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Formulating Innovative Societal Educational Learning Systems Using Gamification Techniques in 3D Environments

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Gamified education has set the ground for the delineation of state-of-the-art literacy skills, enabling learners to develop their digital, cognitive, emotional and social competencies, through active experimentation, motivation and engagement, all while ensuring that pedagogical objectives are being effectuated, therefore capacitating the optimization of the learning process, as a whole. In this paper, we commence by assessing some of the most fundamental frameworks, models and theories evolved around the concept of gamification. We, additionally, showcase schemes through which it stimulates the actualization of active, multidimensional learning, by promoting the application of technological advancements, for the enhancement of learners' hard and soft skills, within time and cost effective frameworks. Ultimately, we, thoroughly, present a newly introduced, cross-platform, innovative educational learning system product, funded by the Hellenic Republic Ministry of Development and Investments, *howlearn*. Using gamification techniques, in 3D virtual environments, for the realization of STEAM related experiments which cover the vast majority of learners' subject material, while, simultaneously functioning as an authoring tool, whilst essentially accounting for accessibility, geographical and other socio-economic considerations, *howlearn* advocates youth-centered learning, providing the foundations towards the establishment of gamified, socially sustainable, multifaceted, inclusive educational learning systems.

Keywords: gamified education, learner-centered, inclusion, social sustainability, innovation

Introduction

Gamification in education concerns the usage of game-based mechanisms and game dynamics to stimulate learners' motivation, curiosity and engagement, all while enhancing their problem solving, critical thinking and communication skills, so that specific educational objectives are attained (Kapp, 2016).

This paper initially focuses on an extensive literature review of various educational models making use of gamification best practices, such as the MDA framework of gamification, the ARCS model, as well as the ARCS + G model. Through these models, we assess how gamification may positively affect education, on a cognitive, emotional, social and technologically sustainable spectrum, while simultaneously serving as a means towards the achievement of personalized learning.

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A comprehensive comparative mapping between gamification and game-based learning then occurs, through which, we demonstrate how gamification revolves around the application of gamification (game) elements, within a specific educational activity of interest (non-game scenario), so that the learning process is gratified through closed-script game realization, while game-based learning emphasizes on the implementation of real games, for the fulfillment of educational objectives.

Moreover, we compare the type of the game (gamification vs. game-based learning) to the breadth of the application within the classroom that it allows for, concluding to 3 main circles of educational games: Circle A: "Gamified Learning, Wide Teaching Application", Circle B: "Less Game, Greater Teaching Application", and Circle C: "A Lot of Play, Little Educational Application".

We, subsequently present the main objective of this work: a case study, with regard to the formulation of a "Circle B" societal innovative 3D learning system—*howlearn*; a cross-platform innovative educational learning system product (also functioning as an authoring gamification environment), eliminating socio-economic boundaries and accessibility considerations in education, through the utilization of gamified "STEAM"-related educational material, within 3D virtual spaces. *howlearn*, hence, constitutes our initial attempt towards multidimensional, inclusive, socially sustainable, innovative education, while it, contemporaneously, manages to bridge the digital skills gap between young people and the IT ecosystem, therefore, holistically, reinforcing learner-centered learning.

Literature Review: Educational Models via Gamification Practices

What Is Gamification

Gamification, a rather newly introduced terminology, reflects the social phenomenon concerning the formulation of a digitally educated population. More particularly, it refers to the use of "game-based mechanisms to engage people, activate motivation, promote learning, and solve problems" (Kapp, 2016).

This definition incorporates pedagogical aspects of vital importance: emphasis is being placed on the holistic promotion of the process of learning itself, while digital game mechanics are being highlighted, including, yet not limited to, ideas such as "character incorporation", "badges and virtual rewards", as well as "levels of difficulty". Moreover, the dynamics of the game are being stressed out, focusing on the elements enabling social interaction between participants. Additionally, motivation and engagement are being underlined, hence addressing the necessity for critical thinking skills enhancement.

