Digital Educational Escape Rooms as E-courses Using D-EER4SmL: Investigation of Motivational Affordances

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Abstract: Research has shown that educational escape rooms (EERs) motivate and engage learners in the learning process, mainly due to the incorporation of game elements into their educational context. As a result, various frameworks have been proposed to design and develop EERs over the past few years. However, these frameworks fail to highlight the important "D"-digital factor of technology which transforms EERs into Digital Educational Escape Rooms (DEERs), as well as the smart pedagogy (SmP), which in turn goes beyond game-based approaches and is currently essential for the design and the development of well-orchestrated and reusable smart learning solutions. Due to the fact that technology increases motivation, this study introduces the work-in-progress framework D-EER4SmL, primarily based on John Keller's theory of ARCS and the 10-step systematic design process for the development of motivational e-courses, tailored to learners' preferences. The framework was aligned with various EER design principles, along with Smart Pedagogical (SmP) approaches, which could be facilitated by web technologies in order to design and develop DEERs as e-courses. To confirm the motivational aspect of smart learning and the assumption that digital technology provides additional motivation, a DEER e-course was developed, based on this framework. The DEER e-course was delivered to ICT students - future ICT teachers/e-learning educators - who would be trained in instructional/e-learning design utilizing web technologies. A total of 108 higher education students of digital systems voluntarily participated in the workflows of the DEER e-course, played the game, and evaluated motivational affordances (MAs), after completing it. Quantitative data analysis was conducted, based on an improvised questionnaire for DEERs, aligned with Keller's Instructional Materials Motivation Survey (IMMS). As far as motivation is concerned, the framework was proven effective in the initial research findings; however, further research is needed to confirm its effectiveness within the wider context of smart learning.

Keywords: Digital Educational Escape Rooms, Motivational Design Process, ARCS, Project-Based Learning, Smart Learning

1. Introduction

Escape Rooms (ERs) were first introduced in Japan in 2007 as recreational games. Yet, since 2012, they have spread around the world and are used in various fields, including education, as innovative tools (Makri, Vlachopoulos, and Martina, 2021). In Educational Escape Rooms (EERs) learners engage in cooperatively playful, problem-based activities within a constrained timeframe, developing their knowledge and soft skills in accordance with learning objectives (Fotaris and Mastoras, 2022) and pedagogical guidelines (Makri, Vlachopoulos, and Martina, 2021). In light of the rapid integration of ICT and particularly Smart Technology (SmT) in education, EERs have become more engaging, authentic, and learner-centered learning environments. In EERs, ICT mainly serves the following purposes to: a) structure a Digital Educational Escape Room (DEER) game, such as revealing the narrative, supplying codes, solving puzzles, and/or providing additional information; b) foster immersion by facilitating learners' discovery and interpretation of new knowledge; c) keep track of learners' safety; d) help learners acquire ICT skills related to their subject matter; e) facilitate educators' work; f) handle large groups well. Despite technological advances facilitating EER installation, DEERs still lack clarity regarding the "D"-igital factor as a result of their definitions. In Fotaris and Mastoras's definition of DEERs (2022), players unlock digital locks through technology, usually by completing online forms or password-protected documents (e.g., smart phones, apps, VR/AR, QR codes, etc.). Is this, however, sufficient to describe the role of ICT in a DEER? If DEERs are considered virtual learning spaces, namely Technology-enhanced Learning Environments (TELEs), what learning aspects do they actually enhance by integrating technology? What about the case of DEERs as e-courses? Using technology to enhance learning can be beneficial in five different ways, according to Daniela (2021), provided we consider the perspectives of each dimension separately. As one of the five dimensions, motivation can be enhanced by technology. A number of studies have concluded that DEERs motivate learners even when used in on-line and remote learning settings (i.e., Grāvelsiņa and Daniela, 2021; López-Pernas et al., 2021 etc.). In addition, they argue that DEERs are more effective when game-based learning or gamification is incorporated, but in order to assess the levels of efficacy based on motivation, game practices should be combined with motivational theories. The international literature describes several EERs design frameworks (i.e., Clarke et al., 2017; Fotaris and Mastoras, 2022 etc.) without all of them being validated or emphasizing how ICT can enhance learning (Karampa and Paraskeva, 2022). Because of this, little data is

available on how DEERs should be designed, especially in the form of e-courses, to provide optimal learning, currently referred to as Smart Learning (SmL). The proposed D-EER4SmL framework aspires to offer a solution to all the above-mentioned questions, although it has not yet been validated. In this study, it is employed in an effort to explore how technology facilitates pedagogy to enhance learners' motivation, evaluating the Motivational Affordances (MAs) of SmL that learners perceive. In the following paragraphs, the research method and the findings of this study are described, with recommendations for future improvements.

