feedback conditions played longer than in the control group without any feedback.

TABLE II
QUESTIONS ANSWERED

Condition	N	M	SD
No feedback	13	40.31	19.29
Right/Wrong	15	54.27*	22.81
Social Ranking	14	55.14*	20.63
Both Feedbacks	13	56.69*	21.19

* $p < 0.05$

The results of the Mann–Whitney inferential test show that the feedback conditions outperform the control condition. But these positive results come with a drawback, namely the time on task. The results for the average time needed for each question are shown in Table III. Remarkably the new feedback generated statistically significant more time to answer the questions than the traditional feedback.

TABLE III
AVERAGE TIME NEEDED FOR EACH QUESTION IN SECONDS

Condition	N	M	SD
No feedback	13	14.58*	12.63
Right/Wrong	15	9.10	1.80
Social Ranking	14	13.56***	4.34
Both Feedbacks	13	11.34*	2.92

* $p < 0.05$; *** $p < 0.001$

Figure 5 shows a box plot of the four different conditions. Also a comparison for gender differences is displayed. In general male participants answered more questions (M = 53.26, SD = 21.23) than female subjects did (M = 48.41, SD = 21.67), but this difference is not statistical significant.

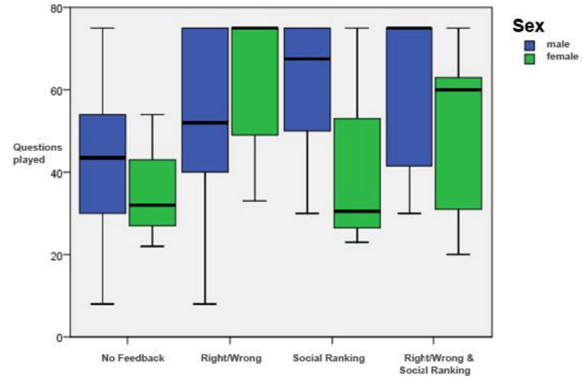

Fig. 5. Box plot overview for the four conditions and additional analysis for the different genders.

The analysis of the data reveals that feedback motivates to engage longer with the game, but an unexpected visualization could make the subjects need more time to conduct the experiment which is a considerable drawback. It is clear that the subjects with unfamiliar information (no feedback, social ranking or both feedbacks) on average needed longer for each question instead of the condition with the right/wrong feedback.

IV. DISCUSSION

The goal of the first five studies was to investigate, if feedback mechanisms can raise the participation in course wikis and if so which gamification elements perform best. The Social Ranking Feedback achieved by far the best results, whereat the feedback mechanisms in general show a statistically significant impact on user motivation. Gratitude and relative ranking are considerable alternatives, which also obtained statistical significant results. This is in line with other empirical results for relative ranking [11] and gratitude [2], [10], [11]. In summary using Social Ranking Feedback to increase user engagement worked very well for these five studies. A combination of competitiveness and additional information makes this feedback a well implemented gamification element.

The sixth study did take a different approach without using any additional incentives for a game to support learning analytics. The average participant in the feedback conditions played the game longer than in the no feedback condition. Despite this interesting result, participants in the feedback conditions need to elaborate longer if provided with missing or unexpected feedback. One possible explanation for this result could be a longer cognitive processing time by the subjects. Because no further measures were applied, other explanations despite cognitive workload could be responsible for this result. Additional interpretations need to be taken into account. For example, environmental factors (e.g. usability) and personal characteristics (e.g. intrinsic motivation) need to be included and analyzed in future studies as well [21].

Another issue to consider is the focus of only incentivizing quantity and not quality. Besides the problem of assessing quality, a recent study has shown that the valence of feedback can advance unwanted effects on participation [18].

These results maybe are only applicable to this kind of game and cannot be generalized to other learning situations. Further experiments are needed to verify the presented results.

Finally, this research is a unique approach which is hardly comparable to other studies. This due to the fact, that only quantitative aspects are relevant for the feedback. Also the feedback is generated automatically and not by humans [18].

V. Conclusion

This article summarizes the findings of six different studies regarding the effectiveness of feedback mechanisms for user motivation in different settings. The results show clearly that providing feedback mechanisms can enhance the participation of users to provide knowledge in a shared information pool like a wiki. Especially the Social Ranking Feedback At this point the use of feedback mechanisms to support technology enhanced learning is strongly recommended.

Nevertheless, by boosting participation, we do not only raise motivation of the subjects and students, but we can also gather more data for e.g. learning analytics and other related fields. Further field experiments are planned with this kind of feedback, e.g. to improve Massive Open Online Course (MOOC) services.

The development of successful and motivating applications to enhance user motivation is still considered more an art then scientific work [13]. “Fun is not a panacea” and it still very difficult to decide which game elements to use to enhance long term motivation [29]. The newly introduced Social Ranking Feedback proves to be a valuable addition to the possibilities of gamification. This feedback mechanism should be considered for new and existing applications, where user participation is crucial for the success of an online community.

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Teaching industrial plant using serious games

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***Abstract*—The development of tools that assist teachers in the teaching process and stimulate students to remain attracted to the subject being presented is a very important topic. This paper aims to present a serious game type simulator that can be used by students in high school and university. The simulator is intended to help the students to learn topics in physics and industrial automation by providing the simulation of the development and experimentation of industrial plants. Thus, it brings to the students an interactive computational environment to study the phenomena that are present in industrial processes.**

***Index Terms*— Serious Games, Industrial Plants, Education**

I. INTRODUCTION

Educational processes are under constant change over the years, boosted by techniques and tools that come with the intention of adding ways to improve the absorption of knowledge presented, and also provide more effective, dynamic and diverse forms of learning.

The principle of simulation facilitates the cognition, develops skills and beliefs on topics through practical experimentation and eliminates the need for tactile features that were necessary for the study of the processes involved in real environments. According to [1], the simulation allows us to check the operation of a real environment in a virtual environment, generating models that behave as reality, considering the system variability and demonstrating what will happen in reality, in a dynamic way.

The development of educational simulators are inserted in the field of serious games, an area that presents real expansion and acceptability in the current market, where consolidated companies focus their attention to use this technology as tools in different areas of activity. As examples of companies that use serious games and simulators for employee training, we can cite McDonald's, Burger King, Coca-Cola, Intel, Petrobras and Navy of Brazil.

This paper presents the development of a serious game for teaching industrial plants concepts to high school and university students. It is structured in 5 sections. The theoretical basis is presented in section 2. In the section 3, the proposed game is presented and in the section 4 the partial results of work are presented, Section 5 presents the conclusion and the future works.

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II. THEORETICAL REFERENCE

A. Serious Games as Teaching Tools

It is observed in the literature a large volume of studies in which the main aim is to validate the use of educational games and simulations in educational process of children, youth and adults. In most cases, positive skills were expanded as assimilation, acceptance and conviction about the topics covered. In general, the explanation most used by researchers in this area points out that with the use of simulators and educational games the knowledge transfer becomes more intuitive. In this way, the player/student learns in a dynamic and enjoyable way [6].

It is important to note that the concept and use of games as a way of learning is not new. Games have been used for education and training in various areas for a long time. As an example we can mention the "Army Battlezone", a project developed by Atari in the 80s, designed with the purpose of developing new forms of military training in battlefield situations. Since then, the development of this type of game presented a steady increase over the years and is used in numerous areas, such as oil industry, automotive industry, airline industry, management training, personal management, accessibility for people with special needs, medicine and so on. To better understand the application of simulation in education we follow [5]. According to [5] simulation is a form of experimenting new ideas and concepts under conditions that would be impossible to be obtained in the real world due to factors such as risks, costs or time.

In this way, it is possible to observe the importance of simulators and educational games as tools to learning process in different fields of knowledge, especially nowadays, where technology and video games have an increasingly participation in life and training of young people.

B. Industrial Plants

The development of Industrial Plants involves well structured procedures that make up a series of mechanisms that are part of the manufacture of one or more items.

The represented processes and the different structures that make up an industrial plant (see Figure 1) are supported by international standards that provide high level of use in all production levels, as evidenced by the components of the system. They can be stipulated in development, providing better strategic use of resources and enabling technical feasibility analysis, economic feasibility, aesthetic, product ergonomics and environmental impact [3].

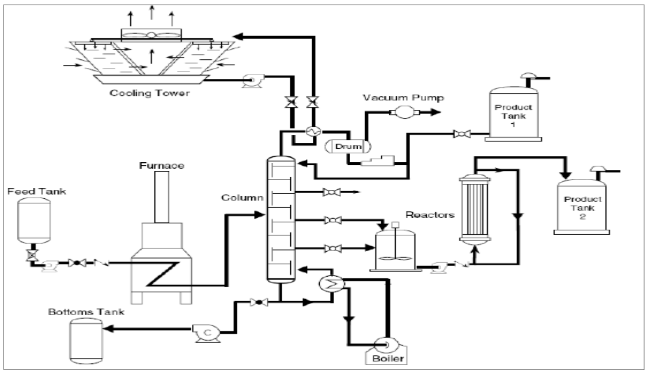

Fig. 1. Example engineering flowchart P&ID [4].

The development of industrial plants employs sets of dynamical systems. These dynamical systems can be modeled physically through the implementation of pilot plants based in prototypes or through their representation in mathematical models where the reality is abstracted in equations. According to [2], a mathematical model "is a representation of the essential aspects of a system that has knowledge of its system into a usable form." To [3], an industrial plant "is a system of equations with a solution, basing in a input data set that represents a process response."

III. The Proposed Game

Industrial plants are an important subject for learning in technical and engineering courses, because they are highly used by industries. However, it is a complex area (there are a very large variety of components and rules) and it is quite dynamic (for each situation, a different component must be used). In this way, we have decided to model this subject using a serious game, making the process of learning more fun.

The proposed serious game was developed based on software engineering principles [8] [9] [10]. All the modeling of the game can be found in [1].

The proposed game uses gamefication ideas [11] in the score of the game (the time to conclude each phase) and the rules to solve each phase (for example: the cylindrical tanks cannot link to control valves directly and hydraulic pipes are necessary). In this game, there is not a “game over”. All students will conclude each phase, with a different score (the time to solve the problem), but the idea is that in a second time playing, students will finish each phase faster.

The game was developed in Java and in its current version it has three phases. In each phase, the student can structure the solution to solve a problem through the development of an industrial plant, initially handling the following components: cylindrical tanks, control valves, hydraulic pumps and hydraulic pipes. Each phase has a complexity level related with the number of available components (in the first phase, the simpler, there are just three components). The next phases are more difficult to complete, thus the learning is incremental.

As part of the learning process, the student must configure and connect the components. He/she should change the parameters, as tank dimensions, the connector diameter or the pump power. After this, the student will simulate the process in a dynamic interface. Therefore, the student can stop the simulation and can change the values at any moment, until the simulation occurs in a correct way. The interface shows the values during the simulation, to help the students to better understand all the process.

Because the game is a challenge at the start of each phase an explanation screen is presented. In this screen a problem to be solved as well as brief explanations of how the students manipulate the components are showed. In each phase the time to solve the problem is recorded and a score is showed to the students. After the third phase the student obtains a final score and can compare it with the score of the other students.

At any time, the student may require a brief explanation or specific help about any component. In such case the interface presents a explanation of the equation used to model each process and how to use it in this game phase.

