

DEVELOPING AN ‘OUT OF THE SCHOOL DOORS’ APPROACH FOR TEACHING INNOVATION BASED ON DESIGN THINKING: FOCUS ON GAMIFIED MOBILE APPLICATIONS

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Abstract— In this paper, the development of a gamified mobile-app for teaching innovation, based on design thinking, is described. The method extends the current designerly approaches for learning by focusing not only on the pedagogical and educational considerations but also on how design thinking and innovation could be taught in an ‘out of the school doors’ approach through gamified methods provided by mobile applications. The proposed method fits to all levels of educational system and to lifelong learning. The gamified approach was developed as a mobile application with augmented reality (AR) features that combines real-world objects and digital artifacts giving the ability to the players to actively participate in the educational process. A pilot was conducted in order to evaluate the appropriateness and effectiveness of the proposed method. The results confirmed the validity and reliability of the proposed educational approach which could be used either alone or in combination with the current educational methodologies in order to teach trainees how to become design thinkers and thus innovative and responsible members of the economy and society.

Keywords— Education, Pedagogy, Design Thinking, Innovation, Co-Creation, ICT, Gamification, Entrepreneurship

1. INTRODUCTION

All international educational organizations and official bodies agree that education in the 21st century should provide students with specialized knowledge and skills to reinforce their future roles as active citizens and professionals [1-3]. Among these skills, innovative skills play a crucial role in entrepreneurship, social entrepreneurship and sustainable growth of the planet and thus should be emphasized in the educational system [4,5]. As of now, innovative skills and competences cannot be sufficiently offered to young students since creativity and innovation are not valued enough by the current educational system.

Teaching innovation in 21st century should primarily be based on an experimental culture of the educational process; that is, an ‘out of the school doors’ approach where students tackle with real-world problems, create new knowledge and develop new products and services with social and economic value towards a more sustainable world [6]. In that sense, innovation is closely related to entrepreneurship since the cultivation of new ideas and practices forms the basis for starting new businesses. Moreover, innovation is a participatory process, a human-centered process that includes users. The incorporation of

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users in the design process and the gradual increment of knowledge based on users' feedback is a contemporary approach in design process called design thinking.

In this paper, design thinking is combined with gamification of learning to develop a mobile application for teaching innovation [7]. Design Thinking is a human-centered approach to innovation which fosters values such as empathy, interdisciplinarity, co-creation, risk-taking and entrepreneurship [8]. As an educational practice design thinking through an artful experimental procedure of thought and action makes the students particularly creative and innovative. At the same time, this procedure makes students far more responsible because it allows them to have the ownership of the creation process.

Also, educators need educational support since teaching methods must adjust to the socioeconomic changes and respond to 21st century skills and employability requirements. [9, 10]. One way to do so is to find new ways to teach innovation at school. Nowadays, innovation is becoming more and more necessary to cultivate entrepreneurial thinking through educational processes as students prepare themselves for a demanding job market in which innovation should be fostered [11].

The educational models for teaching innovation that have been proposed so far are in many ways limited, since they follow traditional approaches that do not give students the option for a heuristic and experimental approach. It is, therefore, required to introduce into the modern curriculum learning activities that promote and encourage characteristics specific to entrepreneurial thinking [12-13].

The remainder of the paper is organized as follows: in Section 2, we present a literature review where we explore the basic components of our approach. In Section 3, we formulate the design-based educational methodology and we present the gamified application. In Section 4, we present a journey map and determine the results of our approach. In Section 5, we further determine the consequences of the proposed approach and make comparisons. We finally conclude the paper in Section 6.

2. LITERATURE REVIEW

A precondition for teaching innovation and entrepreneurship in the modern educational system is to minimize the fear of failure. Unfortunately, the current educational systems are assessment-based and thus stigmatize the students who fail. The fear of failure follows those students later in their professional career and do not let them be innovative and successful entrepreneurs, since innovation and entrepreneurship involve testing different solutions, fail in the initial stages of a project and taking risk.