According to Simões, Redondo, and Vilas (2013), gamification is the exploitation of game mechanics and game dynamics in "non-game applications", a definition focusing on collaboration, thus giving prominence to the social aspect of gamification.

Other definitions place more emphasis on critical thinking skills that are typically applied in games, yet, may as well, be applied in non-educational settings (Farber, 2013), whilst some focus on the application of gamification, as a means of achieving pedagogical objectives: Kingsley and Grabner-Hagen (2015) considered gamification to be the combination of: "delineating 21st century teaching content, language literacy and learning skills, in a highly engaging learning environment". According to Hamari, Koivisto, and Sarsa (2014), on the other hand, gamification has the potential to become more complex of a notion, when concentrated on "financial incentives", resulting in behavioral change.

Application of Gamification Theory in Education

By applying gamification in education, students achieve more profound levels of understanding of their school material, while actively enjoying the process of learning. On top of that, the learning patterns they are developing have been proven to be much more meaningful, once gamified goals and achievements have been set for. Since video games are being developed with the intention to motivate children (and adults) to actively participate in a given scenario, it is no wonder that similar levels of student engagement would be documented, when examining educational programs in which game-based features are being implemented.

Through gamification, students may experiment with rules, emotions, as well as social roles. Teachers may, therefore, apply a set of rules, over a pre-defined number of challenges that the students will eventually have to complete, accompanied with prizes, conformable to the completion of each and every single one of them. For instance, if students read an optional book, on a specific educational topic of interest, which has been previously taught in class, they are being rewarded by receiving "reading points". Similarly, in cases of active class participation and on-time homework completion, they earn badges concordant with their success (Lee & Hammer, 2011).

Game design elements that may, consequently, be used to engage and motivate students are:

- Narration,
- Immediate feedback,
- Progressively increasing challenges,
- Progress indicators (i.e., through points/badges/leaderboards, also called PBL),
- The use of avatars by "players-students".

Based on the pre-mentioned definitions, there exist three main aspects, where gamification may, beneficially, affect education, as a means of educational intervention:

Cognitive aspect. Games provide a specific set of rules, under which, players are allowed to co-exist in the gaming environment they are being transported into, through active experimentation and discovery. In an educational environment, structured on the principles of gamification, players-students ultimately manage to stay actively engaged in the entire process, from beginning to end, since they are being requested to actively be part of it, by solving a certain amount of tasks, usually of ascending difficulty. An educational goal that is considered difficult to achieve, requiring extra effort from the students in question, or related to multiple learning paths that have to be acquired, within the gamified learning environment, thereby, enhances, not only the motivation of the student-gamer to learn, but also, their commitment to it (Lee & Hammer, 2011).

Emotional aspect. A gamified learning environment allows students to express a wide range of emotions, from curiosity to frustration and joy. In addition, it provides them with positively affected emotions, such as optimism and pride. Even in cases where negative feelings are being generated, due to failure in a given educational activity, consequent motivational feelings are shaping up, allowing for feelings of persistence to occur, so that the given task is, eventually, successfully completed. More particularly, gamification has the power to rein in learners against the feeling of failure, turning the application of gamified techniques into a rather requisite part of the learning process; an opportunity for further educational effort to be made, until the final goal has been met (Lee & Hammer, 2011).

Social aspect. Games allow players to experiment with distinct identities, through in-game decision-making. Players may adopt some of these identities, while in-game, hence exploring new potential

perspectives of their own identity, while remaining in the safety zone of the game. Likewise, in the educational process; through gamification, students adopt various identities/roles, in a gamified educational environment. As they progress in achievements, they receive recognition, either from their teacher and classmates, or, even, from the gamified educational environment itself (for instance, through a high leaderboard ranking). Thus, via gamification and students' successful progress in a gamified educational environment, new skills (which would have never, otherwise, come to the surface) sprout (Lee & Hammer, 2011).