Figures 2, 3 and 4 show the interfaces of the game of each phase (first, second and third phase).

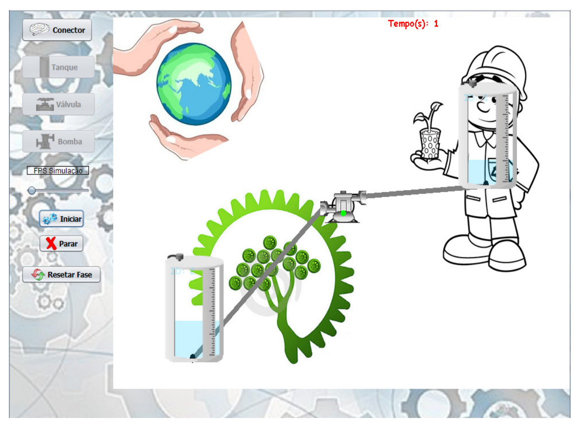

Figure 2 . Game First Phase.

In the first phase, the student must transfer water from the first tank to the second tank. It is a simple challenge, but it helps the student to understand the components and provide a quick solution. The second phase requires a similar reasoning as the first phase. However, in second phase there are two tanks that need to be connected in level to have water in equilibrium, thus, the power of the hydraulic pump must be configured to pass a higher volume of water to the other two tanks. In the third phase, the problem is to fill three different types of tanks (small house, medium house and apartments). To turn the problem closer to reality and to add some difficulty to it in this last phase the apartments' tank is larger, therefore, the student must change the flow rate to reach a good score and finish the filling of the tanks together.

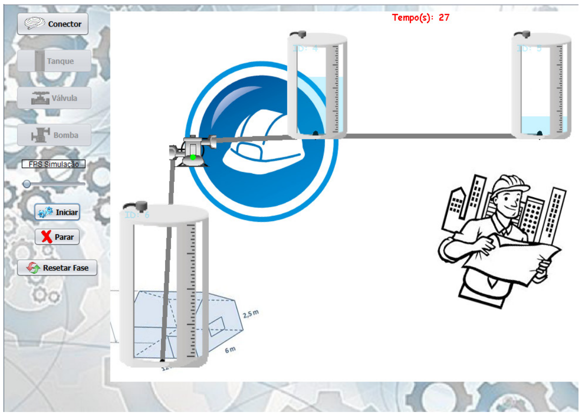

Figure 3. Game Second Phase.

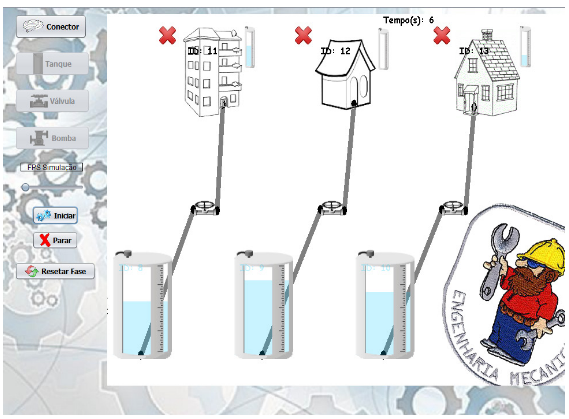

Figure 4. Game Third Phase.

Throughout the game, the student plays the game by configuring the simulator components. All the configurable parameters, game sets and data are recorded automatically in a database. Our idea is to analyze, in the future, the profile of players (There are different ways to learn? How do the students decide to change the parameters of the components?).

The database was implemented using PostgreSQL. The database contains six tables: User, which stores the student name and game date; Phase, which stores the phase data, as time; the other four tables (cylindrical tanks, control valves, hydraulic pumps and hydraulic pipes), store specific parameters of each components, as power or diameter (Figure 4). Each time that the student changes the values of each component, the database is updated.

IV. Parcial Results

We have tested the game with twenty five high school students (two groups) during the development of the game. The first student group tested the first phase, where some problems and difficulties were found. Their suggestions have helped us to improve the game experience. Considering, the players suggestions, the game was changed to make it more attractive to new players.

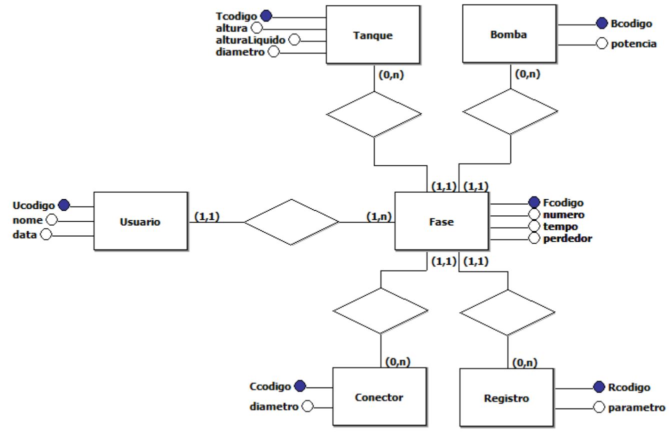

Figure 4. Data base entity model

The second group tested the first and second phases. They suggested some new tools/components, as for example the time (score) and the help during the game (explanation about each component).

The next step is to implement the fourth phase, where the student will enter in an extra phase with an empty scenario, but with a specific problem to solve. This problem could be: “There are three houses that need to link water from a single cylindrical tank. How to assemble this structure? Which components could you use?”. The students will have the freedom to assemble his/her own industrial plant and simulate this process. In this way, he/she will test new combinations of hydraulic components or to repair his/her doubts. To evaluate the fourth phase, we will verify if the student proposed solution solves the problem using the minimal components to it. If the student has used a bigger number of components, but the solution is correct, he/she will receive a lower score.

V. Conclusions and Further Works

In this paper, we presented a serious game with the proposal to teach industrial plants concepts to high school or university students.

We believe that the use of serious games can provide a motivational factor for the teaching of disciplines called "difficult", in a playful and intuitive way. Our game was implemented based on design patterns as modularity and reuse.

It was developed in Java, in order to ensure its portability. The game has been tested with high school student groups to check the usability and understanding of the game as well as store their moves to populating the database. As further works we will analyze these data and we will apply data mining techniques to identify players' profiles.

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Is this new? Family Resemblances in Gamification in Education

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***Abstract*—Gamification in education is often hard to distinguish from traditional approaches to teaching and learning as well as from educational games. We briefly present an instrument for the structured assessment of gamification in a given system, discuss its evaluation, and interpret results from its application to learning management systems. We discuss the usefulness of such a tool for further research in gamification in education and in answering the question whether gamification is actually new or just a digital adaptation of well-known principles.**

***Index Terms*—gamification, education, evaluation, learning management systems**

I. Introduction

GAMES, in various forms, play a large part in academic discussion of technology enhanced learning these days. Game-based learning (or serious games) and recently gamification have shown promising results and are experimented with in a variety of settings. (See [1] for an overview of gamification in education.) While both terms are derived from the term game, they differ in their application and use. We will briefly introduce a variety of definitions and discuss their usefulness.

In one early academic work on gamification, Deterding et al. distinguish between serious games and gamification as being on different ends of a scale from full game to elements [2]. Gamification, according to the authors, is "the use of game design elements in non-game contexts" [2]. Definitions of the term serious game mostly differ in their limitation to an educational context. Many follow Abt's definition of serious games as games with an "explicit and carefully thought-out educational purpose" [3, p. 9] whereas others include a broader spectrum of areas of application. Zyda, for example, considers serious games to be "a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives" [4]. A variety of similar terms exist, such as (digital) game-based learning or edutainment. Bente & Breuer [5] provide a good overview.

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Often, discussions of serious games and gamification are conflated and the two terms used interchangeably. When we reviewed the papers discussed in Hamari et al.'s review of gamification literature [6], we had to exclude some that dealt with full games instead [7]. Some authors question this distinction; Kapp, for example, considers serious games to be a subset of gamification [8, p. 18]. No matter how you frame the definitions, however, it is obvious that full games can have different effects (and require a different design approach) than the application of individual game design elements to a non-game context. In fact, much of the critique of classic approaches to gamification (such as points, badges, and leaderboards) stresses that adding these elements to an activity does not make it a game (c.f. [9]). It is therefore necessary to distinguish between the two in research, as one cannot generalize the success or failure of one approach to cover the other.

It follows that a good understanding of the term gamification is necessary for its study. Many authors have tried to define gamification, varying from rather precise definitions such as the one by Deterding et al. above to very broad ones such as Kapp's "using game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning, and solve problems" [8, p. 10] or even Zichermann and Linder's "the process of engaging audiences by leveraging the best of loyalty programs, game design, and behavioral economics" [10, p. xii]. The latter correctly refer to gamification as a process, a view indicated by the term itself (something is being game-ified) but not often discussed. If we pick any of the above definitions, it is relatively easy to identify whether a process can be considered gamification or not. Are the designers of the system taking elements from game design and applying them to a non-game context? If so, Deterding et al. would consider it gamification. Unfortunately, researchers rarely have the opportunity to investigate the process, instead we have to look at a finished system and identify whether it is the result of gamification.

Especially in education, this can be very difficult as many of the concepts used for gamification have already been used in education before the term even existed and did not necessarily originate in games. Gold stars or stickers given to students (c.f. [11]) have a strong similarity to badges, a mainstay of contemporary gamification, and the focus on autonomy, competence, and relatedness stressed by gamification literature is hardly new to education either (c.f. e.g. [12]). Awarding stickers to elementary school children could easily be considered gamification according to Deterding et al.'s definition, even though teachers most likely did not actually make use of an element from games but rather one that happens to also be used in games.

One tempting distinction is the choice of medium. Most implementations of gamification discussed in literature use digital media (see [1] for a breakdown focused on education) and many elements are adapted from computer games. One could therefore argue that the methods of gamification are not new, but that their use in digital media is. That would mean that getting a sticker for handing in your homework on time would not be gamification, but getting a badge in a digital system would be. While such a distinction would solve the problem of gamification not being new, it does not seem very useful. Technology certainly has an influence, but it is dangerous to overemphasize its importance. In the context of literature, Aarseth points out that such distinctions often "obscure the more profound structural kinships between superficially heterogenous media" [13, p. 14]. Excluding non-digital forms from the definition of gamification would mean the loss of much information that is very likely to transcend the choice of medium.

Nevertheless, the process of gamification is relatively new, even if its results are often similar to other approaches. Furthermore, we see a large variety of definitions being used, depending, among other factors, on the context that the gamified system is used in. A similar variety of definitions can be observed for the term game itself. Many scholars and game designers have attempted to find proper definitions of the term (e.g. [14, p. 80], [15, p. 36], [16, p. 34]), making the question of whether something constitutes a game increasingly complicated. Arjoranta [17] proposes an approach to defining games that is not nominal in nature, but rather follows the idea of Wittgenstein's family resemblances [18, p. 27e]. There are various kinds of games that have some properties in common with other games - but not necessarily all of them. Following such a definition, one cannot have one set of properties that defines all games, but rather a larger set of properties that can be found among games.

