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Cloud-assisted gamification for education and learning – Recent advances and challenges☆

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ABSTRACT

Gamification has gained considerable interest in education circles due to its capability of enhancing the learning process among students. In the future, it is expected that gamification will overtake the traditional way of learning resulting in issues such as scalability, upgradation of learning modules. To address these issues, merging gamification with cloud computing seems a viable solution. However, the employability of gamification through cloud computing is still in its infant stage. Hence, this article investigates the applicability of gamification through cloud computing and presents a comprehensive survey of state-of-the-art gamification in education and learning. We also identify the subject areas that can be gamified and taught using the cloud service. The critical elements and minimum requirements necessary to gamify education are also identified. Moreover, a specific cloud-assisted gamification architecture is proposed and discussed together with its possible applications. The article is concluded with the research challenges and suggestions for future work.

1. Introduction

With the advent of innovative technologies, new areas for solving different problems appear. Gamification constitutes one such area that has promise. The application of game-like environments (game mechanics) to promote motivation for learning and solving problems is known as gamification [1]. This concept possesses a number of applications in the area of promoting business and learning. However, the most recent studies have focused on applying gamification in the education sector to promote the learning process. According to Nah et al. [2], the use of games in the process of educationally instituted learning can considerably enhance the motivation of students. Gamification allows students to engage in difficult tasks (missions) and achieve the required goal within a short span of time. Besides, games allow the user to repeat a particular task in the event of failure. The repeated cause of failure helps students (users) to analyze their previous mistakes, correct those mistakes,

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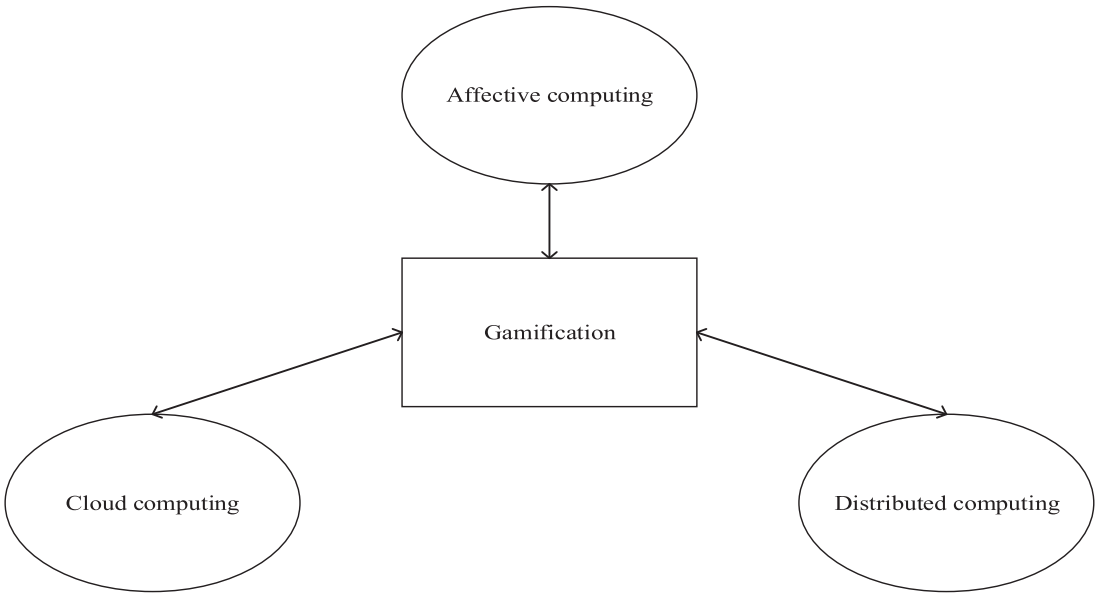

Fig. 1. Potential platforms for gamification.

and finally achieve the desired goal. This promotes a positive attitude to learning which the students are encouraged to acquire by acknowledging temporary negative experiences for the sake of eventual success [2].

1.1. Different platforms for implementing gamification

There are many platforms that can be employed for implementing gamification. The possible potential platforms include cloud computing, affective computing, and distributed computing as shown in Fig. 1.

(i) *Promoting gamification through Cloud computing*: Cloud computing constitutes a platform that offers three main services of infrastructure as a service (IAAS), platform as a service (PAAS) and software as a service (SAAS) [3]. It offers a pool of configurable computing resources to its end users based on the selection of service. Cloud computing can be employed for gamification by exploring all potential configurable resources and utilizing those resources for designing and developing games with learning outcomes. This solves the problem of the cost incurred by educational institutions when upgrading existing computing facilities [4].

(ii) *Applying affective computing through gamification:* Affective computing constitutes one of the promising paradigms that also promote the gamification concept. The main aim of affective computing is the design and development of a computer interface in order to detect and respond automatically to the user's emotion [5]. In game designing, emotions play a key role, and detecting user emotions in advance can help game designers in developing more interesting and engaging games. There are numerous applications of affective computing in the area of artificial intelligence and other related sciences, technology, engineering and mathematics (STEM) areas. It can be explored for promoting learning through gamification. The interface can be designed in such a way that can help students to enhance their learning ability and improve concentration.

(iii) *Promoting gamification through distributed computing:* Networking is the exchange of data through different types of media between computing devices. The area of networking is quite massive, and there are numerous applications of networking in different areas. This technology can be found in healthcare, wireless communication, the education sector and other various fields. In distributed computing, several computing resources are used for processing particular applications, which may consist of data, multiplayer games or other related features. Gamification can be employed by designing multi-user games in a distributed environment. In this manner, the gamified learning environment can promote learning among multiple end users connected through different personal computers.

All the above-mentioned platforms can be employed for gamification and used to promote the learning process in education. However, in order to narrow down the scope of this paper, we have focused on the cloud computing paradigm in promoting gamification.