The MDA (Mechanics, Dynamics, Aesthetics) Framework of Gamification

The MDA framework of gamification, based on game design theory, consists of three main components: (1) game mechanics, (2) dynamics, and (3) aesthetics. The mechanics of the MDA framework include the functional components of a game: its points, levels, challenges, virtual goods/gifts, leaderboards, as well as its algorithms. Game dynamics, on the other hand, refer to the speed at which the aforementioned mechanisms appear in the gamified environment, as the player enters and/or exits the game. Finally, the aesthetic part of the MDA framework describes the emotional response of the player, when interacting with the game, and is closely related to the notions of satisfaction, pleasure, envy, respect, and connection with the game environment as a whole (Hamzah, Ali, Saman, Yusoff, & Yacob, 2014).

Personalized Feedback

Teachers' main focus should be on the design of a learning environment that provides resources to support self-regulation, especially when using their students' data, to design ways of learning (Basham, Hall, Carter Jr., & Stahl, 2016). What is more, "designing with diversity" creates opportunities for multiple, multidimensional learning pathways (Basham et al., 2016).

Keller's Motivation Theory—ARCS Model

The challenge of stimulating and maintaining students' motivation, as well as the difficulty of finding reliable and valid methods to motivate them, is known to every teacher. To address the above-mentioned challenge, a model of motivation theory, known as the "ARCS model", was established, emphasizing on the factors which tend to motivate students the most, thus providing assistance, in the design process of motivational strategies, based on these very factors (Keller, 2000).

Characteristics of the ARCS Model—Gamification and the ARCS Model

The ARCS model is based on four fundamental factors through which the increase and maintenance of student motivation is achieved, attention, relevance, confidence and satisfaction, namely. The initial letters of these four factors constitute the term "ARCS model".

The use of gamification in learning environments is currently widespread, motivating the learner towards lifelong learning. The integration of gamification within the ARCS model enhances the utility of game design elements in learning environments. Additionally, the ARCS model's ability to expand and adapt to educational design makes it suitable for educational use.

The educational model combining the ARCS model with gamification is called the ARCS + G model (Hamzah et al., 2014). The gamification elements to be used in this model are highly correlated to the game mechanics as defined by the MDA framework, such as reward, competition and achievement—items matched with the four factors of the ARCS model: attention, relevance, confidence and satisfaction.

Educational Gamified Models

Kingsley and Grabner-Hagen (2015) investigated (a) how gamification in education may support the multimodal and social nature of the newly inserted definition of digital literacy and (b) how gamification may provide opportunities for creativity, critical thinking, communication, and collaboration, so that new skills are mastered. According to the illustration of their observations, gamification empowers knowledge formulation and, thus, better understanding of the material that is being taught, since learners get to learn through "real-life scenarios", with opportunities for experimentation, commonly, occurring through multiple means of collaboration.

They conclude that thoughtfully applied educational games give new impetus to digital literacy acquisition, as they innovate the way through which instruction is delivered and, by extension, the way through which knowledge is acquired. According to recent research, conducted by Park and Kim (2021), gamification, especially in online learning programs, in the midst of the Covid-19 pandemic, has contributed to the realization of the SDG4 and the goal of "leaving no one behind" by providing equal access to education.

More specifically, Park and Kim (2021) stated that, due to the impossibility of face-to-face education, in the midst of a pandemic, the ability to access knowledge through technology and smart devices has zeroed out the distance between learners, their instructors and their respective educational programs. Therewith, students' extrinsic and intrinsic motivation automatically increases, as a multitude of learning needs is being served. In that way, gamified learning goes hand in hand with the theory of self-determination, with three basic elements of sustainable education being reinforced:

(a) Autonomy: having total control over a set of actions taking place throughout the gamified learning process; students gain confidence in themselves, in the making of decisions, thus intensifying their critical thinking skills [key condition of the SDG4—Sustainable Development Goal 4—Quality Education—United Nations Development Programme (2023)].

(b) Readiness and competitiveness: the self-awareness of the student's ability to perform a specific task, to a certain degree, as well as the awareness of its relative relationship to other relevant tasks. According to Park and Kim (2021), the most applicable, to sustainable educational practices, elements of gamified learning, are rewards, points, goal achievements, performance categorization, role assignment, challenges, strategic choices and feedback.