We have taken a similar approach to an attempt to define gamification. Instead of looking for the one, true definition of the term we are rather interested in a list of properties that many gamified systems have. Individually, such properties would not signify gamification, but a system that has several of those properties would resemble other gamified systems enough to be considered gamified itself. One would expect that gamified systems for education would also share some of those properties with other educational approaches, but in a smaller proportion. Ideally, such research would also allow us to identify groups of gamified systems that are related closely to each other, with other groups being considered extended family. Furthermore, it would be able to show the relation between gamification and established teaching techniques and their differences. Unfortunately, literature does not provide us with a consolidated set of properties of gamified systems. Many authors mention some, but only points, badges, levels, and leaderboards are almost ubiquitous in literature. We will briefly describe an approach to generating such a catalogue, the instrument itself, as well as early results of its use.

TABLE I
EXAMPLE ITEMS FROM THE GAMIFICATION INVENTORY

#	Category	Subcategory	Question
E1	experiential	accomplishment	Does the system provide the user with a sense of accomplishment?
E3	experiential	challenge	Does the system include tasks designed to be challenging for the user to complete?
M1	mechanics	collecting	Does the system provide opportunities for the user to collect things?
M7	mechanics	storytelling	Does the system make use of storytelling?
R5	rewards	points	Does the system reward users with points of any kind?
G1	goals	clear goals	Does the system provide the user with clear goals / ideas about what to do next?
S1	social	fame / getting attention	Does the system provide means for the user to gain fame / attention?

Full instrument available at: https://db.tt/DaZNzaTA

II. Gamification Inventory

A. Method

In order to identify a set of properties that may signify membership in the family of gamified systems, we followed a two-step process. At first we collected a set of 60 terms that are used in literature (e.g. [8], [12], [15], [19], [20]) to describe games or gamification. Similar terms were conflated. A full list of all terms and an example reference for each can be found at https://db.tt/WOyS3CTf. Please note that many of these terms have been adopted by a variety of authors and that the examples listed do not necessarily point to their first mention. These 60 terms were then distributed to 13 experts in an expert survey. Experts were recruited from a list of authors of peer-reviewed papers on gamification as well as among the participants of a workshop on gamification at the Mensch und Computer 2014 conference. The experts were asked to rate each term as a) relevant to a description of a gamified system of their choice, b) relevant to a description of gamification in general, or c) not relevant for a description of gamification. The experts were further asked to name any other terms that they considered to be relevant. There was no limit to the amount of items the experts could mark as relevant. Unlike nominal definitions, this approach embraces the fact that not all gamification has identical results, but rather results that resemble each other. By asking experts what the most important properties for describing gamified systems are, we could identify areas in which gamified systems may overlap.

Out of the 60 predefined terms, all terms that were mentioned as relevant by at least two thirds of the experts in either a) or b) were included for further consideration as well as all terms that at least a quarter of experts added manually.

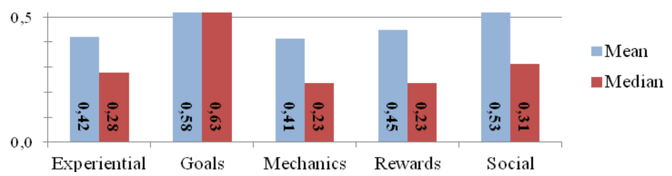

Fig. 1. Average disagreement between raters in each category as the sum of variances in responses for each item.

B. Description of the Instrument

This resulted in 38 terms, which we grouped into five categories. Two categories contain most of the items, split according to an experiential / systemic dichotomy (c.f. [21]). The other three categories (rewards, goals, social) are mostly systemic in nature as well, but address specific issues often discussed in gamification literature and therefore deserve highlighting.

The experiential category contains terms dealing with the user's experience, or, more specifically, with affordances for specific experiences. An example item is competence, meaning whether the system affords the user feeling competent. The second category, system mechanics, deals purely with the functionality of the system. (Interactive) storytelling, for example, is a mechanic that can be adopted from games. The rewards category highlights some mechanics that are very common in gamification, those dealing with extrinsic rewards – such as points or badges. Similarly, the goals category includes those items that stress the importance of goals and structured tasks in games. Finally, the social category encompasses social functionalities that one might adopt from games.

For the use of experts, we have expanded the terms from the survey to questions that can be answered in the positive or the negative and asked for descriptions of how each term was expressed in the analyzed system. The resulting inventory (see Table 1 for example items) allows for a structured investigation of gamification aspects in a given system and a structured comparison of such systems.

C. Evaluation

The catalogue is by no means final, but rather provides a preliminary synthesis of gamification literature and expert opinions. Further adaptation is best done through application of the instrument. We have taken a structured approach to a first evaluation of the instrument by asking four evaluators (one expert and three evaluators with basic training in gamification) to analyze the same five systems for gamification and comparing their results. Details of the evaluation will be available elsewhere, but we will include a summary of conclusions here.

Inter-rater reliability on the standardized part of the instrument was rather low (Fleiss' kappa, $\kappa = 0.23$). A variety of possible explanations exist – among them the relatively low knowledge of gamification theory among three of the evaluators, leading to a misunderstanding of terms, the test setup, and the inclusion of a "maybe" option in the standardized part of the instrument. Analysis of the free-form responses shows, that in many cases evaluators found the same functionality but chose to rate it differently in the standardized part.

Such disagreements in ratings as well as in the understanding of the meaning of certain questions were not evenly split among questions. In order to identify the items with the highest disagreement among evaluators (indicating the need for improvement of those items), we calculated the sum of variances in ratings. Items with high disagreements were spread widely among the five categories (see Fig. 1) and included (in order of disagreement, highest first) learning / mastery, social engagement loops, points, nurturing/growing, positive emotions, challenges / quests / missions / tasks, time pressure, clear goals, relatedness, competition, cooperation, fixed rules, and progress. All other items showed very low variance in their rating.

While these results show that there is room for improvement in the instrument (as well as a need for additional validation), a disagreement between raters is irrelevant when the instrument is used for its primary purpose – structuring an individual expert's analysis of gamified systems and providing a framework for the detection of family resemblances.

D. Application to Learning Management Systems

An example application of the inventory on a set of learning management systems (LMS) is described in [22]. Four experts were asked to describe the gamification of each of five LMS using our instrument. The results showed strong family resemblances between the systems, employing a gamification strategy mostly focused on the awarding of badges to students. All systems were also rated as providing a sense of accomplishment, learning/mastery, and positive emotions to the user as well as allowing for autonomy. Curiosity, purpose and concentration were notably absent in the experiential category, as were game-like mechanics such as nurturing/growing, storytelling, and surprise. The systems were not identical in their expression of each item, however, exemplified by the use of time pressure and cooperation in some but not all systems.

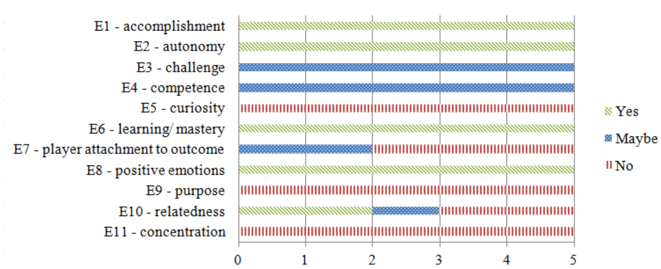

Fig. 2. Comparison of five learning management systems in the experiential category. Originally published in [22].

III. Discussion

The instrument we have briefly introduced here is an application of Wittgenstein's concept of family resemblances to gamification. As the results of our expert survey show, there are many properties of gamified systems that experts consider to be important to describe its gamification but that do not individually signify its presence. E.g. accomplishment, autonomy, or feedback alone do not signify that one is dealing with a gamified system. The system may have been created through the process of gamification, but it might as well not have any connection to games at all. The higher the amount of items in our inventory that are answered in the positive, the more likely it is that gamification played a role in the process. Applying our inventory produces much more useful information, however. For one, one can identify similarities and differences between different gamified systems, eventually allowing for subcategories within the family of gamified systems that allow for more focused research. One example of such similarities has already been shown in [22] between different learning management systems. For another, it allows for a structured comparison between the expressions of each property of gamification. Some properties in the instrument are already rather specific (e.g. badges), but other properties allow for many different implementations. Autonomy, for example, may be reached in a variety of ways and degrees. In the example of LMS, autonomy was mostly provided through the ability to choose when to complete tasks and the order in which to complete them. Further possibilities for autonomy could be the ability for learners to choose what to learn or how to prove acquired competences to the teacher. The open, qualitative part of our instrument is essential for such comparisons and more detailed analysis.

Returning to the question of gamification's novelty, it will be very interesting to analyze the resemblances between educational systems that are considered to be gamified and traditional approaches to teaching. If gamification really is just a collection of old techniques applied to a new medium, one should be able to find very strong similarities in the analysis. If there are differences, these may help us to identify which parts of gamification are actually new and innovative - and possibly even candidates for use in traditional media as well.

IV. Conclusion

We have introduced the Gamification Inventory, an instrument for structured assessment of gamification in a given system. While improvements and further evaluation are necessary, the instrument has shown itself to be useful in comparing the results of gamification in different systems. We have shown a strong family resemblance in the way LMS are gamified. The concept of using family resemblances instead of nominal definitions seems to be useful for the discussion of gamification and may help to bridge the gap in understanding between gamification and traditional teaching methods. We hope that both such a more nuanced approach to gamification and our instrument can be helpful in further research on the topic. Examples of further research include the application of the Gamification Inventory to additional digital systems and to more traditional teaching methods. Not only will this deepen our understanding, it will also help improve the instrument itself. Eventually, we should be able to understand whether gamification is simply a way of doing old things with a new technology or whether it has inherent added value.

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On Using Games to Enhance the Learning Experience in Egypt

Shaimaa Lazem, Kamal Bassuony, Mostafa Gaber, Karim Youssef, and Mohammed Morsy Farag

***Abstract*—The presented research is based in a rural community of a developing country with major socio-economical challenges; Egypt. We discuss how educational technologies, games in particular, could motivate the students cope with some of the stresses in their learning environment such as the lack of appropriate teacher feedback due to the crowdedness in the classroom. Educational games could additionally help the teachers better organize their limited time. We propose a model for integrating educational games in the learning environment inside and outside the school. Furthermore, we present a prototype for an affordable multi-player interactive floor that allows for various gaming scenarios.**

***Index Terms*— Game Technologies, Interactive Floors, Cooperative Play, Technology-Enhanced Learning**

I. Introduction

Rural communities in Egypt are the least receiving of adequate services. Students face various stresses such as the lack of qualified teachers, and the lack of parental support due to illiteracy. Moreover, the crowdedness in the classrooms prohibits the students from receiving appropriate attention and feedback from their teachers. Students hence resort to private tutoring [1], [2].

It is worth mentioning that despite the economic challenges, there are significant efforts to supply every school with a computer lab, and an Internet connection, sometimes with the help of foreign aids and technology giants such as Intel.

This research is based in Borg El-Arab, a rural community located in the North West of Egypt. The children in Borg El-Arab have access to some sort of technology. Many of them have personal computers or access to Internet cafes at moderate prices. Recently, a cloud infrastructure has been set up in a national research center, the City of Scientific Research and Technological Applications, located in Borg EL-Arab. Therefore, planning for an educational reform in Borg El-Arab that benefits from large-scale digital solutions is an attainable target.

The focus of the presented work is primary school students, hoping that the enhanced learning environment will discourage the students from dropping out of school.

Educational games could come in a variety of genres and difficulty levels, and could be designed to emphasize either the understanding or the practice of various skills [3].