Therefore, there are many benefits of utilizing game-like approaches as learning tools. For instance, given that a game is an enjoyable activity it can attract the students' interest and trigger their active participation and interplay in the learning process. It is equally important that the students are encouraged to take risks in a safe environment of simulated reality. As a result, the students familiarize themselves with failure, they accept it as a possible aftermath and learn to handle it [14]. What is more, games prepare students for problem solving in real life, because games usually ask the players to provide a solution for a problem by designing and following a strategic methodology. Finally, games can be proved an efficient method for students to address the fear of failure, as the core concept behind game-based learning is teaching through repetition, failure and the accomplishment of goals. It is also supported that playing games and occupying yourself with artful activities are essential components of creativity [15]. Moreover, such practices cultivate the students' imagination and develop abstract thinking. For this reason, game-like learning activities are encouraged to be employed for teaching purposes.

However, we have to draw a distinction between Game-Based Learning (GBL) and Gamified Learning [16]. Gamified learning is not a game. It just uses game-like features such as leaderboards, badges, game-like terminology (*e.g.*, mission, players, stages, *etc.*) in order to gamify the learning process and increase students' engagement. Furthermore, in

our context, gamified learning is also used to implement the ‘out of the school doors’ approach. Thus, our approach focuses on fostering innovation by putting gamification, design-thinking and users’ participation (*i.e.*, co-creation) into a joint pedagogical framework implemented by a mobile application with augmented reality features where students are able to cultivate their creativity and produce innovative solutions to real-world problems in a systematic way without the fear of failure.

The suggested teaching method itself builds on design thinking. Design thinking is based on a well-known design-oriented approach, British Council’s Double Diamond methodology [17], and it is proposed in this paper as a creative process that generates innovative solutions to real-world problems. The problems, that may be cultural, technological, or socio-economic real-world problems are defined or even redefined after research that has been done in collaboration with users. Afterwards many potential solutions are designed and then gradually converge in a unique solution after an iterative process of testing with users’ feedback, evaluation, and refinement. Finally, the proposed solution is created in the form of a prototype.

Design thinking is divided into five main stages: Empathize, Define, Ideate, Prototype and Test. Empathy is the foundation of the human-centered design process where you observe and engage with users and immerse yourself to uncover their needs [18]. The aim of empathizing is to observe, understand and realize the dysfunctional situation and attempt to define or redefine the problem so as to deeply comprehend it. For this purpose, it is of great importance to approach the users. Such an approach, which may also be called users’ analysis can be achieved through field research, that is discussion with the users as well as through interviews, questionnaires and other types of documentation.

The second stage is called Definition and it is a data processing phase. All the information and data that has been selected at the stage of Empathy is edited and analyzed in order to reach conclusions about the nature of the problem, the factors that aggravate it and the real needs of the people affected. The stage of defining is critical to the design process because it explicitly defines the problem you are striving to address and also recognizes the constraints of the potential solutions.

Ideation is the phase where the creativity happens, and it is a judgement-free zone. Designers hold ideation sessions in order to come up with as many new angles and ideas as possible [19]. Ideating needs cognitive flexibility, creative thinking and designers should be able to avoid the pitfall of coming up with the obvious idea. What it does matter during this phase is the quantity, not the quality of the ideas. Having concluded to the best one among the ideas that have emerged during the ideation process the stage of constructing the prototype comes. The “prototype” is a unique representation of the final idea, or in other words, a transfer of the idea schemed in the designer’s mind into the physical world and it could be a tangible artifact, a software application, a web-based or mobile app [20].

As a final stage design thinking suggests the testing of the prototype. The test is not only about assessing the efficiency of the final product but also about improving the experience that the users get from the consumption of the service or product. The user experience should be maximized while at the same time the business goals should be met and aligned with user needs. An effective prototype evaluation by its potential users guarantees an acceptable and desirable solution to the problem [21].

The soundest feature of design thinking which takes place among all stages is called co-creation. That is, the design of the final solution is the outcome of an iterative procedure where during each iteration, feedback is given by the users to design thinkers. The users evaluate the possible solutions and improve or drop a solution and finally test the prototype in order to increase user experience.

3. METHODOLOGY

3.1. PROBLEM DEFINITION AND INSIGHTS

To begin with the development of the gamified mobile application that will provide innovative skills to the users, the first step was to approach twenty-five graduate and postgraduate students of the Greek Educational System and by interacting with them through interviews to investigate their needs, goals, feelings, and obstacles regarding the issue that we are interested in; teaching innovation through a gamified mobile app. We then compiled the data and grouped the user profiles based on users' personality and demographics and finally created several groups of representative users.

The data collection led to helpful conclusions, the most crucial of which were the existence of pain points in current educational system in higher education with regard to technology, creativity, innovation, design skills and entrepreneurship and the need to introduce new methods so that innovation could be successfully taught.