Through such tools, students become agents of the "sustainable best learning practices", cultivating their emotional stimulation and awareness. According to Caballero-Gonzalez, Muñoz-Repiso, and García-Holgado (2019) the conceptualization of a skillful professional workforce requires, not only knowledge, but also soft skills, which will later enable the latter to develop an entrepreneurial spirit, accompanied with full awareness of the impact of the application of their strategic best practices upon it. Problem solving, critical thinking, creativity, teamwork, communication skills, as well as the ability to resolve conflicts, all fall into the spectrum of such best learning practices.

In this context, it is clearly being intonated, how the creation of such gamified environments may strengthen the foundations of the above-mentioned skills, given the fact that, through the interaction with them, learners' performance is constantly being evaluated (or even, re-evaluated, when improved practices leading to SDG4 skills are being applied for), upon a received—often personalized—feedback, therefore, perpetually intensifying their motivation towards continuous self-improvement. If, additionally, learners' data are being

stored, statistical inference/data analysis upon them, through machine learning algorithms, might demonstrate patterns/ways/forecasts, towards the achievement of learning goals, the adaptation of critical professional behaviors, as well as the holistic summit of knowledge.

Gatti, Ulrich, and Seele (2019) highlighted that, particularly in university education, gamification increases the "critical ability" rate, leading students to ownership of their learning, via the acquirement of their metacognitive skills.

Furthermore, as demonstrated by professional simulation games, the increase in motivation as a result of the application of gamification, has a direct positive correlation with the increase in performance and the achievement of the learning goals in question, since, experimental learning leads to the adoption of best learning practices, hereby expediting sustainable education.

Spanellis and Harviainen (2021) demonstrated the conclusions that emerge, regarding the transformation of organizations and societies, through gamified educational programs. Specifically, they refer to educational programs, as a means of impugnment of/surpassing the "educational poverty" and the implementation of a globally sustainable education, through gamified programs that are inclusive of (sensitive towards) all potential learners.

In conclusion, gamification in its results, in addition to the per se goal number four (4), for sustainable education, extends to the further interrelated goals of 2030, being a decisive factor in the implementation of recommendations for actions that will bring about sustainable change in quality education by providing (1) borderless educational material, which supports the enhancement of decision-making skills, sheer knowledge erudition and cultural exchange, (2) open access to education, for marginalized social groups or students living in inaccessible areas, and (3) necessary tools for adult trainees to carry on with pursuing their lifelong learning, therewith intensifying the enrichment of their overall qualifications.

Current Technological Gamification Trends and the Ingredients of Contemporary Personalized Learning

Nowadays, personalized learning has, globally, become a rather widespread learning approach, advocated, particularly, in the United States of America, where, entire school networks are collaborating with one another, so as to share and forge ahead their personalized best learning practices. The MAPLE Consortium (Massachusetts Personalizing Learning for Equity and Excellence) network of schools is a member of this initiative, comprising dozens of schools of the Massachusetts area, proposing the following components of personalized learning:

- Creation of in-depth connections between students, teachers and all those contributing to the educational process as a whole.
- Establishment of personalized learning paths, for each student, complying with their own set of personal needs and relevant goals which have been set to be achieved.
- Acquirement of skills (competency-based progression), based on a detailed analysis of the competencies expected to be developed/embellished by the students.
- Formulation of a comprehensive learner profile, capable of recording the students' personal path, skills, preferences, and needs, according to which, teachers may re-adjust and ameliorate their teaching approaches.
- Inauguration of flexible learning environments, facilitating the "what, when, how, and where" of the learning process.

- Application of technological advancements, to actualize all of the above-mentioned processes, within time and cost effective frameworks.

Educational Games: Analysis, Dimensioning, Mapping—Gamification vs. Game-Based Learning

Educational games massively contribute to the nascency of meaningful personalized learning. From a theoretical point of view (to the educational theorist, that is), however, the rationale behind the existence of games, as part of the personalized learning process is of question; while, based on constructivism, predominant emphasis on personalized learning is being placed on the active role of the student, based on behaviorism, games are usually thought of as tools of "student submission".