Often educational games track and record the students' performances, which allow the teachers who have access to this data to provide their attention to the students who need it the most (*e.g.,* low-achievers). It additionally means that the good students could advance their skills by playing the games with minimal supervision. Moreover, games could create a good basis for a dialogue between the illiterate parents and their children about the children's performance in the school.

We present a model for integrating educational games in the schools. We further propose a prototype for an affordable interactive technology that could be appropriated for various gaming experiences. A further discussion about the games supported by the prototype is presented.

II. A Model for Integrating Educational Games in the Schools

We argue that educational games should be integrated with the curriculum, and personalized for one-to-one use outside the classroom. Figure 1 demonstrates an example for a web platform that includes educational games, a communication and collaboration platform (e.g., social media), and an analytics engine. The students, their parents and the teachers could access the web platform.

The educational games provide educational games designed to support the curriculum. The students play individually or in groups. The games provide feedback to the students to help them reflect on their mistakes. Classic gamification techniques such as badges and leaderboards, could be used as extrinsic motivators that are recognized, but not enforced, by the school to encourage the use of the platform.

For every student, the games record some performance indicators such as the number of correct and wrong answers, and the time taken to solve a question. The logged data is analyzed by the analytics engine, and the results are shared in a comprehensible format with the parents and the teachers. The automated data recording and analysis reduce any possible intimidation for the students to enroll in private tutoring.

The web platform allows the students to communicate and share their play and study practices with their peers from the same school or other schools. They could start a study group, or explore material outside the curriculum.

We propose one example for re-designing a learning activity in math classrooms around educational games. A substantial

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part of the Egyptian math curriculum in the second and third primary grades is dedicated to memorizing multiplication facts. Using educational games, the teachers could focus in the classroom on the conceptual understanding of the multiplication process and its properties, while the students play multiplication games to help them with the memorization part. The teachers could plan their lessons around providing compelling examples for the multiplication facts, where the students struggle the most, or providing feedback about the students' performance in the game.

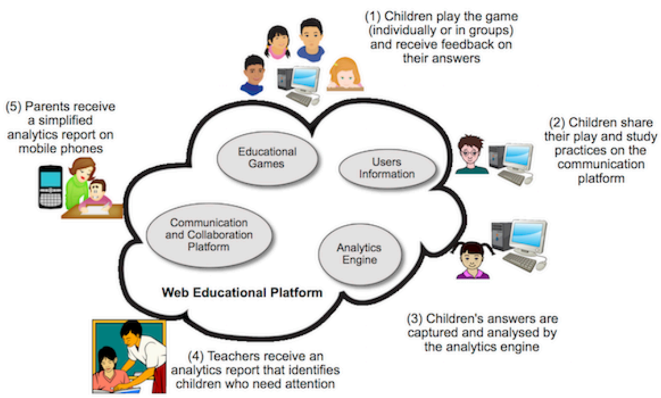

Figure 1: The proposed model for integrating educational games in the Egyptian schools.

Multi-player games offer opportunities for knowledge sharing among the students and their peers. An open technical challenge for developing countries is to provide an exciting multiplayer gaming experience using affordable technologies.

In the following we propose an example for an affordable interactive floor that simultaneously identifies and tracks multiple students. We review the literature of interactive floors to position our contribution. The interactive floor implementation is then described.

III. Related Work

Interactive floors could be designed using several technologies such as vision-based tracking, pressure sensors, wireless sensor networks (WSN), Radio Frequency Identification (RFID), and Light Emitting Diodes (LED). Examples from the literature are provided below.

iGame Floor [4] is an interactive floor that is covered by a glass projection surface ($3m \times 4m$). The glass surface consists of the carrying glass, a diffusion layer, and a hard protection surface glass. Four cameras are placed $3m$ under the floor, which capture pictures for the floor to detect the limb contact points and hence the movement of the person on the floor.

Luzardo *et al.* [5] introduced an interactive floor with a client-server system. The server processes the image stream from an overhead mounted camera and generates information about the location and shapes of users' blobs. The information is passed to the client, which creates the responsive graphics that are projected on the floor.

Z-tiles [6] were proposed as a modular design for pressure sensing floors. The floor is assembled into tiles. A Z-tile has 20 force sensitive resistors on its surface, designed with a mixture of silicon rubber and carbon granules. When a person stands on the tile, the tile senses the pressure of the person and detects her position but not her identity.

Scherhaufl *et al.* [7] proposed a passive ultra high frequency RFID tag localisation system using a multichannel reader. The RFID reader generates a continuous wave and the tag reflects the signal to the reader, which receives it on multiple channels. The phase of arrival indicates the length of the signal path, and hence the tag position.

Nadeem *et al.* [8] proposed a system for 3D positioning using white LEDs. LEDs are attached to the ceiling of the room as transmitters, one of them is considered the reference LED. LEDs transmit signals using frequency division multiplexing, meaning that each LED transmits at a different frequency. The receiver is a photodiode, which has a circuit contains a band pass filter, frequency down converter, and the positioning algorithm. Estimation of the position is done by solving simultaneous equations based on the phase difference. They did not tackle the case of multiple users.

Vision systems are often affected by environmental factors, such as ambient light and shadows, which may limit the flexibility in deploying the floor inside the school. Moreover, the precise tracking of multiple persons is possible only if every person limits her movement to a pre-defined area on the floor, which constrains the type of games being played on the floor.

On the other hand, pressure sensors are robust against environmental factors, but less accurate in distinguishing individuals of similar weight or footstep pattern.

Wireless communication technologies such as WSN, RFID, or LEDs are more capable of identifying the user since the sensor sends and/or receives identification data. We chose passive low frequency RFID tags because they are light-weight, low-cost, and portable as they do not require external power sources.

IV. An Affordable Multi-player Interactive Floor

The proposed interactive floor design allows simultaneous positioning and identification for multi-players. We describe the technical design, and propose examples for using the floor in multi-player games. General design principles for the games are discussed.

A. Technology Description

The multi-player interactive floor consists of N tiles as shown in Figure 2. The hardware system consists of one master circuit, and slave circuits (RFID detection circuits) embedded underneath each tile.

The students wear the RFID tag in their feet, the tag is read by the RFID detection circuit. The floor uses proximity-based identification, where the location of the RFID reader position is used to indicate the student's position.

The design supports up to N students moving concurrently on the floor as long as each student stands exactly on one tile.

The system returns the tag ID and the tile number on which the student is standing.

The master circuit is connected to the computer (PC) via a USB port and wirelessly to the *N* RFID detection circuits. It is responsible for managing the communication between the slave detection circuits and the PC.

The master circuit includes a low-cost wireless module nRF24L01, a USB to Universal Asynchronous Serial Receiver and Transmitter (UART) converter, and a low-cost micro-controller ATMEL ATmega8.

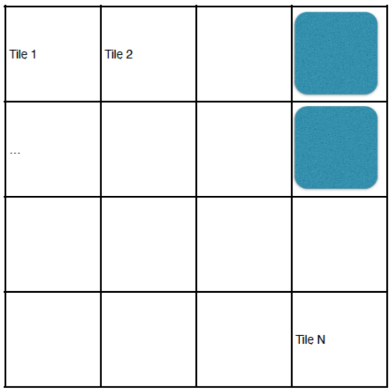

Figure 2: The RFID detection circuit, represented by the colored rectangle, are placed underneath each tile.

The nRF24L01 module has high speed communication air data rates up to 2*Mbps* with low power operation (*i.e.,* 11.3*mA* TX current and 13.5*mA* RX current), and its communication range is up to 60*m*. The communication protocol between nRFn24L01 and the PC is the Serial Peripheral Interface (SPI). Due to the unavailability of USB to SPI converters in our local stores, we used a USB to UART converter instead.

The ATMEL ATmega8 micro-controller, which has the two communications peripherals SPI and UART, is used to bridge the communication between the PC and the nRF24L01 wireless module. The nRF24L01 was configured using an open source firmware [9] .

The slave detection circuit consists of a passive RFID reader, a low-cost micro-controller ATMEL ATmega8, and a wireless module nRF24L01 that is similar to the one used in the master circuit. The circuit is responsible for reading the ID of the RFID tag or lack thereof and sending the readings wirelessly to the master circuit along with the number of the tile being read.

We use a RDM6300 module, which is an affordable low frequency passive RFID reader. RDM6300 reads the tag ID by sending an RF signal to the tag and receiving the reflected signal back from it using external loop antenna made of copper coil that operates at 125*KHz*. The dimensions of the antenna are 2.5*cm* × 3*cm*.

The system has two concurrent operations. The first operation is performed by the slave circuits periodically and independent from the PC. The RFID reader detects the tag ID (if present on the tile), and stores the ID along with the tile number (from 1 to *N*) in the slave micro-controller.

The second operation is performed by the master circuit to collect the data from all the slave micro-controllers, and forward it to the PC. For each tile, the PC sends the number of the tile to the master micro-controller, which forwards it to the corresponding slave micro-controller via the wireless modules. The slave micro-controller uploads the data back to the master circuit, which forwards it to the PC.

Figure 3 shows the analytical and empirical measurements for the total time taken by the PC to scan 1 ≤ N ≤ 12 tiles (Tscan). Our analytical model provides a good estimate for the empirical results. A floor with 12 tiles, could be scanned in less than 100*msec* thus providing a real-time multi-player gaming experience.

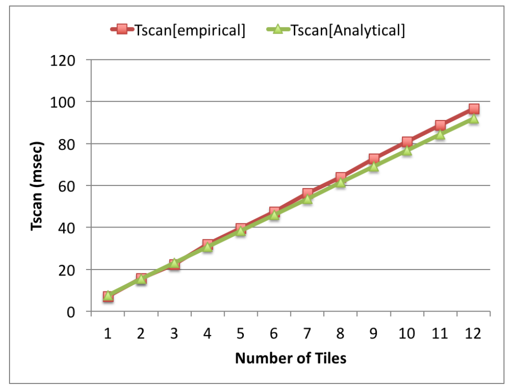

Figure 3: Empirical vs. analytical results of Tscan or the time needed for the computer to read the tag IDs from the floor (if present), for different number of tiles.

B. *Multi-player Interactive Floor: Gaming Scenarios*

We present several scenarios for multi-player games that could benefit from the proposed floor design. Students could interact with the game floor using several alternatives offering different user experiences. They could wear feet bands with RFID tags and move on the tiles. Alternatively, the RFID tags could be attached to some game tokens that students move on the tiles. Furthermore, since the tiles are not connected to each other, and connected wirelessly to the master circuit, the floor could be re-organized in different shapes to fit with a variety of game designs.

When students move on the floor, the game information is projected on the floor or the wall so that all the students could conveniently read it. Figure 4 shows an example for a simple game interface, that maps the floor tiles on the screen.

Games could be played without data projection by covering the floor with indicating labels, *e.g.* board games. The game information is displayed on a tablet held by a teacher/ or a facilitator who leads the game and provide the game instructions.

A suggested educational game is one that displays, on the screen, a question and multiple answers randomly distributed on a board analogous to the floor board. The students take turns to move on the floor and stand on the tiles corresponding to the right answer. For instance, the questions could be multiple choice arithmetic or spelling questions.

Games could be played by more than one team. A suggested example for a two-teams game is a word game, where each team is supposed to make moves on the board to construct a sentence or a word from a given set of words or letters distributed on the game board.