1.2. Research goal and questions

To our best knowledge, no survey paper has yet explored the use of the cloud computing paradigm for gamification or investigated the courses that have been taught using games. The published surveys include *Gamification in Theory and*

Action: A survey [6] which focuses on analyzing the application of gamification in computer-based systems. Another survey is *Gamification of Education: A Review of Literature* [2] which explores the impact of gamification on learners. While these studies offer valuable insight related to issues relevant to gamification, none have examined the different subjects that can be gamified using cloud computing nor the future advancements in gamification. Compared to the above-mentioned studies, the major contributions of this survey are as follows: (a) classification of game-based learning courses based on subject areas; (b) a comprehensive survey of the-state-of-the-art advancements in gamification; (c) an investigation into the gamification requirements to identify key elements for enhancing learning process in an education domain; (d) a conceptual gamification model utilizing cloud computing service; and (e) an identification of challenges in the gamification domain.

Based on the above contribution, this article will help future researchers in better integrating the gamification module in the cloud computing paradigm. Fellow researchers can easily identify the minimum requirements for designing a learning module that includes gamification and enhance the learning process using the cloud computing concept.

The work is motivated by the following listed research questions (RQ):

(i) RQ1: To what extent has the concept of gamification been employed for enhancing the learning process in the education sector?
   - Which areas in the education sector have been targeted to enhance the learning process through games? This follows the observation that games are being developed to teach students.
   - What are the recent advancements of gamification within the education domain? This follows the observation that studies have utilized the concept of gamification within the education sector.

(ii) RQ2: How can gamification be applied in education-related areas using cloud computing?
   - What are the minimum requirements for employing gamification? This question probes into the key-requirements that any gamification-based application must inherit.
   - How can cloud architecture be used for gamification to enhance the learning process? This question explores the general architecture of cloud computing and examines the cloud-computing platform for employing gamification.

(iii) RQ3: What are the challenges in utilizing gamification in the education sector?
   - What are the different factors that inhibit the gamification of educational courses?
   - What are the guidelines to address this challenge?

The first two research questions (RQ1 and RQ2) are addressed in Sections 2–5, respectively. RQ3 is addressed in Section 6.

The paper is organized into the following sections: Introduction and motivation are presented in Section 1 followed by the adaptation of games in learning in Section 2, in addition to the features of games and the possibility of games being used for gamification through the cloud. Section 3 highlights the state-of-the-art approaches used in gamification as part of established educational courses. The key requirements of gamification are identified in Section 4, followed by the architecture of the cloud and gamification in Section 5. Future work is discussed in Section 5, and the article is concluded in Section 6.

2. Adaptation of games in learning

Since the evolution of the internet, numerous games have been developed for entertainment purposes [7], yet games related to imparting education or enhancing learning has not received much focus. The trend of using games for learning has only developed recently [8] and a lot of serious games for education and learning has been developed since. It will be of immense help to researchers if all existing online games based on subject content can be surveyed and their limitations highlighted. This will avoid the confusion of developing similar games for the same subject. Hence, an attempt has been made to survey popular learning games available online. For this purpose, several blogs, description of games, and latest articles on games were studied. The aim was to understand the learning outcome of these games and the focus of their subjects. The list of games [9] is found in Table 1.

During the ongoing research, it was found that there are many games based on learning content. However, it could also be observed that there are many games focusing on a single subject. Based on our initial research, we found that most games focus on subjects related to Medicine and Mathematics. Referring to Table 1, online gamification through the cloud can be classified based on the criteria shown in Fig. 2.

In order to implant gamification effectively through the cloud, it is essential to identify the audience. Using the cloud service helps overcome the issue of having to upgrade the existing computing resources. A proper classification can help further to improve the quality of learning and overhead of minimizing budget considerations. For adults, there are various learning topics ranging from Medicine and Engineering to Humanities. Adults prefer games with high definition graphics [10]. The learning applications based on these games may require more computing resources compared to gaming for children. Since the cost of cloud service depends on the service a user chooses, the selection of the audience can help in minimizing the cost by selecting the appropriate cloud service. All the essential components from all the subjects necessary for learning purposes can be embedded into a single learning application and handed over to the cloud vendor for gamification without having to consider the problem of abstraction at any level. However, more research is necessary in order to determine whether the learning application comprising of all subject elements fulfills the minimum criteria that are required for gamification. There are a lot of issues and challenges that need to be addressed before gamification can revolutionize modern education.

Table 1
Games based on learning content.

Name of the game	Purpose
RobotBASIC: A STEM-focused Programming Language	Most powerful educational game for learning programming languages.
The Blood Typing Game	Teaches the basics of human blood like the classification of blood and blood transfusion.
DNA – The Double Helix	Allows the user to match DNA molecules base pairs to their respective strands.
The Immune System	To teach the basics of the immune system where the user must protect the human body against bacteria by utilizing white blood cells through a finger wound.
Control of the Cell Cycle	Teaches the cell division process.
Lord of the Flies	Powerful memory-based game to improve analytical skills.
The Transistor	Physics-based course game to teach the basics of the transistor.
Dice: Fractions, Order of Operations, Adam Dream: Numbers Nightmare, Axiom, Champs of Numeria, Chima, Zeus vs Monsters, YodelOh Math Mountain, Door 24, Funbrain, Magnahigh.	Enhancing mathematical capability in young kids.
BrainNook, Cackleberries, Clever Island, Cookie, DimensionU, Futaba, Fuel the Brain, Gadzookery, Game Classroom, Gamequarium, GameUp, Grading Game, Moody Monster Manor.	To enhance the overall behavior of students by focusing on a variety of subjects like English language, arts, reading and help in refining their thinking skills.
Historia, Learning Games For Kids, Lure of the Labyrinth, Science Heroes, SimCityEDU	These games offer students to learn about history, nature, health, geography, adventure