Trying to understand why this might be the case, one may recall on the two distinctive kinds of games that exist: (a) those in which the game scenario is open, allowing players to apply skills such as creativity and imagination, and (b) those in which the players follow a pre-determined game flow, scoring points, as they progress in the given scenario (Kapp, 2016).

According to (b), games are being used "behaviorally", since they "manipulate" the user into focusing on their individual score, while, certainly, also witnessing the rest of the gaming elements, such as graphics, music, and between-players-competition.

Thereupon, in the language of education, the first type of learning, through games in which players create their own scenarios, while using a variety of skills, is called "game-based learning", whilst the second type of learning, through closed-script game realization, where key elements of gamification are being apparent through the process of collecting scoring points, is called "gamified learning".

Table 1 below compares the characteristics of the two pre-mentioned types of learning, with their key differentiator being the application of "real" games, to fulfill educational objectives, vs. the application of gamification elements within a specific educational activity, so as to make the learning process more enjoyable, within the students' community:

Table 1

Gamification vs. Game-Based Learning

Gamification Adding game elements to a non-game scenario, while rewarding certain behaviors, either with benefits or, by "unlocking" new features or services.	Game-Based Learning Rather than implementing game-like tropes into lessons, GBL uses actual games to teach.
Adding game-like elements (badges, experience points etc.) to a lesson.	Using games (such as Minecraft) to teach specific learning objectives.
Motivation: Likely extrinsically rewarding (i.e. reward tied to grades).	Motivation: Games designed to be intrinsically rewarding (may also be extrinsically rewarding).
Assessment does not occur within the game.	In-game assessment.
Game-like aspects adjusted to fit the lesson content.	Lesson content adjusted to fit the game.

Note. Source: EdSurge (2023).

In practice, both types of gaming approaches are being utilized in education, nowadays. Free play comes with excellent scrolls and allows for the enhancement of soft skills, such as creativity and imagination (Anderson, 2019; Noonoo, 2019). On the downside, it comes with limited applicability within the classroom.

On the contrary, a gamified learning software might, extremely positively, affect the personalization of the learning process.

Most importantly, whatever the case might be, moderation in the use, as well as, a good combination of both of the pre-mentioned kinds of educational games, is what will, ultimately, upgrade the learning process, holistically. Below, we place, on two axes, certain examples of existing games; the horizontal axis identifies the type of the game (game-based learning vs. gamified learning), while the vertical axis ranks the game, according to the breadth of its application in the classroom [note: this last dimension is a complex equation, depending mainly on two characteristics: (a) the direct connection of the educational game to the curriculum, and (b) the ability to collect analytical data on students' performance].

As one may tell, from Figure 1, the graph is being divided into three sections, each of which, corresponds to one of its presented circles:

- The first section "A Lot of Play, Little Educational Application" includes games belonging to circle C, i.e. games which, although enhance the development of skills, are not widely used in the classroom, since they fail to meet the needs of school-based teaching and material.
- The second section "Less Game, Greater Teaching Application" corresponds to circle B and describes games that are less creative, yet, more useful in the classroom because they manage to cover parts of the material (usually small, but, specific) allowing teachers to monitor their students' progress.
- The third section "Gamified Learning, Wide Teaching Application" corresponds to circle A, including gamified educational products, which allow for less free play. However, they have the upside of perfectly fitting with large chunks of the school curriculum, while, simultaneously recording student progress in detail (these constitute the very features making them especially useful within the classroom).