Another example would be an arithmetic game, where two teams compete to find the factors of a certain number from a set of random numbers distributed on the game board, the team who moves to the correct answers first wins.

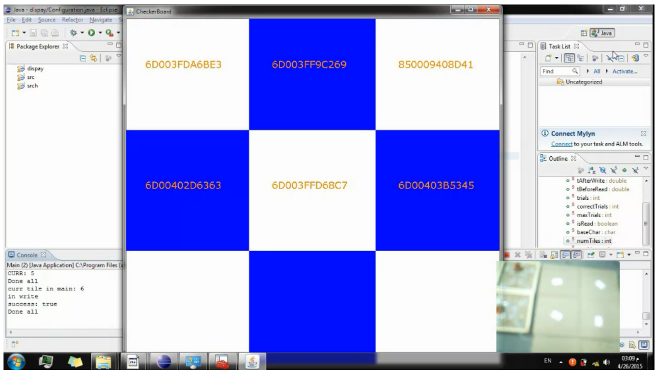

Figure 4: The bottom right corner shows six tiles (with two flipped to show the circuits), above which the tags are present, the game board shows the tag numbers. The numbers could be replaced by the player names.

C. *Design Principles*

We propose some design principles for the educational games designed for the interactive floor.

Firstly, the games employ physical movement and thus require the students to coordinate their body movement and their thinking. Therefore, sufficient time should be allowed for the students to solve the game exercises. The physical play might be of particular importance in Egypt and other countries with similar economic challenges that lead to the reduction or elimination of the physical training activities.

Secondly, the game design adopts a form of retrieval practice [10], as a learning strategy that helps the students strategize their study practice based on what they do not master. Other learning strategies should be explored.

Thirdly, the content of the games is self-explanatory so it could be administrated by facilitators (inside the school), or illiterate parents (outside the school).

V. Conclusion

We proposed a model for integrating educational games in the classroom activities in the Egyptian schools. The merits of using the educational games will be fully achieved, when aligned with the curriculum, and the teachers' pedagogy in the classroom. Therefore, we argue that each school should have the flexibility of implementing the proposed model according to its available technological and human resources.

We presented a prototype for an interactive technology that support cooperative game scenarios beyond the desktop. We work on designing educational games for the proposed technology with the participation of teachers and students as major stakeholders.

The psychological and emotional implications for using educational games in an open shared space will be considered in the design process. Furthermore, a balance should be sought between competition as a classic derive in games and tolerance for failure to maintain safe, comfortable, and accepting learning environment.

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“Everybody is playing the game, but nobody's rules are the same”: towards adaptation of gamification based on users’ characteristics

Ana C. T. Klock, Isabela Gasparini, Marcelo S. Pimenta and José Palazzo M. de Oliveira

Abstract — **Nowadays it is usual to implement game elements and design in non-game contexts to promote user´s motivation and engagement. This process is called gamification. However, gamification is being implemented in a one-size-fits-all approach, considering that all users react the same way for the gamification elements. The purpose of this work is to explore some characteristics that influence the gamification success and could be considered to adapt the use of these elements in an adaptive educational hypermedia system. Some influencing characteristics found were player type, age, gender, motivation, personality and culture. Based on these findings, we present a conceptual model for the gamification of educational environments. This is the first step to an approach to adapt the gamification elements in an adaptive educational hypermedia named AdaptWeb®.**

Index Terms —**Adaptation, Adaptive Educational Hypermedia System, Conceptual Model, Gamification, Users’ Characteristics.**

I. INTRODUCTION

THE use of game elements and game design in non-game contexts (i.e., gamification) is increasing each day more by the motivation it provides to achieve an specific goal [1]. These non-game contexts include shopping (e.g., eBay gives badges to the best sellers), hanging out (e.g., Swarm levels up the users who share their experiences about places), working out (e.g., Nike+ gives points for each workout the user does), recycling (e.g., RecycleBank gives points to users who recycle and use less resources like water, electricity and fuel) and learning (e.g., Duolingo rewards users while they learn a new language) [2]. But, despite being widely used, gamification has been applied using the traditional one-size-fits-all approach and ignores that users’ characteristics can influence their behavior within the system and, consequently, in gamification success.

Based on it, the purpose of this work is to expose some users’ characteristics that influence the success of gamification elements and to present a conceptual model to gamify educational environments considering why gamification would be important (what are the wanted behaviors?), who would be influenced (what are the students’ characteristics?), how this influence would be (what are the most recommended gamification elements?) and what must be changed (what implementation requires?). To achieve this goal, section 2 provides a conceptual foundation about gamification and adaptive hypermedia systems. Section 3 exposes the related works, describing some characteristics that influence users’ behavior in the system. Section 4 describes the conceptual model for the gamification of educational environments. Section 5 concludes with final remarks obtained with this work and our future work.

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II. CONCEPTUAL FOUNDATION

A. *Gamification*

Gamification can mean different things to different people because it brings together all the disparate threads that have been advanced in games for non-gaming contexts [3]. Generically, it can be defined as the process of game-thinking and game mechanics to engage users and solve problems [3]. In the educational context, gamification is “a careful and considered application of game thinking to solve problems and encouraging learning using all the elements of games that are appropriate” [4].

Currently the term “gamification” has become equal to the concept of rewards [5]. To promote this reward, gamification uses a series of elements that, when correctly applied, promises a meaningful response from the players [3]. These elements can be divided into three categories: i) Dynamics: big-picture aspects considered but which can never directly be applied to the game; ii) Mechanics: basic process to drive action forward and generate player engagement and; iii) Components: specific instantiations of mechanics and dynamics [6]. Some of the most used gamification elements are described below.

Challenges, customization, feedback, cooperation and competition are examples of Dynamics. *Challenges* are tasks that require effort to be solved [6] and they direct players for what must be done in the system (i.e., the goal to be achieved) [3]. *Customization* allows the user to change the environment and even a simple player headshot or screen name provides an opportunity to customize [3]. *Feedback* consists of returning information to keep players motivated and they are generally seen in the interplay between points and levels [3]. *Cooperation* and *Competition* put players in touch with others, requiring them to work together to achieve a shared goal or competing against others [6].

Constraints, narrative and progression are examples of Mechanics. *Constraints* impose characteristics (hard limitations or forced trade-offs), defining what actions players can and cannot do [7]. *Narrative* brings a consistent or ongoing storyline to interconnect the gamification elements used [6]. *Progression* demonstrates the player's growth and development in the system over time [6].

Badges, leaderboards, levels, points and virtual goods are examples of Components. *Badges* reward users after the completion of goals and can be used to measure progress [3]. *Leaderboards* give meaning to other components (e.g., points and levels) by putting them in a context (how the player is when compared with others) [7]. *Levels* structure the tasks users must complete to finish the level, usually giving the sense of progression [8]. *Points* are a numerical representation of the user progression [6] and they can be divided into *Experience Points* (reward for everything the player does), *Redeemable Points* (used in exchange for things), *Skill Points* (assigned to specific activities), *Karma Points* (that a player can give to another player) and *Reputation Points* (used to indicate trust between players) [3]. *Virtual Goods* are a component with perceived or real-money value [6], generally used for customization or as a reward of a challenge and possibly encouraging cooperation.

B. Adaptive Hypermedia Systems

Adaptive Hypermedia Systems (AHS) are hypertext or hypermedia systems that store data of the user's profile in a model to be used throughout the interaction in order to adapt the system according to the needs of a particular user [9]. AHS are an alternative to the traditional one-size-fits-all approach, where all users receive the same contents and materials, and access the same set of links [10].

The user model stores data from various sources: by observing the user interaction (implicitly) or by requesting data through a form to be filled out manually by the user (explicitly) [11]. The amount and type of information stored in depends on the type of adaptation of the AHS. Some examples of information are goals, tasks, knowledge about the subject or about the hyperspace structure, background, point of view and perspective and preferences [9].

Through the user model, the AHS can adapt the presentation or the navigation. The presentation of content is based on the user and the context of the human-computer interaction to organize and present the information to users [12]. This adaptation can be done in the content level (which defines the most relevant contents to the current user and how to structure these contents before presenting them to the user) or in the presentation level (which defines how to adapt the presentation of content selected more efficiently to the user) [12]. To adapt the navigation, the AHS can use various elements to suggest the best path to continue the navigation, to prioritizing certain links or even to hide, remove or disabling irrelevant links [13].

AdaptWeb® (Adaptive Web-based Learning environment) is an open source and web-based adaptive system for distance education that adapts contents, presentation and navigation [14]. To do so, it stores information about course, knowledge, navigational preferences and history of each student. The AdaptWeb® architecture is based on four modules: authoring, storage, content adaptation and adaptive interface. The authoring module involves structuring and organizing of instructional content in an authoring tool. The storage module receives the authoring module structure and stores data in an XML file that will serve as the basis for generation of the files that are used in the other two modules. The content adaptation and the adaptive interface modules work in an integrated way, adapting the content and the menu through the XML generated in the storage module based on the user model [15].

III. Related Work

In this section, it is discussed some studies and experiments that reported the influence of the users' characteristics on the success of gamification elements used.

Some of them indicate that **player type** is one of these characteristics. The work of Barata *et al.* [16], for instance, classified the students of a engineering course by their performance and gaming preferences: i) *Achievers*, students who do their best to earn points and are benefited by most gamification elements; ii) *Regular Students*, students who are motivated by challenges and achievements; iii) *Students halfhearted*, students motivated only by challenges and; iv) *Underachievers*, students who are not motivated by the gamification elements and do just enough to pass.

Another work about player type, applied in general context, makes a correlation between five personality types and traits and eight player types. As a result, Ferro *et al.* [17] proposed a classification unifying all personality traits and player types analyzed into 5 types: i) *Dominant*, users with a strong need to be visible and usually confident, egotistical and self-driven (motivated by badges and leaderboards); ii) *Objectivist*, users who seeks to achieve and build upon their knowledge through demonstrating their dexterity and intelligence (motivated by levels and progression); iii) *Humanists*, users more inclined to be social and involve themselves in tasks that rely on social engagement (motivated by customization and narrative); iv) Inquisitive, users who like to explore and investigate new things (motivated by challenges and narrative) and; v) Creative individuals like to create and develop things through utilizing skills that they obtain through experimentation (motivated by challenges and customization).

Besides the player type, the **age** of the user may interfere in the gamification process. For instance, the work of Atalli *et al.* [18] evaluated the effect of points on the students' performance in an assessment about basic mathematics concepts. To do this, they conducted two studies. The first one (with adults) found no effect of the point manipulation on accuracy of responses, although the speed of responses increased [18]. The second one (with 6 e 8 grade middle school students) found the same results for accuracy and speed [18]. But, in the second study, the students' reactions revealed higher likeability ratings for the test using points [18]. This indicates that teens can be more engaged than adults when using a gamified system.

There are also studies evaluating the influence of the **gender** of the users in gamified educational systems. One of them is the work of Christy *et al.* [19] which used leaderboards to assess the engagement of female students in a math class, separating the students into two groups: the first group visualized a leaderboard with a predominance of male names and the second group visualized a leaderboard with the predominance of female names [19]. In this experiment, the first group had higher scores on knowledge tests than second group, but also, the second group had a better academic identification (which involves academic preferences such as liking or not going to class) according to a questionnaire [19]. Su *et al.* [20] performed an experiment with three classes of fourth grade students that were studying the fundamental knowledge of insects in a natural science course. When using the gamified system, male students have higher learning performances than female students [20].