Furthermore, most of the students expressed strong interest in the integration of digital media and games with the educational practices while they seemed eager to undertake a more active role as learners as well as they expressed the need to take initiatives. Also, students were very happy with the introduction of art in the educational process, while they were not satisfied with the 'indoors school' approach of the current educational system.

3.2. THE GAMIFIED MOBILE APPLICATION

The proposed gamified approach is a mobile application which does not apply in the classroom environment but works outdoors and gives the students the chance to study a problem-solving activity in real life circumstances, to participate actively in the learning process and take initiatives. We designed and developed a mobile augmented reality application titled "Think to Design!". This gamified app is an application for mobile devices (*e.g.*, smartphones and tablets) intended for a group of players (three to six members are suggested for each team). The gamified approach is a carefully designed implementation of a game-like approach enhanced with augmented reality-like features.

Augmented reality characteristics allows the interaction of players with the physical real-world environment while at the same time the players are guided and interact with the digital app. This interplay between physical and cyber world is the core feature of Industry 4.0, the fourth industrial revolution [22], and the proposed app is a prototype of how this type of cyber-physical systems could be applied in education.

Conceptually, it is an implementation of design-oriented pedagogy that focuses on teaching innovation to the players. The gamified app initially sets a goal, which is to find a solution to a real-world problem. Then, it urges the players on with questions, trials, missions, surveys and other activities, to get through each stage of design thinking (Empathy, Definition, Ideation, Prototype, Test) so as to further define, design and prototype a solution to the real-world issue.

There is a great range of real-world issues that could be used as application contexts such as cultural, societal, technological and economic ones and it depends on the characteristics of the users (demographics, cultural level, marginalized members, *etc.*) which context approach will be used. It is thus a flexible application that can be scaled up and aligned with the learning goals but also with the students' preferences and needs.

The context we have chosen is the artful and cultural environment of Athens, Greece and especially the cultural and archaeological sites and museums of the city center. The players are asked to approach, identify and study the problem of low traffic in archaeological sites and museums mainly by local visitors. Subsequently, they have to design a creative and innovative solution. The product-solution will be the outcome of the collaboration of the designers with the users in designing and co-creating a solution that will be feasible to construct, potentially profitable as a product or service and desirable by

the users. The outcome has to provide an effective solution for increasing the traffic of archaeological sites and museums.

For the development of this app we have created images, photographs and sounds and we have composed pieces of text using discourse and linguistic style that is appropriate to the users. We made use of photographs personally captured at our visit in the archeological sites and the places where the events of the gamified app are taking place. As for the sound material, we decided to record the text so that the app becomes suitable for blind and partially sighted participants. Also, the language is compatible with the gamified context, and that is why we have mainly employed the second person plural for the instructions. In addition, we have included in the text many exclamation marks, words and phrases in bold text, interjections showing reward (*e.g.*, Well Done!, Congratulations! *Etc.*), time expressions indicating the flow of the game-like process (*e.g.*, The first day of the mission, it's time, the next mission is, Let's start, *etc.*) and matching gaming vocabulary (*e.g.*, mission, player, trial, challenge, *etc.*). However, the language of the game is the Greek language, but this could easily be replaced and mapped into many other languages as well.

As far as the structure of the mobile application is concerned, it is a multiplayer one consisting of five stages: Intro, Mission-1, Mission-2, Mission-3 and Mission-4. The type of pages included in the app are information pages which give guidelines to the players, quizzes which test the players' background knowledge, find the spot quests in which players are asked to move towards a specific location, surveys and missions related with the design thinking processes.

The layout of the stages and missions of the application are described in the following graph depicted in Fig. 1. The graph is a representation of the order that the stages appear and the sequence of the missions.