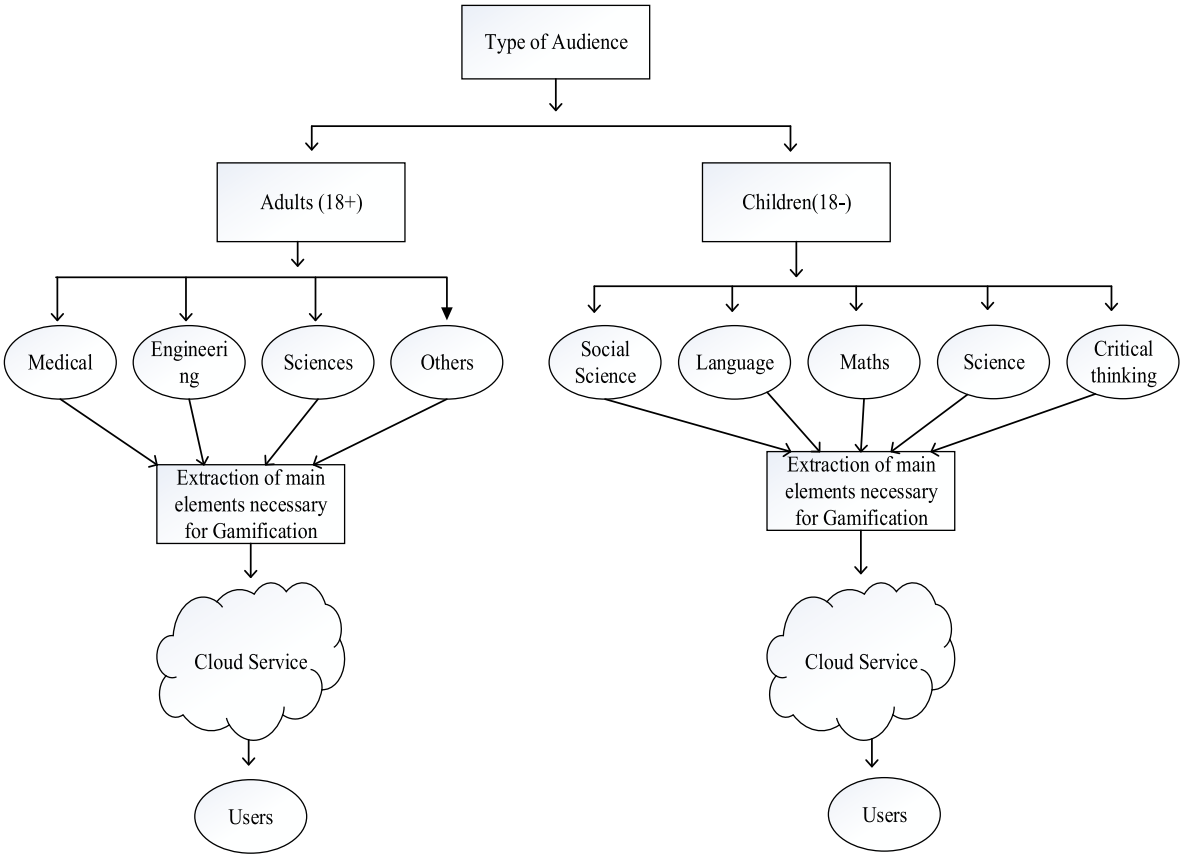

Fig. 2. Classification for using cloud service.

3. Recent advances in gamification

A number of studies that can referred in the work of [1] have proposed frameworks for gamification. Since this area is still in the early stage, it is essential to identify the important elements of efficient gamification. A social gamification framework has been proposed by Pivec and Dziabenko. The aim of this study is the application of different game elements in classes, motivation being a key factor in gamification for educational purposes. De Freitas and Oliver have proposed a

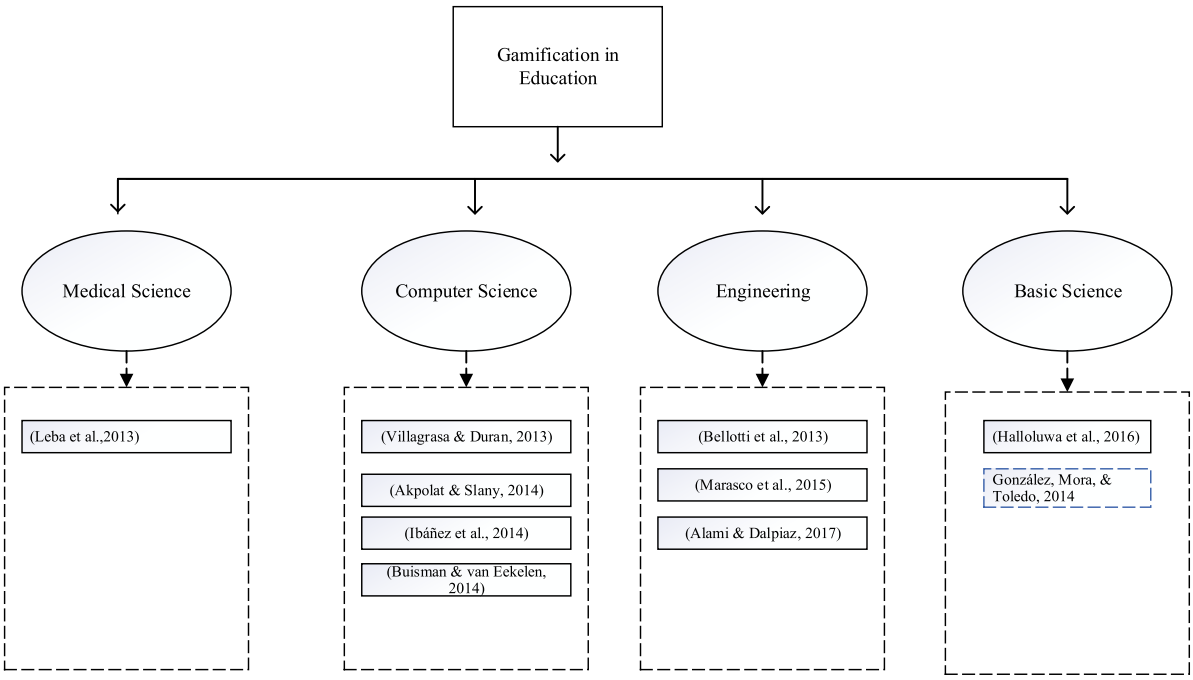

Fig. 3. Classification of existing studies.

four-dimensional framework for supporting game design and aid the teaching process by considering the factors of flexibility (ease of use), practicing content for teachers, and sufficient practice sessions. Similarly, Tan have studied different frameworks for adaptive learning and found that the essential elements for games to be used for educational purposes consist of a story, challenge, goals, and objectives. Besides, each objective should have some outcome to boost the morale of the end user [11, 12].