The **motivation** of the users may also influence on the gamification process, as explained by Hakulinen *et al.* [21]. They analyzed students based on the "achievement goal orientation", which is a psychological conceptualization that characterizes students' preferences to different goals and outcomes [21]. Typically, goals are classified into mastery goals (to master a task) and performance (to show competence in relation to the others) [21]. These goals can be further divided into intrinsic mastery (learning new skills), extrinsic mastery (succeed in school), approach valence (being better than the other students) and avoidance valence (avoid situations where mistakes may occur) [21]. They are not mutually exclusive but each individual has a mixture of goals with varying intensities [21]. Their work states that the users' motivation can interfere with gamification process, because students motivated by intrinsic mastery, extrinsic mastery and approach valence tend to be more engaged by the badges than the students motivated by avoidance valence [21].

The **personality** is another characteristic being studied in the gamification process. Codish *et al.* [22] made an experiment with an undergraduate information systems course to examine the students' perception of playfulness. Students completed a five-factor personality test and answered questions about their gaming preference. Their analysis concluded a higher preference level for badges by introverts and higher preference for progression by extrovert personalities [22].

When talking about feedback, the **culture** may also be considered. One study applied in general context conducted by Almalik et al. [22] identified some key differences between Western (United Kingdom, Netherlands and Spain) and Middle Eastern (Saudi Arabia, Iran and Egypt) users on what motivated them to provide feedback and what could have an influence on the feedback they gave. They found that Middle Eastern users consider feedback more important than Western users and there are some gamification elements that motivate more Middle Eastern users (e.g., badges and customization) than Western users [23].

All exposed related works are studies that evaluated the reaction of the users over the gamification elements and all of them used the same gamification elements for all users. Our proposal is to use an adaptive educational hypermedia system to adapt the gamification elements based on these characteristics. It is important to identify who the users are and what are their preferences to make possible to add the most recommended gamification elements to each user [24].

IV. Towards to Adaptation Of Gamification

As described in the previous section, the users' characteristics may influence the gamification process. Based on this, we believe there are gamification elements more suitable and motivational for each user/student and that it is possible to adapt them to promote a user-centered experience. This adaptation can further motivate the students instead of possibly demotivate if the "wrong" elements were applied.

AdaptWeb® has different gamification elements based on our gamification conceptual model [25]. This conceptual model proposes that, to gamify a virtual learning environment, it must be known these four dimensions: i) ***Why?***: defines what behaviors to be stimulated in students and it has three facets – create new habits (e.g., access the system, good performance), engage in activities (e.g., create and answer exercises, forum participation, use of communication tools) and content access (e.g., studying the concepts, examples, exercises, complementary material and links); ii) ***Who?***: defines who the students are and prepares the environment to have the game elements they enjoy most. It is related to student's identification (by surveys, interviews, observations, personas, focus group, interaction in the environment, etc.), and profile (e.g., player type, age, gender, motivation, personality, culture); iii) ***How?***: defines how stimulate these behaviors (i.e., why) on each specific student (i.e., who), based on the desired type of motivation (e.g., positive and negative stimulus, intrinsic and extrinsic motivation, short or long term) and how to convert them into gamification dynamics that can be achieved through some mechanics and components; iv) ***What?***: defines what must be changed to gamify the environment, such as data and architecture. Some prototypes can be made to define these changes and they can also be tested using HCI methods like usability testing, heuristic evaluation, surveys, etc. The results would guide the implementation and the improvement of the proposed gamification.

The conceptual model is shown in Fig. 1. These dimensions are related to each other in an iterative cycle towards an adaptive gamification.

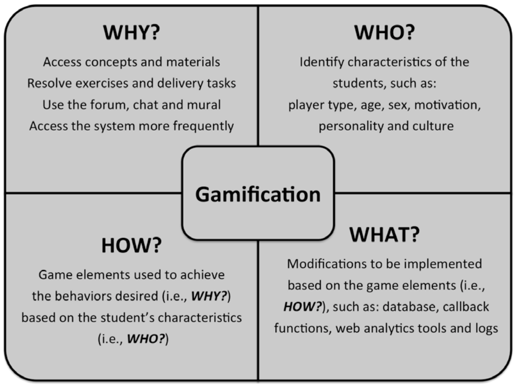

Figure 1. Conceptual Model

As it is a work in progress, some other dimensions are being considered. For instance, "**How much?**" would evaluate how much gamification really works (in a quantitative and/or qualitative way, by designing experiments with actual students). A protocol of evaluation must be established to ensure the same conditions to all students (e.g., control group versus students engaged in the gamification process).

V. Conclusion

Gamification is being each day more present in our everyday life, but the motivation factor is considered during its application. This study exposes some characteristics of the users (such as player type, age, gender, motivation, personality and culture) influence in the success of gamification. Based on the related works, this paper proposes a conceptual model to gamify educational environments, considering different student´s characteristics as potential features to adapt gamification elements to each student. This is the first step to an approach to adapt the gamification elements in an adaptive educational hypermedia system named AdaptWeb®. As future work, we will improve the proposed conceptual model and conduct some experiments with actual users to demonstrate if the characteristics analyzed really influence in the experience of the user.

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A Gamification Approach to Getting Students Engaged in Academic Study

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***Abstract*—Serious games and gamification are emerging in many areas of society. In addition to an effective way of entertainment, games can be adopted as a persuading tool to guide person to achieve specific goal, citing their ultimate attraction. In this paper, we are interested in the mechanism and application of gamification in the field of academic education. Games feature a potential to promote students to learn in a spontaneous and effective manner, since the challenge and fun in games encourage students to hold on to the end. We propose a framework for gamification in education by integrating the procedures for designing academic courses and the game elements. A case study in digital circuit course, which is filled with diagrams, equations and is hence complicated and some kind of boring for some students, is conducted to illustrate the proposed approach in academic education.**

***Index Terms*—academic education, gamification, digital circuit course, serious games**

I. Introduction

IN the current era of knowledge explosion, education is playing a more significant role than ever. It is through education that knowledge is maintained, delivered and enlarged, while the methods of thinking and new knowledge are obtained. Learning, the act of acquiring new knowledge, always needs an instructor who can teach knowledge and methods of learning to beginners, especially in the field of academic education. Specific instructions are required (for beginners), since the scientific knowledge and methods are quite different from the general ones used in daily life and difficult to understand.

However, teaching process can fall into a mechanical and tedious procedure, due to its complicated contents and requirements of rigorous logic, while the learning process for attendee is like finishing an assignment, or a work without any pleasure. This causes involuntariness, and may further lead to inefficiency and have little effects.

In addition to entertainment, serious games [1,2] and gamification [3,4] are also emerging in many areas of society, especially in the field of education [5]. Games can guide one to learn in a voluntary manner, citing their ultimate attraction. Therefore, instructors may use game design elements to motivate attendees and thus increase their attention in courses. Since adoption could have attendees motivated and involved, it is expected to improve the effectiveness of education, thus reducing the burden on the instructor.

Serious game and gamification has been applied in some non-academic fields. For example, in its Office productivity suite, Microsoft released a game named Ribbon Hero 2 as an add-on to help people learn to use Office conveniently and effectively. Companies including SAP Community Network, Yahoo, LinkedIn, and governments such as the US military have also employed gamification in training their employees. These examples show the possibility and potential to use serious game and gamification in the field of academic education to enhance learning. In this paper, we are interested in investigating the mechanism and application of gamification in the field of academic education. Particularly, digital circuit course is selected as an application field to illustrate the method with a case study.

The rest of this paper is organized as follows. In Section II, preliminaries about gamification are introduced. Following that, the method of applying the gamification framework in education is investigated in Section III. A case study is carried out in Section IV by applying the gamification approach to a digital circuit course, as a typical example in academic education. In Section V, we discuss details of the application of game elements in the designed game for education. Section VI is the conclusion of this paper with a brief summary and future work.

II. Gamification

Gamification primarily refers to a process of making systems, services and activities more enjoyable and motivating. It aims at improving user engagement, organizational productivity, flow, employee recruitment, and learning, etc., by using game elements and game design techniques in non-game contexts. There are three key parts in the formulation: game elements, game design techniques and non-game context.

1) *Game elements:* Game elements are a kind of service that uses some game's attributes such as characters, props, achievements and ranking list to interact with players. Game elements, a significant part of the interaction between game and game players, affect the playability of a game directly. Consequently, the design of game elements should be abundant and reasonable.

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2) *Game design techniques:* In the design of a game, it should be ensured that the game is neither too difficult nor too easy, every level of the game is reasonable and designer clearly understands the motivation of players, etc. Game design techniques serve as a way of thinking, and provide a systematic method to analyze those questions above. Game design techniques, in particular, can be adopted to attract and engage users in non-game environment.

3) *Non-game context:* Non-game context means anything other than the game. This means what players are doing may still be game-like but the purpose and the rationale for the experience is something outside of the game. For example, one may play to fulfill some business objectives of his/her company, to try to learn something, to get a job, or to persist in running.

In this paper, we are interested in using game elements and the relevant design techniques to design education applications that can help enhance learning in the field of academic education.

III. Gamification Approach in Education

In this section, we propose a framework for gamification in education by integrating the procedures for designing academic courses and the game elements. The design of a game for enhancing learning could be conducted in the following five steps. The workflow is explained in the end of this section.

A. Understanding target students

A key factor to achieving the final success in an education program lies in understanding the target students. In this process, game designers should have a clear understanding of the background of target students including their age group, learning abilities and current skill-set. Issues including student group size, duration of the learning program, sequencing of skills, and the place where the program will be conducted, should be taken into consideration in researching the target audience. After the analysis to these factors, some significant 'pain points' could be concluded. More attention should be paid to these pain points in the upcoming design process. Common pain points in education include focus, motivation, skills, pride, physical, mental, and emotional factors, learning environment & nature of the course, see e.g. ref [5] for details.

B. Defining learning objectives

Every instructor should assign a specific learning goal which students are expected to achieve by the end of the learning program, and students may accomplish the desired learning goal by completing assignments, passing examinations, as well as designing and implementing team projects, etc. While some learning programs may encompass several different objectives together, the success of the education program depends on the ability of the instructor to clearly define the learning objectives that underlie the education program.

C. Structuring the learning process

It is necessary for instructors to structure the learning process into different stages, due to obstacles and accidents during students' learning process. Stages and milestones are powerful tools that enable instructors to sequence knowledge and quantity what students need to learn and achieve, and to predict obstacles that may exist in each stage. Dividing a whole education program into different stages gives instructors the priority to judge the objectives, context, and pain points, and to prepare a more effective overall game process for education.

D. Identifying resources

After identifying the stages and milestones, the instructor can identify the stages that could be gamified, and hence design the game. In designing a stage, the following terms should be taken into account.

- *Tracking mechanism:* A tool to measure students' progress.
- *Currency:* The unit of measure, which could be points, time, money, etc.
- *Level:* A specific amount of a currency used to accomplish an objective.
- *Rules:* Boundaries for what a student can or cannot do in their learning program, so as to ensure the fairness in learning environment.
- *Feedback:* A mechanism that the instructor and students can use to evaluate the progress.

E. Applying gamification elements

The raw materials of games and gamification are called game elements. In order to design a serious game, instructors should analyze how to apply different kinds of elements or pieces from games. The pyramid structure in Fig.1 divides game elements into three levels.