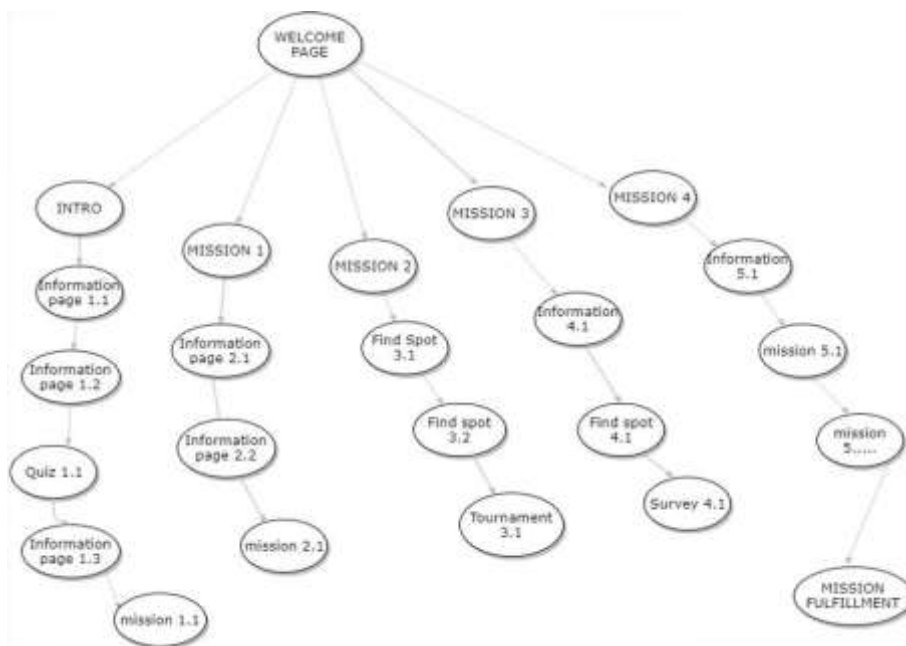


Fig. 1 Graph Displaying the Sequence of Stages and Missions

The first stage, called 'Intro' is the phase where the main player is asked to form a team of players. It is highlighted that a group of people can be proved more effective in relation to problem solving, when its members belong to interdisciplinary fields. Thus, the initial player may invite friends, colleagues, or even other members that would be willing to participate in the 'game'. The feature that will give the ability to the initial player to be able to search online for participants has not currently been implemented but it will be included in a feature update of the app. A brief explanation of design thinking methodology is also

provided in the first stage. The ‘journey’ begins from the Kerameikos Metro Station, a modern metro station near Archeological Site of Kerameikos in Athens, Greece.

In Mission-1, the players are asked to observe the environment of the Archeological Site of Kerameikos, to come into contact with the visitors, to ask them questions about their experience of visiting Archeological Sites in Athens, to keep notes, to take pictures and video and thus to gather information for carrying out challenges and missions. Apart from the missions, quizzes are also included in the game, so that the game becomes more interesting with an educational dimension. To answer these quizzes, the players need to collect information from the area where Mission-1 is taking place.

Mission-2 takes place at Thissio, a traditional place in downtown Athens with sound archeological value and specifically at Apostolou Pavlou Street, which is the main route to Acropolis, and which is a five-minute walk from Kerameikos. The players continue to interact with the app but also with the users collecting more data. What is more, they are asked to perform a brainstorming process, alternatively a meeting in a tranquil and pleasant environment (*e.g.*, a coffee shop in Thissio) where they can recapitulate their data, discuss with each other and start to ideate a solution to the problem. It is suggested that brainstorming is much more efficient when sessions between team members take place outside of the working environment [23].

Given that the problem has been adequately defined, in Mission-3 the team has to collaborate with the users into ideating a solution and then into designing it. At this stage the team is asked by the app to move to a museum such as the Acropolis Museum where more visitors are approached. It is of great importance that the players may design and create their own public pop-up events that are required by the app and thus directly receive feedback from the users in order to co-create the prototype solution. The players are also asked to contact the museum people and authorities and speak with them about the several dimensions of the issue as well as for the possible solutions.

In the final stage of Mission-4, the final idea has been designed and needs to be piloted and tested. The players are asked to visit another museum, such as the Benaki Museum of Greek Culture but the choice is not restrictive. In Mission-4, the players are being taught about the importance of having their idea evaluated and thus accepted and implemented by market agents (*e.g.*, museums). Their journey to entrepreneurship has just begun.

Table I presents how the stages of the ‘game’ are associated with the stages of Design Thinking methodology, Innovation and Entrepreneurship and displays the location where they take place.

The several phases of the application are not intended to get sorted out in a one-day period. Instead, the players may choose the time frame that is more suitable for them. The current state of the app may be saved and continued in a later point in time.

A collage of some pages of the app is presented in Fig. 2.