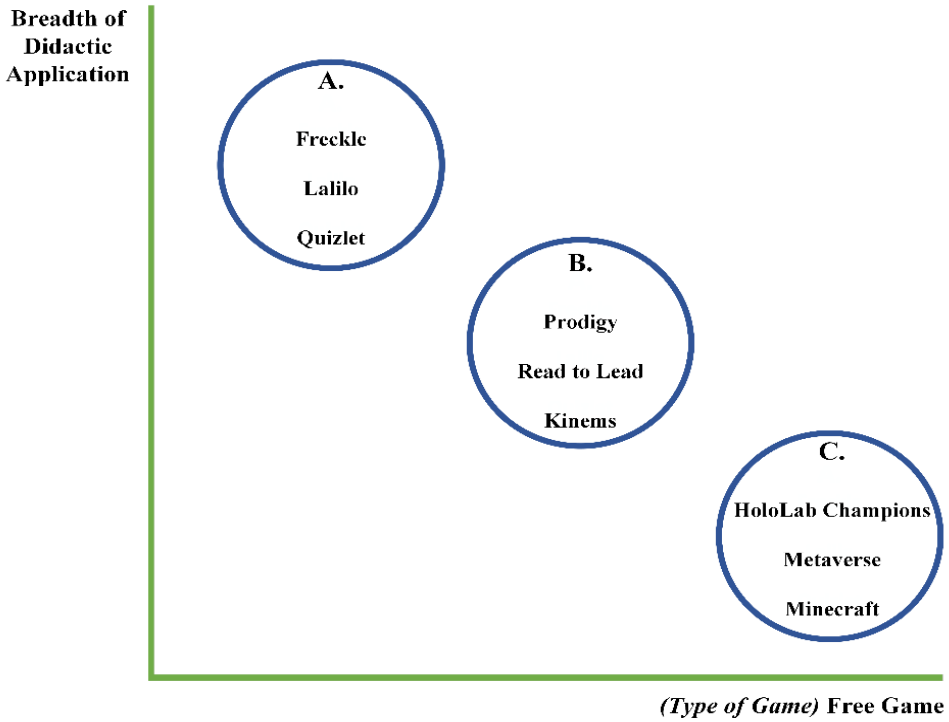

Figure 1. Types of educational games. Source: EdSurge (2023).

Formulating a "Circle B" Societal Innovative 3D Learning System—A Case Study: "howlearn"

howlearn is a cross-platform (Windows, Android/iOS and Web) innovative educational learning system product, funded by the Hellenic Republic Ministry of Development and Investments, using gamification techniques, in 3D virtual environments, within which, learners complete experiments/exercises, covering the vast majority of their subject material.

These virtual spaces simulate classrooms, laboratories, as well as entrepreneurship and innovation offices, hence allowing their users (educational institutions, instructors and learners, namely, the "use cases" of *howlearn*) to participate in realistic, material-based scenarios, without the necessity of physical appearance.

All of the experiments are being created via "unity", a cross-platform game engine, supporting a variety of desktop, mobile, console and virtual reality platforms. More particularly, *howlearn*'s "virtual library of experiments" focuses on providing gamified education in the area of "STEAM" (Science, Technology, Engineering, Arts and Mathematics), through:

- 10 virtual thematic experimental laboratory simulations (Physics, Chemistry, Biology).
- 5 virtual labs in Mechanics and ICT.
- 10 interactive storytelling (narration) scenarios (English and Mathematics).
- 5 Literature and Arts simulations and case studies.
- 2 educational scenarios of interactive storytelling & decision-making, via the usage of virtual worlds, so that students are familiarized with the concepts of entrepreneurship and innovation.

On top of that, both the educational institutions and instructors acquire full access to a "repository", including all of the virtual 3D objects, constituting the experiments of the library (see Figure 2 and Figure 3). They may, therefore, compose new experiments, for their students, from scratch, without any "advanced computational skills" requirements; a simplistic "drag-and-drop technology", is more than enough, in order for the new experiments to be formulated, or, for, already existing experiments to constantly be reformulated (which is why *howlearn* also functions as an authoring gamification environment).

Last, but not least, special importance has, additionally, been given to the compliance of the system with the accessibility specifications, as implied by WCAG 2.1 ("Web Content Accessibility Guidelines"), so that the content of *howlearn* is accessible to a wider range of people with disabilities, such as blindness and low vision, deafness and hearing loss, learning disabilities, cognitive limitations, restricted movement, speech impairments, photosensitivity and combinations thereof. With foreground and background colors being required to have a contrast ratio of 4.5:1 at Level AA and a contrast ratio of 7:1 at Level AAA, it falls into place that, in *howlearn*'s case, the entire user experience of the integrated system is fully compliant with the WCAG guidelines (AAA—"Excellent"—color palette: #FFC845 #1B365D #007478 #FFFFF #00000).