2. Research Method

2.1 Research Objective and Research Questions

The concept of SmL can be defined as optimal learning that takes place in a learning environment, operating as service or product of the teaching and learning process when SmP and SmT interoperate effectively to provide learners with a range of learning affordances. The purpose of this study is to investigate the motivational affordances (MAs) that learners perceive from participating in a DEER e-course based on the above-mentioned consideration of SmL using the D-EER4SmL framework. Following are more specific research questions that address this broad research objective of this study:

- RQ1. Does the DEER e-course developed based on the D-EER4SmL framework *stimulate learners' curiosity, arouse, and sustain their interest (MA1)*?
- RQ2. Does the DEER e-course developed based on the D-EER4SmL framework *guide learners to effective goals (MA2)*?
- RQ3. Does the DEER e-course developed based on the D-EER4SmL framework *involve learners in authentic tasks (MA3)*?
- RQ4. Does the DEER e-course that is developed based on the D-EER4SmL framework *involve learners in inquiry and problem-based processes (MA4)*?
- RQ5. Does the DEER e-course that is developed based on the D-EER4SmL framework *help learners control and regulate their learning (MA5)*?
- RQ6. Does the DEER e-course that is developed based on the D-EER4SmL framework *enhance collaborative learning among learners (MA6)*?
- RQ7. Does the DEER e-course developed based on the D-EER4SmL framework *promote learners' assessment and reflection on their learning, so that their achievements can be recognized (MA7)*?

2.2 Creating a DEER E-course Using the "D-EER4SmL" Framework

The D-EER4SmL framework (

Figure 1) is a work-in-progress framework for creating DEERs in the form of e-courses, aiming to provide SmL. This consideration is based on the following four guidelines (Karampa and Paraskeva, 2022): a) select innovative pedagogies, namely SmP, beyond game-centered approaches to well-orchestrate learning designs; b) outline the role of technology and its integration in DEER structure, content, and functionality in alignment with selected pedagogies to provide Smart Learning Affordances (SLAs); c) identify frameworks or even strategies and recommendations proposed internationally in the literature on designing (D)EERs and combine them with proposals related to SLAs; d) evaluate the framework through the development and implementation of DEERs in the form of e-courses by investigating the related SLAs. As a result of these guidelines and considering the fact that technology: a) is the essential but unclear "D" factor in creating Digital EERs; b) facilitates SmP, the driving wheel behind SmL (Daniela, 2021); c) might affect the learning process by creating additional motivation (Keller, 2000), which in turn has impact on learners' performance, including competences, and future achievements (Ryan and Deci, 2009); the D-EER4SmL framework attempts to provide a holistic solution. It is primarily based on Keller's (1987) ARCS motivational theory (Attention, Relevance, Confidence, Satisfaction), which uses a systematic 10-step design process to develop motivational courses and e-courses (Keller and Suzuki, 2004), tailored to learner preferences. These steps are divided into four distinct phases, these of Analysis (MD1), Design (MD2), Development (MD3) and Pilot – Evaluation (MD4).