Table I. Stages of the App in Relation to Design Thinking Stages and their Location

Conceptual Phases	Stage in ‘Game’	Location
Smart Team Development	Intro	Athens: Kerameikos Metro Station
Empathy / Definition	Mission-1	Archeological Site of Kerameikos
Ideation	Mission-2	Apostolou Pavlou Street, Thissio
Prototype / Test	Mission-3	The Acropolis Museum
Pilot – Entrepreneurial journey begins	Mission-4	The Benaki Museum of Greek Culture (cultural institution)

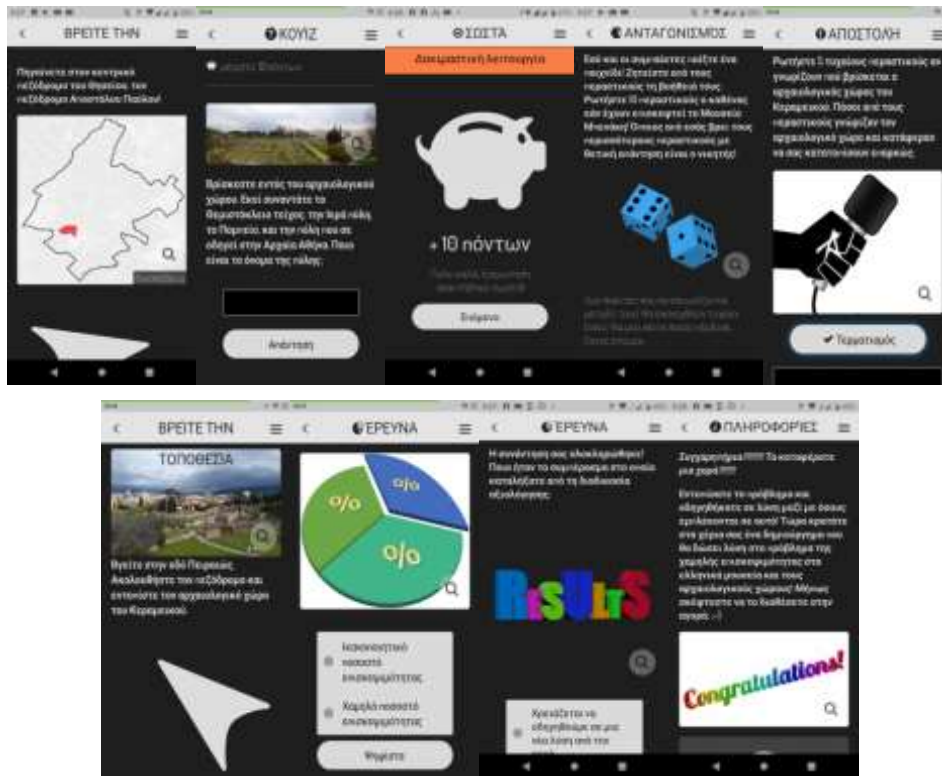


Fig. 2 A Collage of Pages of the Gamified App

4. RESULTS AND IMPLICATIONS

The gamified teaching method was piloted with a small number of graduate and postgraduate students that had initially answered the field-research questionnaire and co-created the app. More precisely, six students created a group and used the app. Then, based on an interview with each member of the team, we have created a representative-user journey map that reflects users' 'game' experience. Thus, the pilot was based on a Usability Test [24].

Usability tests do not require large numbers of participants. It is useful to know that a number between five and eight participants is the best option, since about 80% of the usability problems are found, while sampling more than ten participants will not lead to better results [25].

During the evaluation phase, the users interacted with all the stages of the app and design thinking phases and mapped their experiences in the journey map, depicted in Fig. 3.

		Before using the app / Expectations	Using the App					After using the app
Stages			Smart Team Development	Empathy / Definition	Ideation	Prototype / Test	Pilot – Entrepreneurial journey begins	Comparison to other Educational Methods
Experience/ Feelings	Excited 😄							
	Happy 😊							
	Indifference 😐							
	Sad 😞							
	Disappointed 😞							

Fig. 3 Users' Journey Map of the Gamified Mobile App

According to the findings, the proposed app constitutes an engaging learning tool which enhances teamwork and teaches a great deal of innovation skills.

The overall experience of the users is high, since according to the final feedback users' expectations and goals were met. Nevertheless, there are pain points especially regarding entrepreneurial skills that need better design.

However, the proposed method seems to contribute to a more profound understanding of the learning objects compared to traditional educational methods. Moreover, the proposed solution is considered as an effective empathy and ideation method.