- *Dynamics:* Grammars, the hidden elements (constraints, emotions, progression and relationships)
- *Game mechanics:* Verbs, process that drives action forward (challenges, chance, competition/cooperation, feedback, resource acquisition, rewards, etc.)
- *Components:* Nouns, specific instances of mechanics and dynamics achievements (achievements, badges, levels, collections, points, social graph, teams, etc.)

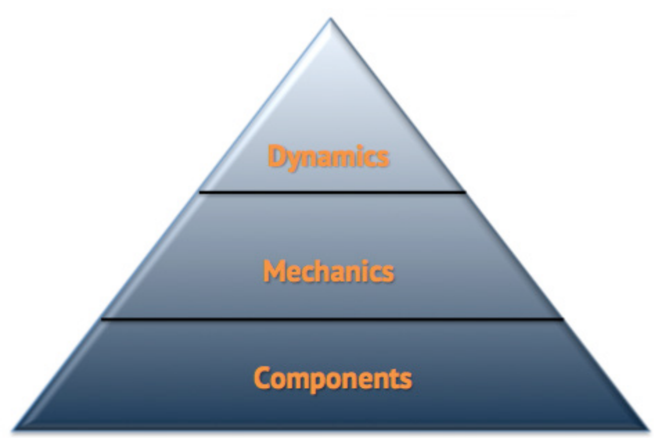

Fig.1. The model for game elements.

F. Workflow

By going through the above five steps (A to E) of gamifying education, instructors can effectively implement game elements in learning programs to achieve different educational objectives. Once the objectives are clear, the context helps to determine the pain points. Dividing the whole learning program into stages/ milestones makes the analysis easier. In order to qualify the progress in some stage with gamification framework, a currency-based tracking mechanism and rules are essential to develop levels and provide feedback. At last, determining different types of game elements helps instructors to gamify the education program. In addition, trail runs are necessary to adjust the elements and the game to fulfill the desired objectives based on test results.

IV. Case study: MineCircuit

In this section, we introduce an application of gamification in digital circuit course named MineCircuit. In the game, the thinking of game design techniques is utilized, so that profound knowledge is dispatched with a recreational process.

Due to its complicated structure and contents, digital circuits are shown with a large number of diagrams and equations in traditional classes, which is a common method used in many fields of academic education. Undoubtedly, it is good to teach the scientific contents in a rigorous and logical manner. But it also makes learning in these courses rather tedious and even boring for some students in some worst case scenarios.

Alternatively, we consider using the framework of gamfication in such course to change the situation. Motivated by the fancy game MineCraft developed by the company Mojang, a game named MineCircuit is designed and developed by using Unity 3D [6]. Start screen of MineCircuit is shown in Fig.2.

Fig.2. Start screen of MineCircuit.

Three basic principles for designing the game are as follows:

1) Guide students towards more difficult problems in a step-by-step manner.

The game starts from basic tasks aiming at making students to get familiar with basic circuits' components and design methods. Then, tasks of designing some functional blocks are assigned. This process requires players to practice the contents they have learnt. In addition, these functional blocks may act as a level of abstraction that helps players to understand complex circuits in the following steps. The game levels of MineCircuit are shown in Fig.3.

Fig.3. Game levels of MineCircuit.

2) Combine design task with real world.

Sometimes examples in the real world help to understand the abstract logical circuit. For example, water may be used to understand the current, since water flows from a high position/ the source to a lower position/ the end, and current flows from a node with high potential to a node with low potential. Such examples are adopted in the game. Players are required to design a system for distributing tap water. The task of designing this system is just as same as designing a multiplexer, but in an easier to understand manner.

3) The whole learning process is based on a story.

A whole story gets players engaged until the game is finished, and players keep gaining knowledge and design techniques about digital circuit in playing the game.

An interface of the game is shown in Fig.4. As is shown in the figure, basic components in circuits are taken as the game elements. Players gain scores and pass levels by finishing different kinds of tasks, including designing circuits, completing circuits, and finding errors in existing circuits, etc. One basic version of this game is tested in a small group of students taking digital circuit course with a good feedback.

V. Discussion

In this section, we additionally explain some details about MineCircuit, to illustrate how the framework introduced in Section III is adopted and further discuss how the game could enhance education.

1) The target students are undergraduate students who major in Electronics Engineering or related professions. More specifically, the game is designed for those students who enroll in the digital circuit course and are abecedarian in this field. Before playing game, they are expected to understand related basic theoretical knowledge, and the process of playing is to make students achieve specific knowledge to a digested top.

2) The learning objective for this education game is to help target students accomplish the digital circuit course successfully including completing assignments and passing

examination. If key knowledge points such as CMOS, TTL and Three-state gate etc. could not be well understood, the students will not complete the course smoothly. Consequently, the related knowledge has been put into the game to achieve learning objectives.

3) We set up three different levels (in Fig.3) on the basis of logical order of knowledge to guarantee that the game develops in an ascending order of difficulties. Meanwhile, according to previous study, in every level, we summarized the primary difficulties encountered in the learning process in order to set up indicative information in game. Through the indicative information, students can be guided to explore the correct answer. Last but most important, the logical order of what we design in the game is consistent with that in textbook during the design of those difficulties.

4) The biggest difference of the game from other exercises is that several game elements are utilized appropriately in the design of the game. First of all, the prompt messages are sufficient to guild players in complete tasks. For instance, prompt messages shown in Fig.4 include the statement "press '5' to use 'DOCKING STATION'. It can provide 3 outputs with 1 input" and the button "EMPTY". In addition, we included some other points including timer, score, reward etc.

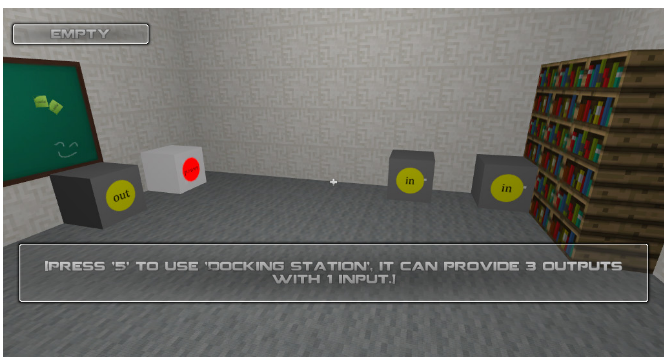

Fig.4. Game interface of MineCircuit.

as game elements in order to enrich the game.

5) Eventually, game design techniques serve as the most significant part of the game designing. Two primary design theories were applied in the game. Firstly, we take advantage of 3-dimensional scenes to stimulate students, because 3-dimensional scenes can give students a different user experience from doing exercises of the digital circuit course. Secondly, we take some methods to retain users' loyalty. As most people are inclined to securing a high score, we set up several score management mechanisms to attract students. For instance, the player can get a high score as long as he/she completes a level in one go within the shortest time.

VI. Conclusions

In this paper, the application of serious game and gamification in the field of academic education is investigated, and a framework is proposed based on the procedures for designing academic courses and the game elements. A case study is carried out to illustrate the gamification-based approach by designing and developing a game named MineCircuit for digital circuit course. As an initial study, this paper shows the possibility and potential of adopting the gamification framework in teaching and learning in the academic field to enhance the voluntariness and efficiency of students. Investigating the power of such adoption is in our on-going research.

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Mobile Learning in a Seminar or Workshop: A Case Study for Evaluating MOBIlearn2 Basic Components and Their Application

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***Abstract*—Mobile devices are getting more powerful and affordable with a variety of useful tools to support students in their learning. With these advantages, many researchers have considered it very important to integrate the pedagogical and technological strengths of mobile devices into learning especially for higher education. However, the challenge for academic institutions is to understand which applications are suitable to support their learning activities and how best they might use them in and beyond formal classroom. This case study focuses on the evaluation of basic components that make up the MOBIlearn2 application for supporting students attending a one hour seminar or workshop of their choice. We conclude that the application is highly suitable for the students to collect data for their learning and it is essential to include them in the design stage in effort to reveal hidden errors unknown to developer.**

***Index Terms*—Mobile learning, seminar attendance, learning application, techno-pedagogical tool**

I. Introduction

HIGHER educational institutions have recently become increasingly interested in mobile learning as many lecturers and students have recognized its positive impacts for their learning. Research has reported that students are performing a wide variety of formal and non-formal educational tasks on their mobile devices both inside and outside their classroom [1]. With today's capability to embed a wide variety of applications, students start to see it as an alternative to a PC or laptop. They believe that using it as a learning tool could be beneficial for their learning experience and they seem ready to adopt it. Researchers have considered the importance of integrating the pedagogical and technological strengths of mobile devices [2]. The challenge for academic institutions is to understand which applications are suitable for students to support their learning activities and how best they might use these applications [3]-[4].

Recently, research [5] has proposed a techno-pedagogical tool called MOBIlearn2 to support students learning in mobile environment. Despite having many components, it has not yet been evaluated in a real situation. In this paper therefore, we are going to evaluate MOBIlearn2 basic components in a case study conducted to a group of students who attended a one-hour seminar or workshop of their choice. The paper is structured as follows: section 2 presents background of MOBIlearn2 application and objectives of this case study, followed by methods in section 3. Section 4 presents results of this study and then the results will be discussed in section 5. Finally, section 6 presents conclusion and future works.

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II. Background

MOBIlearn2 techno-pedagogical tool has been designed based on a systematic analysis on MOBIlearn task model in order to understand pedagogical requirements for mobile learning. The name of MOBIlearn2 has been given to the application in conjunction with MOBIlearn task model and project. More details of the task model and the development of the tool based on the analysis are provided in [5]. Due to time constraints, we tested and evaluated only four basic components (Note, Picture, Audio, Video) that we believe can support students to learn in a one-hour seminar or workshop (Fig. 1). Fig. 2 illustrates main screens of the components.

III. Methods

All levels of students across Sheffield Hallam University (undergraduate, postgraduate and research degree) were included as research subjects. A total of 10 students volunteered to take part in this study. They were enrolled on a diverse range of courses (film study, material science, design, culture, communication and media, pharmacology and biotechnology, finance and investment, international business management, nursing and business studies). Each of them used their own mobile device, thus potentially representing a variety of mobile device models such as Nokia and Samsung with the latest Android versions of platform, all incorporating MOBIlearn2 app.

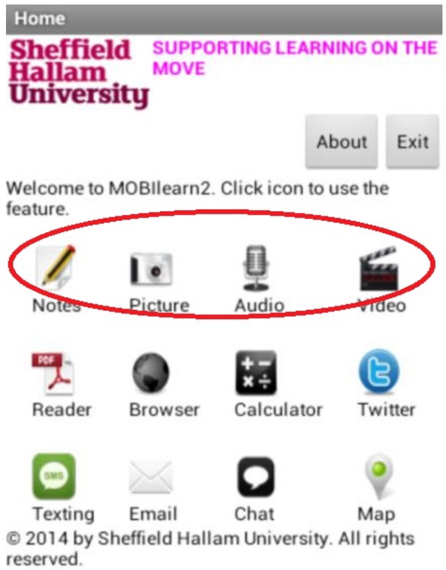

Fig. 1. The components of MOBIlearn2 which are being investigated in this study.