Simões have proposed a social gamification framework based on the K-6 learning environment for enhancing the learning process in education [1]. The K-6 environment offers web services to school communities. The framework is based on game mechanic and dynamic elements including the motivation for students and teachers, repetitive tasks for reaching the desired goal, difficult task completion with advancement, smaller tasks, trying new identities, and a reward system. They have also examined the different guidelines essential to the development of social gamification. The three main approaches to using games for learning purposes are: (i) the game contents can be used to embed the learning element; (ii) combining a serious game learning element with a recreational purpose; and (iii) including problem-solving abilities. Some related studies have offered a few practical steps using the behavior analysis approach and concluded that motivation, timely feedback, goal-oriented task, one-one oriented task and assigning tasks based on users performance are essential elements to create a teaching element in games.

The most recent study completed by Morschheuser and Hamari [12] offers a comprehensive overview of gamification guidelines. It is aimed at understanding the overall picture of designing and developing a gamification environment. The authors identify seven requirements for gamification to be used for educational purposes, which are motivation, clarity of objectives, testing of gamification ideas, ability to control the game cheating scenario, optimization of tasks for long-term progress, and overall outcome of games. Peixoto and Silva [11] have carried out a survey work through systematic study and identified the gamification requirement catalog for education software.

We have categorized the state-of-the-art gamification domains into the following subject areas of Medicine, Computer Science, Engineering, and General Science as shown in Fig. 3. The purpose of this classification was to give researchers a better knowledge of the target subjects in which the gamification approach is being employed.

3.1. Medicine domain

Leba et al. [13] developed an application based on gamification for training medical students. The application focused on anatomy and computed tomography images with the aim of motivating and teaching medical students the procedure of segmenting the different organs of the human body. Leaderboard and virtual award elements were used in the application, which seems promising, however, needs more evaluation in terms of usability.

3.2. Computer Science domain

Villagrasa and Duran [14] proposed the gamification concept as part of a multimedia course for university students. The game elements were applied to a multimedia course in the form of a reward system. Each task completion earned virtual money to the students and thus motivated them to earn more money in the next task. There were no empirical results mentioned such as sample size or the like.

Akpolat and Slany [15] explored the use of gamification for software development teams. A university course was gamified and taught to 50 students consisting of five teams with ten students each. Different tasks were given weekly and rewards were given to each team based on performance. Each challenge was based on an extreme programming challenge. The result showed an increased level of motivation among the students in the area of programming after gamification.

Ibáñez et al. [16] evaluated the learning effectiveness of C-programming language using gamification. The methodology included questionnaires, logs and pre- and -post-tests. The evaluation was done on 22 students with no previous experience of gamified learning. The pre-and post-tests were carried out to analyze the level of learning the outcome of students before and after the completion of the learning activity. The study concluded that gamification increased the learning outcome significantly.

The other gamified approaches proposed in the area of Computer Science particularly related to programming can be found in the work of [17]. The studies concluded that gamification enhances the motivation to learn things quickly and improves the learning outcome. Task design was regarded of utmost importance for motivation causes.

Buisman and van Eekelen [18] argued that software development was often considered a tedious task due to the involvement of programming and made the attempt to gamify educational software development. The purpose was to encourage students and develop their interest in learning software development. For this very purpose, game elements like motivation, reward system were applied to existing open source project management tools such as rapidmine. The students were awarded points based on their daily activities. Although the evaluation was carried out on a small sample, the result was promising in terms of the students increased interest in solving different tasks using gamification.

3.3. Engineering domain

Bellotti et al. [19] proposed a short entrepreneur course for electronic engineering students using gamification. The gamification elements included task completion, reward system, and short-term activities (speaking or writing activity). A group of 34 students was split into 16 teams who were given different assignments ranging from analyzing company data to simulation tasks. The proposed course evidently increased the learning enthusiasm among the students.

Marasco et al. [20] proposed the gamification of electronic design automation for university students. In order to gamify the course of electronic design automation, the first step was to investigate how games could be used to master the technical skills of automation. The algorithms employed in electronic design automation were gamified. However, it is not mentioned which game elements have been applied.

Alami and Dalpiaz [21] proposed a tutorial based on the gamification concept for learning the requirement engineering (RE) course. The aim was to foster self-learning of basic concepts of the course. 17 game elements were studied and distilled in the proposed interactive tutorial. Besides the gamification elements, three other factors were considered when designing the interactive tutorial, namely understanding of curricula design, guidelines for designing interactive tutorials, and principles for gamifying learning experiences. Two separate evaluation studies were carried out using a group of eight postgraduate students of Information Science and five experienced IT professionals. A 90-min time frame was allotted to finish the course. The results showed promising results with 100% and 80% content being completed within the given time.

3.4. General science domain

Halloluwa et al. [22] developed an application based on the gamification concept with the aim of motivating primary students to learn and practice Mathematics. The key elements included rules, levels, and a reward system. This application constitutes a valuable step towards gamification of Mathematics.