In comparison to traditional teaching methods, the current gamified approach seems to surpass them regarding both cumulative users' experience and innovation learning efficiency.

5. DISCUSSION

Compared to traditional teaching practices of contemporary higher education, the proposed gamified pedagogy appears to be an efficient approach for teaching innovation based on design thinking. Since, in the current educational system innovation is not valued enough and failure is stigmatized, the proposed method allows students to get actively engaged into the learning process, make responsible decisions, take risk and fail in the initial stages in order to finally converge into a desirable solution.

Furthermore, since gamified learning is not limited by the fear of failure it increases motivation in performing a task or achieving a goal. As far as design thinking is concerned, gamified education leads the participants to produce ideas and create solutions. Also, interdisciplinarity is encouraged as students of different academic fields can collaboratively participate in the mobile application.

The proposed application and method constitute a human-centered method and a digital education tool, and thus it can be introduced into modern educational systems to provide their students with designerly ways of thinking and innovative skills. The proposed mobile application has been designed in order to maximize user experience since it allows users to follow an 'out of the school doors' approach.

Moreover, the app involves augmented reality features that allows users to combine real-world and computer-generated objects. However, the current implementation does not support seamless interaction between real and cyber world; that is, users have to manually combine physical and digital objects. We intend to allow for a real time interaction between both physical and digital objects in a seamless way in the next update.

Although the proposed solution has been piloted and evaluated by graduate and postgraduate students it is intended to be used in secondary education as well. By using this app, the young boys and girls will be guided on how to create new knowledge and make an impact on their own environment. They will also learn that learning is a ubiquitous process and does not only take place in isolated classroom environments. Instead, knowledge is everywhere and happens all the time. This app provides this type of freedom and ubiquity while also fosters entrepreneurial spirit, responsibility, and creativity.

The fact that the proposed conceptual model takes place in Athens, Greece and the Athenian museums is a unique pedagogical combination of arts, design, technology and entrepreneurship. Cultural institutions and museums exist in almost any city and country all over the world and thus the proposed app could be easily aligned with any culture. Thus, our approach is a holistic arts-based approach where learning, design thinking, and culture are linked to each other. That way art and culture are part of this innovative teaching process and thus the context of the app could be considered as a stimulus for drawing students' engagement and critical thinking.

Also, the proposed gamified app allows culture and art heritage to be included in the educational process for teaching innovation by selecting appropriate pieces of history or

modern art in order to enhance students' aesthetic experience and improve their innovative skills.

Apart from culture, many other socio-economic contexts and disciplines could be used for our method conceptualization. For instance, business scenarios with technological or social dimensions will give the opportunity to learners to develop skills and competencies related to social economy, sustainability and economic responsibility and thus create an innovative ecosystem for the cultivation of new ideas and practices with regard to social capital, social trust, and equity promotion.

Apart from students, the proposed app is a very useful tool for teachers, as well. Teachers are key actors and thus need pedagogical support to tackle with 21st century teaching requirements. The proposed method gives educators new insights to follow an 'out of the school doors' approach. It includes pedagogical guidelines and also a concrete toolkit unfolded in a 'pick a context' approach for setting up particular cyber-physical working spaces, such as an art-based working space, a socio-economic working space, a technological working space and many other working spaces that correspond to different real-world dimensions of our society.

Thus, the proposed method integrates not only technical, conceptual, and pedagogical features but also cultural, economic and social contexts that make this type of gamified mobile educational application the salient pedagogical approach for 21st century education.

6. CONCLUSIONS

The proposed gamified educational method which has been implemented in the form of a mobile application is meaningful because it promotes an anthropocentric way of thinking and doing and teaches innovation more efficiently in comparison to traditional teaching methods. Teamwork and collaboration are also encouraged, the fear of risk-taking is overturned and the benefits of technology are exploited. The positive response of the students that were also the co-creators of the method, indicates that innovation can be effectively taught based on a joint approach of design thinking, mobile digital technology, and gamified learning. The proposed method can be used as an independent learning tool or it could be integrated into a blended learning process and combined with traditional educational approaches. However, there is still potential for further improvement. The proposed method is intended to be translated into English and other languages. The users have also suggested the incorporation of different levels of difficulty to increase the challenging nature of this gamified app. Having developed this method, our intention is to create different conceptual contexts based on different cultures, economies and social environments which will address a wider range of learners regarding age, nationality, and level of education.

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