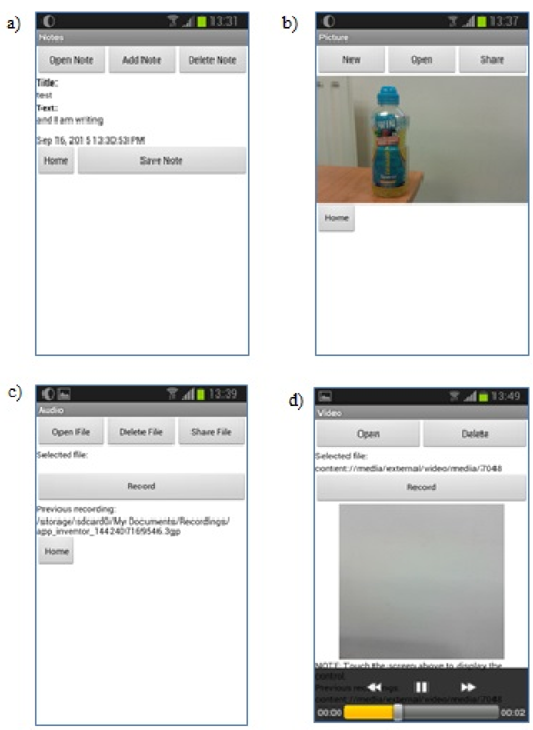

Fig. 2. Main screens for each of the basic components in MOBIlearn2.

The participants were briefed on how to use the app and the pilot study objectives were explained. They were free to use any component in the app they needed in order to support their learning activities while attending one-hour seminar or workshop of their choice. During the seminar or workshop, they were also encouraged to take notes and pictures as well as record audio and video using the tools to capture their learning moments and data which they believe were useful for reflection and revision. At the end of the study, each participant was given a questionnaire to get their feedback on using the app in that learning event. In addition to questionnaires, three students were selected to be interviewed to get deeper understanding of their learning experiences.

The qualitative data gathered from the instruments were analyzed based on thematic approach that begins with identifying key points then marking with separate codes for categorization [6]. Each code was generated based on each component in the MOBIlearn2 pedagogical tool. All the codes were examined to find meaning from the emerged themes.

IV. Results

All the participants completed a seminar or workshop of their choice successfully. The general demographic picture shows:

a) Gender: 7 (70%) are female and 3 (30%) are male

b) Age: 5 (50%) are aged 18-30 and 5 (50%) are aged 31-40

c) Study level: 2 Undergraduates, 3 Master students and 5 PhD students

d) Device used: 1 Sony Experia J; 3 Samsung Galaxy Mini S3; 1 Samsung Galaxy S3; 1 Samsung Galaxy S4; 1 Samsung Galaxy S4 Mini; 1 Samsung Galaxy Note 10 and 1 Galaxy Tab 2, 1 Motorola Moto E 2

A. *Data from Questionnaires*

From the results, it is found that half of the participants used more than one component as shown in Table 1.

TABLE I
Components Used When Attending A Seminar Or Workshop

Components in MOBIlearn2				No. Of Participants
Note	Picture	Audio	Video	
√		√		2
	√	√		1
√	√	√		1
√	√	√	√	1
√				2
	√			2
		√		1
			Total	10

This finding shows that the learners prefer a variety of tools that they can choose from depends on what they perceive useful at a certain time in learning environment.

Figure 3 presents the questionnaire results for each component. It is evident from the results that many participants have used Note and Audio components as well as Picture. 6 (60%) participants took notes and recorded audio when collecting data or information and 5 (50%) took picture when attending the event. Only 1 (10%) participant recorded video using the app. The use of the tools has demonstrated the suitability of the application to support learning activities in the event. Any errors identified are specifically presented in Table 2.

When asked about their perception of the usefulness of each component for their learning, they are all agreed (100%) that the components that they have used are very useful especially

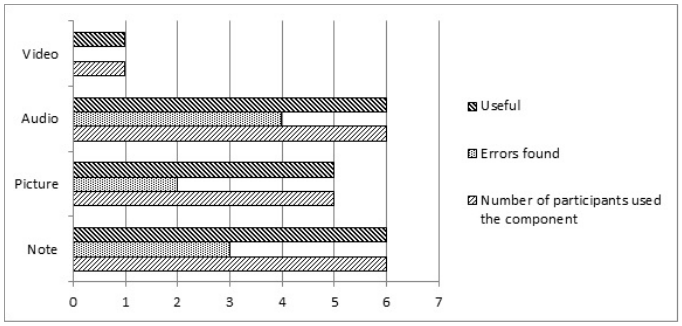

Fig. 3. Numbers of participants, errors, usefulness perception on each of component of MOBIlearn2.

TABLE 2
LIST OF ERRORS OR PROBLEMS FOUND BY PARTICIPANTS ON EACH COMPONENT

Components	Errors
Note	1. hard to type note on a small keyboard
	2. typing note sometimes could not catch up with lecture speed
	3. might lead to misspelling
Picture	1. could not zoom in/out
	2. could not add simple note to image
Audio	1. need to show time of current recording process
	2. could not rename file
	3. could not view list of recorded audio files
	4. add functions to play, pause and stop audio files

to collect data and information during the activity. This perception is supported by the reasons that they have given on each of the component. For example, one of the participants stated that the Picture component is very useful because of it can be used to take picture of presentation slides given by instructor and thus could save her a lot of times as she does not have to write. The Audio component is perceived in the same way. Two of the participants believed that the component is very useful to recall data and facts provided by their instructors during the seminar. Additionally, one participant stated that she could go out for a while (to washroom) without any worry of information loss as she could leave her mobile to record when she were not there. She added that she could play the recorded audio file when she gets back to her room to catch up on the lesson.

The last part of questionnaire was an open ended question where the participants could leave their overall comments or suggestions. Generally, most of the participants were very positive in their feedback on using the MOBIlearn2 tool. They pointed out that it was very efficient when using the tool for data or information gathering as it combines many useful features and provides more learning sources and data for revision and reflection. Furthermore, they could switch between features and tasks easily if needed. In spite of having such advantages, they also commented on several problems as outlined in the Table 2. Equally important, one of them suggested providing text-to-speech and speech recognition functions to support note taking activity.

B. Data from Semi-structured Interviews

Three participants were selected for semi-structured interviews in order to get more insight about the use of the MOBIlearn2 tool and how to refine it. First question was about how they used the tool in the event. Two participants said that before the seminar started, they asked permission from the instructors first to use their mobile devices to collect data and information and got their consent verbally. Once it was allowed, they put their devices on table and launched the application. The third participant said that she did not mention about using the tool to her instructor. However, her instructor did not mind when she was about to take an image of the slides presented in the seminar room. During the seminar, two participants have reported that they used more than one component of their choice.

The second question was intended to detect errors with the tool. Two of the interviewees reported that they had problems with the Note component. They have added that it is difficult to write and type using the small virtual keyboard provided by their devices.

Student A: *"It's hard for me to catch up with the speed of lecturer's speech when using the small virtual keypad provided by my device. So, sometimes I took pictures instead of writing…but I believe I don't have problem if I use it in my field work as there is no time constraint"*.

Student C: *"I think that I am not fast enough to use the keyboard in my phone…but if the keyboard is quite big like in an iPad…I think it's ok"*.

For Picture component, one of the interviewee reported that she could not find a way to insert note on the images taken and the other interviewee said that he could not zoom in the picture taken in order to read notes on it.

Student B: *"When I stretched the saved image, I could not read the texts on slide as it became a blur…so, I think this feature needs to have zoom in and out functions…if possible"*.

Regarding the Audio, most of the interviewees claimed that there is no problem on that component but one interviewee stated that she could not ensure the recording process was successful as she could not view the list of recorded files. On the Video component, one of the interviewees reported that the video captured during on the seminar is not clear enough. Therefore he proposed that those who want to use it need to adjust the brightness in the setting in order to match the lighting conditions in the environment.

Third question was "What features or functions that you think are very helpful for your learning in the event?" All of the interviewees indicated that features of taking notes (Note), taking pictures (Picture) and recording audio notes (Audio) are very helpful for them to do revision on the lesson during their free time. Only one of them added that recording video (Video) was also useful as he could capture the entire details of the situation in the learning place and store it as his personal record.

The purpose of the last question is to get the interviewees comments and suggestions in order to improve the tool for supporting learning activities in that kind of event. One of the interviewee has pointed out that by using the tool it was easy to switch multiple tasks as the design has integrated all required components and thus learners do not need to use different app for different tasks.

Student A: *"I think this tool is good for brainstorming or take notes of idea emerged when I am on the move…anytime. So, I think it is better if you include a mind map application."*

In addition to mind map application, she also suggested finding a way to transfer all files to a computer when storage card in the device is full. This suggestion is similar to that proposed by the second interviewee who has suggested finding a way to do backup properly (could automatically export data in phone to PC). The last interviewee pointed out that the tool is very useful to all research students as it could assist them in their study.

Student B: *"I recommend this tool to research students in my area…ethnography...as all the features I have found such as taking pictures, videos and notes are suitable for our research works…"*

V. Discussion

This research uses a non-probability sampling procedure that has resulted in the subjective judgment of researchers in selecting the respondents. Even though the researchers attempt to cover all different level of study of the participants in the university, this sample and demographic profile are not representative of student population in general. The results therefore primarily indicate diverse behaviour and interest. Whilst this is appropriate for a qualitative study seeking feedbacks on a phenomenon as mentioned by [7], it is not suggested that the quantitative data would be replicated in a similar study.

Comparatively, we have found that most of the qualitative data from questionnaire and interviews are supporting each other. Even so, the data from interviews are quite richer and provides deeper insight on each problem found or suggestion made. For example, one of the participants has come out with a positive suggestion to include a mind map application as a brainstorming tool in the interview. This finding hence shows that it is essential to take into account the context of use which can have important influence on the design and use of the product in future.

From the findings, we have confirmed that most of the features in the basic components of MOBIlearn2 application have been very useful for the students to support their learning activities. Although the learning setting is quite formal, they are efficiently and effectively use their mobile devices to collect data and information as their learning resources. Nevertheless, this usage of the mobile in formal learning setting should get permission or consent from the instructors first.

VI. Conclusion And Future Works

In testing the functions of several basic components of MOBIlearn2 application, this study has successfully revealed several errors and problems by getting comments and feedback from the student participants who have used it to support their learning in a seminar or workshop. As a result of this learner-centered design approach, the learners by themselves have explored and tested the tool in the real world context, reported the findings and suggested some improvements to researchers. All the errors have been noted by researchers and presented in this paper so that it will be addressed when refining it in future development. This study has therefore demonstrated the advantages received when involving real learners in design stage for developing new technologies or innovations in real life environment especially for educational purposes [8].

Evidence from this study has been demonstrated in authentic student voices that may prompt the educators to revise infrastructural support, policies as well as data privacy concerns to allow the use of mobile devices in a seminar or workshop and encourage students to use them for learning purposes. This study also encourages the practice of 'bring your own device' (BYOD) that academic institutions could employ to embed mobile learning into mainstream education. By leveraging what students have and do, educators could combine formal, non-formal and informal learning activities to provide more effective and creative pedagogical approach in mobile environment.

For future work, our study will continue to evaluate the MOBIlearn2 application in an informal learning setting such as visiting a museum gallery. All the basic components of the tool which have been proven useful in this study will be retained and integrated with several new components.

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