González et al. [23] proposed a conceptual gamification framework for intelligent tutoring systems (ITS). According to the authors, the existing intelligent tutoring systems lacked some features, which resulted in boredom for the students. EMATIC was used as a case study, and the game elements of reward system and task design were added in order to make it more engaging and motivating for the students to use this web tool. Since the proposed framework has yet to be validated, it is not possible to evaluate it.

A brief summary of the above-mentioned work is given in Table 2.

4. Requirement for efficient gamification framework

Based on the above literature and observations, we identified five key elements for implementing gamification in education. The key five elements include (i) motivation; (ii) short-term tasks; (iii) reward system; (iv) task design; and (v) game identity as shown in Fig. 4.

The elements [7] mentioned in Fig. 4 above can be briefly explained as follows:

Table 2
Recent advances of gamification in education.

Author	Objective	Evaluation approach	Advantage	Limitations
[13]	To propose a gamification framework for training medical students.	Not evaluated.	The proposed application seems promising in terms of training medical students the basics of human anatomy and anatomical topography through a web-based approach.	The experimental set up has been not fully explained. The proposed application has not been evaluated by any user.
[14]	To motivate and engage students in learning multimedia course using gamification.	Computer animation course has been taken as a source subject for gamification.	The proposed approach is the first step towards gamification of multimedia courses.	No empirical results provided.
[15]	To explore the use of gamification in extreme programming course.	50 student volunteers were grouped into 5 teams. Each team consisted of 10 students. A university course was gamified.	The results show an increased level of motivation among students.	It is not clear, which game elements were taken into consideration.
[16]	To evaluate the learning effectiveness of C programming language using Gamification.	22 students were taken for a sample experiment.	The study concludes that gamification increased the learning outcome of students.	Although the results are promising, there is a need to evaluate the outcome on a larger scale.
[18]	To encourage software development using gamification.	Educational software development course of 6 months.	The small size of the experimental groups.	The proposed approach showed promising results with improvement in student engagement.
[19]	To gamify entrepreneurship course for electronic engineering students.	The one-month course was drafted involving B.Sc., M.Sc. and Ph.D. Electronics Engineering students at the University of Genoa. Different range of topics with increasing level of difficulty in games, game-play and home assignments were embedded in the course.	The proposed course showed positive results in terms of engagement, learning, and promotion of interest towards entrepreneurship.	Small experimental group of 54 students is not enough to reach towards a conclusion of a positive sign.
[20]	To propose gamification for electronic design automation course.	The proposed approach is still under process and to be evaluated in the undergraduate classroom.	Initial observations reveal that the students reported feeling more engaged and motivated to work through technical problems because of their aspirations to create an entertaining, creative, and aesthetically pleasing final product.	The proposed approach needs more validation and large sample size.
[21]	To design an interactive tutorial for learning Requirement Engineering course	The experiments were done using 5 PG students and 2 IT professionals with 3–12 years of experience.	The results showed 100% and 80% course completion which is a positive sign for learning the outcome.	The sample size is not enough to justify the results.
[22]	To gamify mathematics subject.	The approach has been tested based on data obtained from 130 students and 2 teachers.	The approach somehow makes it easier to understand mathematics.	The main focus has been on the reward system only.
[23]	To propose a conceptual gamification framework for intelligent tutoring systems.	There is no validation being done.	The proposed approach may increase motivation among elementary students using gamification elements.	No validation being provided.

- Motivation: Motivation constitutes a primary element that needs to be considered when designing games for educational purposes. The game element used in the learning process must motivate the student to proceed with a given task. Affective computing can help promote the motivation factor in designing interfaces based on emotions.
- Short term tasks: The short-term tasks in a game enhances the ability of a student by completing the task repeatedly after a number of failed attempts. Hence, the element inherited from the game for teaching must be organized in smaller tasks. Time-consuming activities result in boredom and lack of concentration.
- Reward system: Once the tasks in the game are completed, the player expects some token of appreciation, usually in the form of a reward system consisting of points, trophies or gift cards. This game element can be used in gamification at the end of each teaching lesson to encourage students to earn rewards and proceed with the following task.
- Task design: Although after completing each assigned task, the players receive positive feedback in the form of rewards, the difficult design of certain tasks may result in anxiety and inhibit the learning process. Hence, there should be a

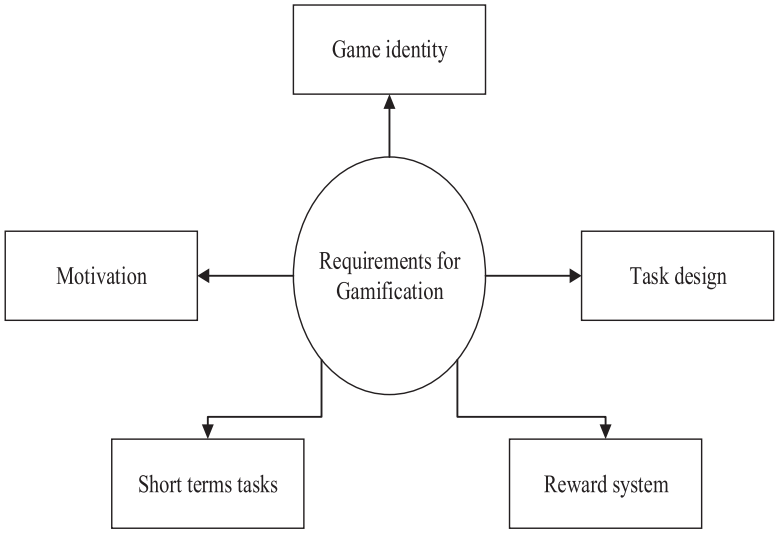

Fig. 4. Requirements for gamification.

flow in designing small tasks that do not require tedious effort. The task design should be balanced in terms of task completion.

- Game identity: In multi-player games, the members of each team cooperate and help each other to reach the goal. Based on the strategy used by different team members to achieve a common goal, a specific status or identity is given to the most rewarding member. For example, the team member who contributed the most to the team's progress is allocated the team leader position. This encourages a competitive spirit among the players who need to devise different strategies in order to climb the ladder. This scenario is highly effective for management students who can learn the tactics of strategies in achieving different business goals.