Figure 2. Interactive storytelling & decision-making entrepreneurship scenario, in *howlearn*'s virtual 3D "Entrepreneurship and Innovation Corporate Headquarters (HQ)".

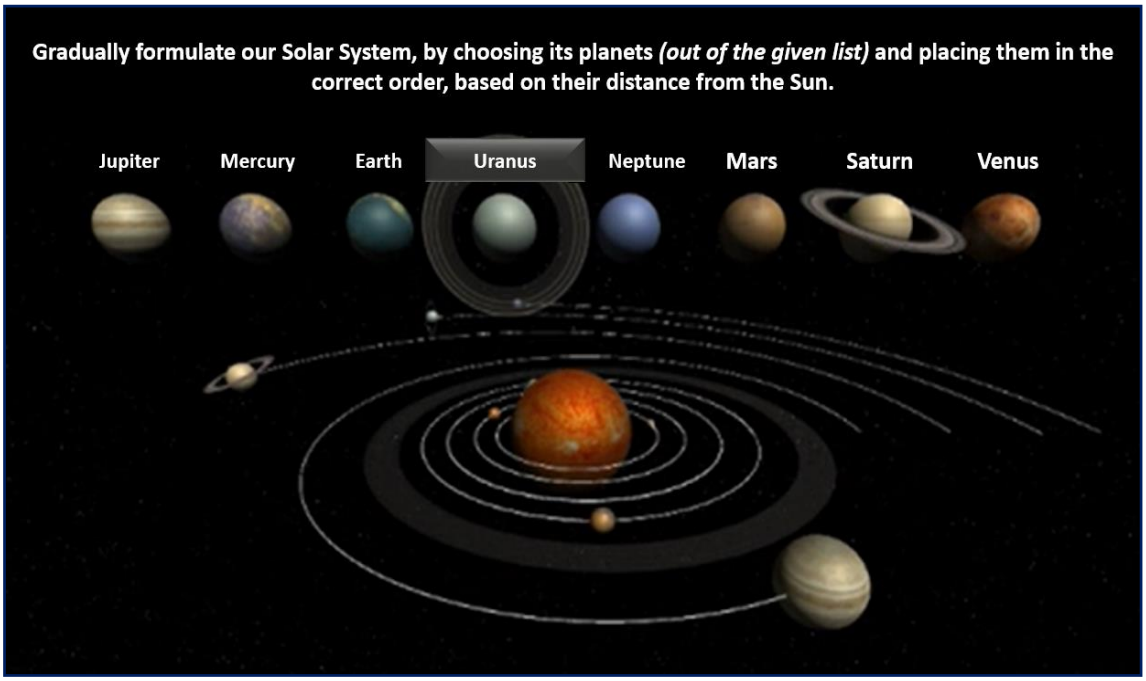

Figure 3. "Celestial Mechanics Virtual Lab", for the apprentisage of our Solar System; the gravitationally bound system of the Sun and the objects that orbit it.

Conclusions—Social Impact of Formulating howlearn; an Innovative 3D Learning System

The integrated solution proposed in the framework of the "Innovative Research Project *howlearn*" provides significant social benefits, since it enables for the holistic and effective implementation of some of the latest technological advancements, to the whole of the educational community (compulsory and post-compulsory education, lifelong & vocational training and education), therefore eliminating geographical boundaries [see section 3 above: gamification … has contributed to the realization of the SDG4 and the goal of

"leaving no one behind" by providing equal access to education (Park & Kim, 2021)] and/or other socio-economic boundaries, giving all users the possibility to receive equal, high-end education/training, while practicing certain state-of-the-art digital skills that business ecosystems seek in their incoming labor force [see section 3 above: … the implementation of a globally sustainable education, through gamified programs that are inclusive of (sensitive towards) all potential learners (Spanellis & Harviainen, 2021)].