The inclusion of the factors mentioned above can enhance the process of learning in education. However, more research is needed to examine the key factors that can influence the gamification learning process. In order to utilize gamification through the cloud, it is important to understand the architecture of the cloud and the ways in which gamification can be incorporated into the different services of IAAS, PAAS, and SAAS.

5. Cloud-assisted gamification architecture

5.1. Cloud computing architecture

Gamification through cloud requires a basic understanding of how cloud and its different services work. Cloud offers a pool of virtualized services ranging from software to hardware support [3, 24]. All the essential services of storage, computing or network are offered by a cloud in the form of infrastructure, platform or software. The basic architecture of the cloud is shown in Fig. 5.

As shown in Fig. 5, software service offers complete abstraction to the end user. The end user simply needs to use the application without having to consider the issues related to installation, implementation or storage details. Platform service, on the other hand, allows users to use different platforms for the development service. Similarly, infrastructure service offers mainly hardware resources like storage, servers and other computing resources. All these services can be utilized for gamification. SAAS can be utilized for gamification of online games. PAAS can be utilized to promote gamification through social media networks, and IAAS can be used for the development of high computing games that need more hardware sources [3,24].

5.1.1. Potential existing cloud computing platforms for gamification

Several popular cloud computing platforms can be utilized to enhance gamification. These cloud computing platforms include: (i) Google cloud platform; (ii) Microsoft Azure; (iii) Alibaba; (iv) IBM bluemix; and (v) Amazon web services. Google offers its cloud services through the public internet known as Google cloud platform. Its services include storage and computing services along with necessary tools for cloud management and security. It also offers on-demand hosting along with a platform for software developers. The Microsoft Azure cloud computing platform is hosted by Microsoft web development and development services for programmers. The code is deployed on its servers rather than on the host machine. It provides a complete platform for programmers including development, management, and security of applications. The Alibaba cloud computing platform seems to be more suitable for enterprises that support the services of hosting, object storage, big data

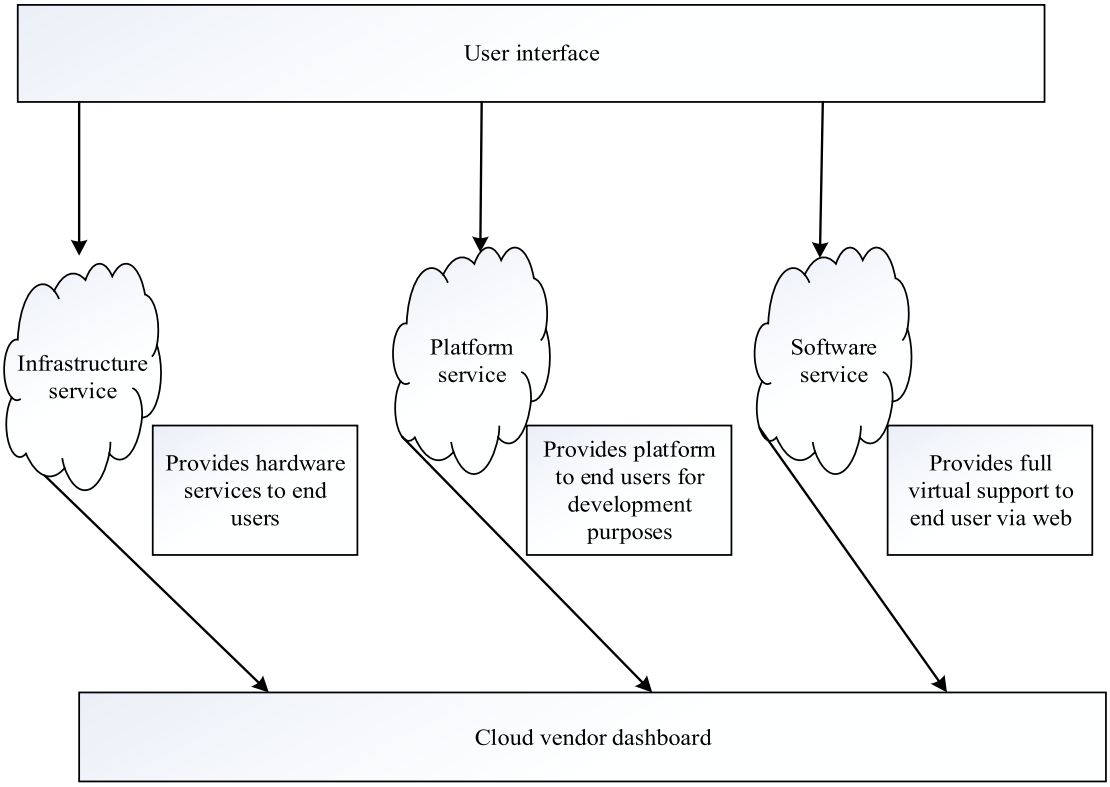

Fig. 5. Services offered by a cloud.

analytics along with Machine Learning and Artificial Intelligence (AI). The IBM bluemix cloud platform is hosted by IBM primary offers PAAS and IAAS services. This platform is suitable for managing and deploying scalable applications with varied support of programming languages like Java, Python, PHP.

5.2. Gamification architecture

A full-fledged architecture has not yet been proposed for gamification due to the diversity of its applications. However, the essential elements of a gamification model have already been identified in recent studies. Kim et al. [8] identified different game mechanics and dynamics for the learning process. Similarly, Su and Cheng [25] proposed to enhance the student's capability in education by using a game-like rule system and player experience. Similarly, Csikszentmihalyi [26] explained that the balanced flow of tasks is critical for improving individual skills and concentration. Urh et al. [27] proposed a gamification architecture based on e-learning elements whereas Kim et al. [8] and González et al. [23] proposed a gamification model for teaching basic mathematical skills. Their model offers different modules for different purposes. For example, its student module contains all relevant information about students, its tutor module contains information about teaching strategies, and its domain module adapts different concepts related to tutorial topics. However, this model does not incorporate all the required criteria expected of a complete gamification model. Hence, we propose our own gamification model based on own observations, in addition to the work of Bunchball and Schonfeld, as shown in Fig. 6.

In the proposed gamification model, the essential elements of game mechanics and dynamics can be extracted from any suitable game that has a potential element of learning. All the basic elements of game dynamics and elements can be extracted from that game and mapped into the learning application. Here, the learning application is independent of any subject, which can be a mathematical subject, a science subject, programming language or any other learning subject. Once the mapping process is complete, the application must fulfill the minimum criteria to be used for learning using the gamification process. These minimum criteria were observed in the studies mentioned in Section 4. If an application fulfills the minimum criteria for gamification, it can be considered as a valid gamification approach, and if not, it is considered as a mere e-learning or game-based approach.

Based on our understanding of the cloud computing architecture and the gamification architecture, it can be concluded games using cloud computing services can be used for gamification purposes. However, the challenges are linked to the issue of whether those games fulfill the minimum criteria of motivation, task-design, small tasks, game identity, and reward system.

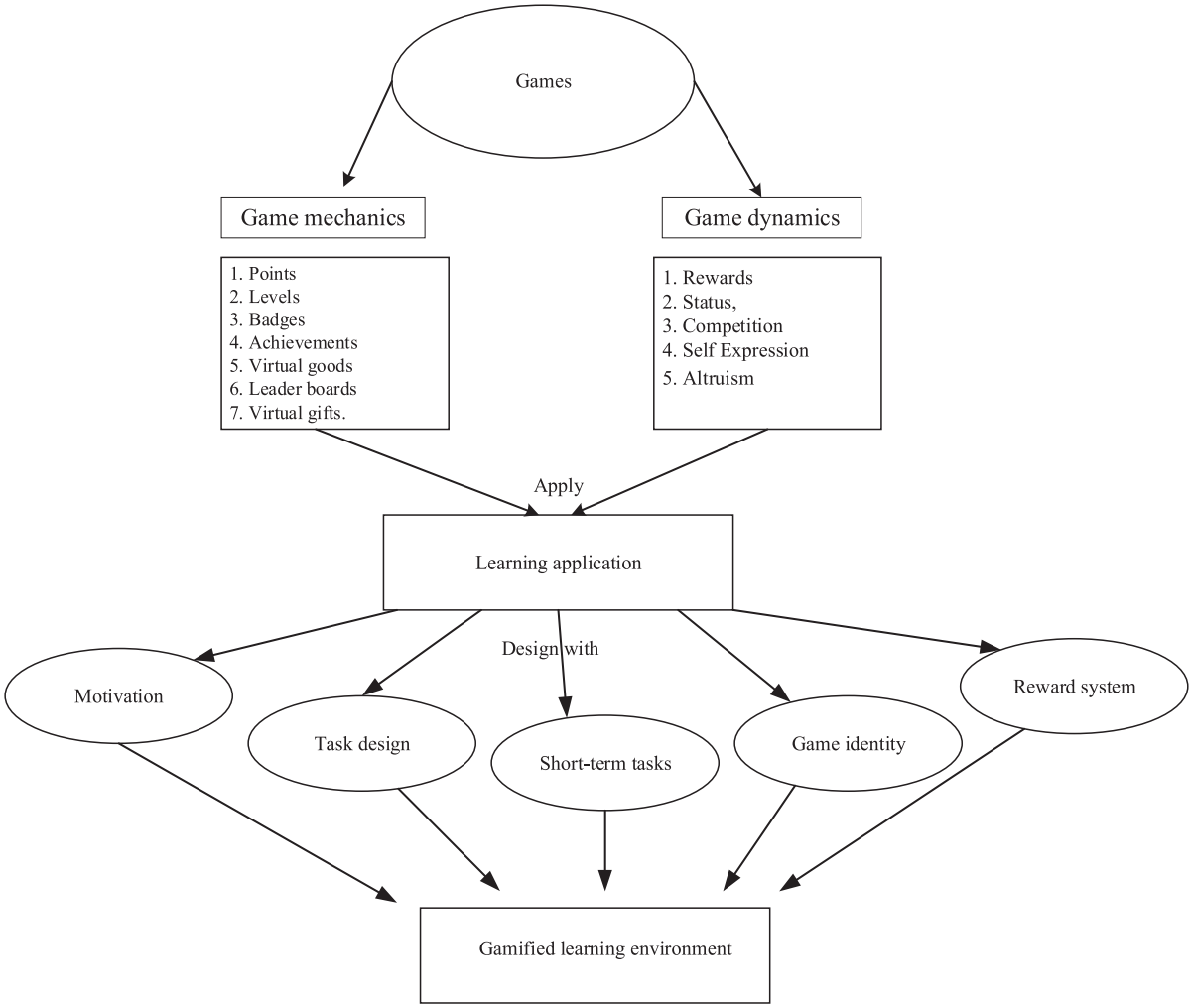

Fig. 6. Gamification architecture.