As a result, the digital skills gap between young people and the IT ecosystem (local and regional labor market ecosystem) is being bridged, through the constant upskilling of young learners' digital competencies, with the latter, actively strengthening their technological literacy, while they, in fact, focus on their specific area of expertise, using STEAM as an access point for guiding their inquiry, dialogue, and problem solving competency [see section 2 above: Gamification … refers to the use of "game-based mechanisms to engage people, activate motivation, promote learning, and solve problems" (Kapp, 2016)].

Consequently, youth-centered learning is being reinforced and youths are being given the opportunity to develop their cognitive reflexes, improve their willingness to take initiatives, boost their self-confidence, be motivated to learn and enhance their translingual skills and reflexion, hence intensifying their creativity, strengthening their collaboration skills and augmenting their critical thinking [see section 2 above … three main aspects, where gamification may, beneficially, affect education, as a means of educational intervention: cognitive aspect, emotional aspect, and social aspect (Lee & Hammer, 2011)].

It, therefore, becomes elucidated that, learning systems like *howlearn* set the ground for the formulation of an economically sustainable environment of knowledge enhancement in the community, since, not only do young people get to sharpen their hard (IT) skills, but they also intensify their soft skills, through their constant cooperation with their professors/tutors and classmates [see section 2 above: … collaboration, thus giving prominence to the social aspect of gamification (Simões et al., 2013); section 3: gamified learning goes hand in hand with the theory of self-determination, with three basic elements of sustainable education being reinforced: autonomy, readiness and competitiveness (Park & Kim, 2021)].

Such learning systems, thus, enhance social sustainability, as a whole, since, learners acquire sought-after multidimensional skills, making it the case that, skillful, well-educated manpower is, ultimately, contributed to the industry world and society, en bloc [see section 3 above: … problem solving, critical thinking, creativity, teamwork, communication skills, as well as the ability to resolve conflicts, all fall into the spectrum of such best learning practices (Caballero-Gonzalez et al., 2019)]. Additionally, inclusive education is being allowed for, since, accessibility considerations have been taken into consideration, allowing all learners to access and gain equal learning opportunities, within the framework of 3D innovative education (see section 6 above).

Concurrently, since, through *howlearn*, learners get to familiarize themselves with game mechanics, dynamics and aesthetics of 3D virtual spaces (as implied by the MDA framework), whilst, simultaneously maintaining student motivation, through attention, relevance, confidence and satisfaction (as implied by the ARCS model), all, while remaining in line with the conceptualization of gamification, we conclude that *howlearn* might very as well be characterized as an "ARCS + G Model Innovative Learning System" (Hamzah et al., 2014).

Therewith, via *howlearn*, some of the latest technological advancements in the field of education are being employed, as a means of actualization of multifaceted education, in flexible learning environments, within time and cost effective frameworks [see section 4 above: MAPLE Consortium (Massachusetts Personalizing Learning for Equity and Excellence)].

Ultimately, in terms of *howlearn*'s "Breadth of Didactic Application and the (Type of Game) Free Game" spectrum, it falls into Circle B, since it constitutes a platform offering less "free play gaming opportunities", allowing, however, for extensive/complete coverage of wider (usually small, yet, rather specific) parts of the material, empowering teachers' capability to monitor their students' progress [Circle B: "Less Game, Greater Teaching Application"—see section 5 above (EdSurge, 2023)]. On that note, however, a small number of *howlearn*'s experiments also allow for "Gamified Learning, Wide Teaching Application", thus reflecting its convergence to Circle A's concept of gamified educational products, allowing for less free play, yet, for a larger chunk of the material in question to be covered.

While major steps have been taken towards the formulation of a thoroughly innovative learning system, there exist additions, which could further improve the final product; the implementation of "game metrics assessment formulas", through the application of data mining and machine learning algorithms, upon learners' gaming data, would enable the latter to receive personalized feedback reports, comprehensively informing them on their overall performance, tailoring education to meet learners' divergent and distinct needs, hence constituting *howlearn*'s upcoming milestone.

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