5.3. Applications of the proposed architecture

As the scope of this research is limited to reviewing the state-of-the-art advancements in gamification and the theoretical approach of utilizing the cloud platform and gamification, several potential applications of the proposed architecture include:

- *Natural Language processing related courses:* The courses that require specific expertise like Arabic and Chinese are quite hard for students to comprehend due to the complexity of symbols used in these languages [28]. Hence, it would be interesting to gamify these courses and teach through the proposed architecture to the end users located across the globe. The proposed gamification architecture can be also used to teach students the concepts related to the authentication of diacritical texts [29].
- *Virtual reality:* Virtual reality constitutes a simulation-based learning environment where audio and visual systems are incorporated [30]. The proposed architecture can be used in merging virtual reality and gamification modules for enhanced learning and skill development.
- *Distributive study system:* A distributive system is a system in which each mobile node can have access to a particular resource. Hence, our proposed architecture can be useful to teach gamified modules to multiple users simultaneously, irrespective of the time difference or physical location.
- *Scalable intelligent tutoring system:* The intelligent tutoring system constitutes a complete computer-aided system that can be used to teach, assess and evaluate the learning outcome of students without any human intervention [23]. As technology is rapidly advancing, particularly in education, the already developed intelligent tutoring systems can be enhanced by incorporating the gamification concept using the proposed architecture.
- *Mobile learning:* The ease, availability, and portability of smartphone devices along with mobile cloud computing has given rise to many potential applications like smart cities, edge computing, and the like. The proposed architecture can

be easily modified through the dynamic cloudlet using mobile cloud computing, and new areas of research like mobile adhoc learning can be explored. Mobile adhoc learning means using a learning platform set up by a group of users in locations with no access to the internet.

- *Real-time learning skills:* There is a great potential for utilizing the proposed architecture for testing real-time learning skills. As learning resources can be easily made available using the cloud, the gamified modules that involve the requirement of practical skills can be easily used as part of this architecture. For example, there is a gamified course in programming using SAAS or PAAS in the cloud guaranteeing the hands-on experience.

Although there may be other potential applications of the proposed architecture, we are certain that the real implementation of this work will open the door to other unique applications.

6. Research challenges

(1) *Budget Issues in developing gamified learning modules*: A budget is the total amount of money spent to complete a project. The development of quality games that can be used for gamification involves huge costs since gamified learning modules need to be tested and evaluated before completion. This evaluation involves hidden charges like salaries of designers, consultation with course experts and the like. A possible solution for this research challenge includes open-source libraries, free online gamification evaluation platforms, and distributed cloud-computing platforms.

(2) *Identification of gamification elements:* The gamification elements can be defined as certain motivating factors that encourage users to play a particular game. These motivating factors become the basis to enhance the learning process within the education domain using gamification. However, different individuals are influenced by different motivating factors, and a motivating factor for one individual can be a demotivating factor for another. Hence, identifying the key gamification elements that can motivate most users to complete a required task and thus enhancing the learning process constitutes a substantial research challenge. This and other research challenges can be addressed and resolved through additional experimentation and engagement with students to identify those remaining hidden elements that can enhance the process of learning.

(3) *Scalability of gamification to other subject areas:* The education domain is quite vast and covers a number of different subjects. As of today, gamification is already being applied to a few subjects, first and foremost to Computer Science. It has been made evident that gamification can be made scalable to other subject areas, even though it may not be effective. In order to determine the usefulness of gamification in different subjects requires large-scale experimentation on a variety of subjects. This query can be resolved by implementing gamification modules in all subject areas.

(4) *The effectiveness of gamification:* The studies completed on gamification show conflicting results and suggest that gamification may have a positive as well as a negative effect on students. This raises another query related to the effectiveness of gamification on the overall learning process. The primary contributing factor here involves experimentation on the small-scale cluster, random use of gamification elements, and limited subject implementation. The potential solution to address this research challenge includes a comparison of traditional and gamified ways of learning in order to determine the actual effectiveness of gamification. Another solution includes nationwide and international assessments.

(5) *Affective computing for disabled children:* As already mentioned, affective computing is computing based on emotions. It would be interesting to explore the combination of affective computing and gamification approaches for enhanced learning among physically disabled children. Numerous input devices can be used for promoting gamification. Language, emotions, and movement are effective ways of providing proper instructions. A single interface input screen with multi-mode instructions via affective computing may constitute the future of gamification. Among the challenges that arise in merging affective computing and gamification are a user-friendly interface that transmits the information to children with hearing and visibility problems. The possible solution may lie in designing gamification learning modules in a way that can accommodate visual and hearing aids.

(6) *Usability and selection of cloud service:* The prime purpose of cloud computing is resource allocation on demand and less overhead in maintaining computing resources. Since cloud computing offers different services, it has to be determined which service proves more useful to educational institutions in terms of productivity and budget. Moreover, cloud computing can be used to develop high-end games at low cost to identify more elements that motivate users to play certain games. Additional minor challenges are resource allocation and scheduling challenges for different games. Very little research has been carried out to explore the use of gamification through cloud computing, probably due to its limited present scope. It is evident from the literature review that only a very limited number of experiments on gamification in education have been carried out so far and that researchers seem reluctant to explore other technologies for gamification.

(7) *Resource allocation and scheduling challenges in game offloading:* Resource allocation is a decision-making process whereby it is decided when to make resources available to a particular user. On the other hand, scheduling includes the process of utilizing the available resources efficiently. While using cloud computing for games, a few challenges need to be addressed such as how to offload game resources and which scheduling mechanism to adapt for the efficient utilization of resources. Moreover, it would be interesting to observe how resource allocation and scheduling can be organized for games through mobile cloud computing.

7. Conclusion

Gamification constitutes part of a general trend promoting modern education. Several platforms can take gamification to the next level and increase its impact on students. These platforms include affective computing, cloud computing, and distributed computing. Discussed were merging of gamification with the cloud service model. In order to propose this model, the minimum requirements needed for gamification were identified from the reviewed literature. It was found that motivation, task design, short-term tasks, game identity, and reward system form the core of gamification. Based on these requirements, a basic understanding of cloud services was developed and an architecture for promoting gamification through cloud computing was proposed and concluded with its applications. A survey of online games for learning was conducted, which found that most of the game content related to Mathematics and Medicine. A model was proposed to incorporate the learning components of all subjects into a single learning application that can serve as an authoritative source for gamification. Such a single application can be made available to the cloud vendor without being worried about abstraction. The article concluded with future research challenges and suggestions for future research. It is planned to implement the proposed cloud-assisted architecture along with the suitable use-cases and further explore the collaborative technologies that can be run on cloud platforms in a gamified learning environment.

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