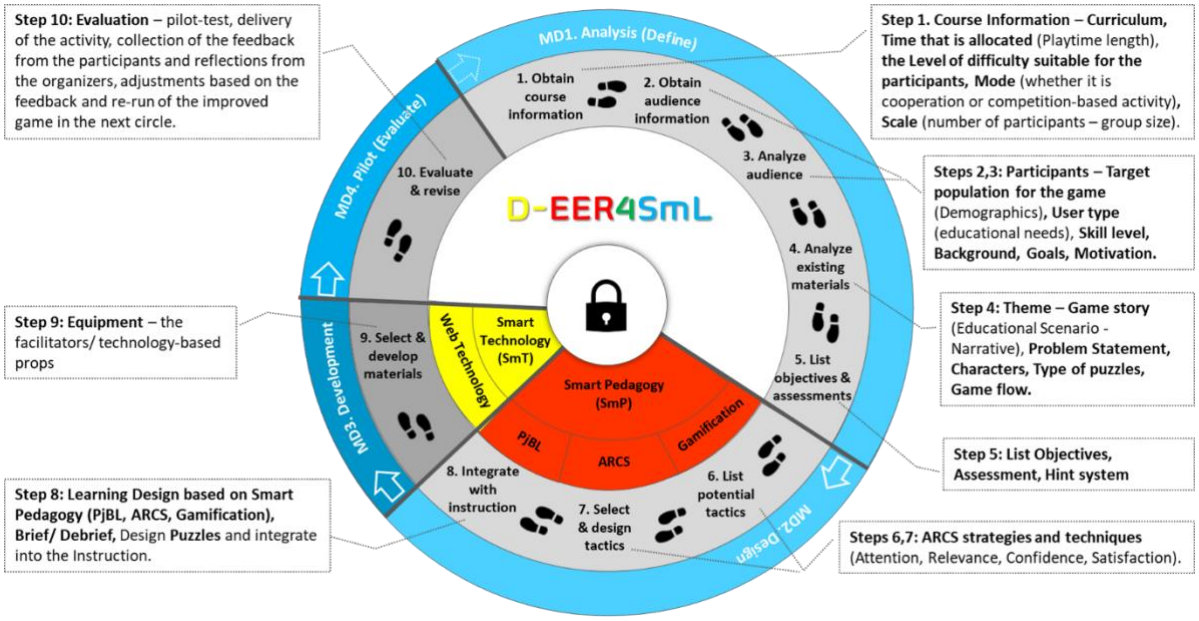

Figure 1: The D-EER4SmL framework

Analysis (MD1): Analysis is necessary to create any learning context. In D-EER4SmL, analysis covers steps 1 to 5. Step 1 identifies the DEER e-course information (title, description, curriculum, and educator details) as well as potential constraints (time for playing and briefing/debriefing), scale (the number of participants), mode (cooperative or competitive), difficulty (educational level), and budget (Fotaris and Mastoras, 2022). Thus, the development of a DEER e-course titled "Workshop on innovative teaching and learning methods and the pedagogical use of ICT in educational practice" was considered essential to prepare 108 postgraduate students at a Greek university department of digital systems for their future careers as e-educators. The DEER e-course namely offered practical application of the theoretical background behind the academic course of e-trainers' training. Therefore, after completing the DEER e-course, learners would be able to apply pedagogical concepts to design, develop, implement, and evaluate the educational process in Technology-Enhanced Learning Environments (TELEs). Moreover, they would be capable of adapting and orchestrating pedagogical methodologies to digital tools and environments. It meant that it would result in a collaborative and open e-course, in which learners would be able to enroll voluntarily. The DEER e-course was planned to last approximately three months (during the spring semester), including two weeks for briefing and debriefing. In the briefing period, participants were profiled based on demographic data, including their starting skill level, background, and goals, along with their motivation. Thus, a questionnaire was given in the form of an interview and the recorded answers were analyzed (steps 2, 3). Individuals in the sample ranged in age from 23 to 58, reflecting a diverse range of ages among postgraduate students. A total of 18,5% (n = 20) of participants were males and 81,5% (n = 88) were females. They came from a wide range of academic disciplines related with STEAM fields (i.e., humanitarian, social, and medical studies, technology/engineering, mathematics etc.). Furthermore, it is worth mentioning that, only 14,8% (n = 16) were unemployed, 52,8% (n = 57) had not any ICT knowledge certification, and 28,7% (n = 31) had no previous experience participating in on-line courses. Nevertheless, a total of 78,7% (n = 85) felt that usability, functionality, and accessibility were the most important factors to consider when developing an e-course, while 14,8% (n = 16) prioritized clear learning design (goals, modules, interaction, duration, resources/tools, forms, and assessment criteria). In terms of competencies, learners mainly highlighted the enhancement of 21st century skills and ICT skills, derived from their participation in the DEER e-course. They emphasized the importance of 4Cs (n = 47), as they expected to boost critical thinking and problem-solving, creativity, and innovation to resolve conflicts, make right decisions, construct digital artifacts and products, through the formulation of interdisciplinary STEAM teams for strengthening communication and collaboration. However, most participants put weight on the enhancement of their pedagogical background as a means to link theoretical concepts (i.e., teaching and learning methodologies, strategies and so on, ER and gamification concepts etc.) with digital (and/or web) technologies and apply this knowledge to educational practice effectively, resulting in well-designed e-learning solutions. They also discussed their short-term and long-term goals. As part of their short-term goals, they acknowledged the successful completion of the DEER e-course, new knowledge, and skills for personal and professional development. On the other hand, their long-term goals included the design and the development of e-courses,

employment as e-educators, namely future career in the e-learning industry. Following the analysis of existing material (Step 4), the DEER theme was identified as an "Escape from School". The educational scenario was based on a case study of an ER, which concerns the escape of teachers from their school (place) where they were trapped. Featuring a humorous narrative, it describes the end of a typical school day (time), when the principal meets with the teachers (participants) to discuss and design school action plans for the current school year about "Evaluation of School Units - Collective Planning - Internal and External Evaluation of the Work of the School Unit" (problem). Since the Institute of Educational Policy (IEP) in Greece has established this policy for the last two years, the problem referred to an authentic situation. This included creating and coordinating working groups, proposing action plans, and recording and evaluating these plans. As the discussion comes to an end, the teachers find themselves "virtually" stranded in the teachers' office amid confusion. They realize that the door is locked, the ground floor windows are all barred for safety, no one has any keys, while the exit key is in the principal's office (puzzles and challenges). Learners were required to act as teachers in groups of four or five and specialize in one of five scientific fields of STEAM. As well, new roles concerning Instructional Designers, Learning Designers, Educational Technologists, and Multimedia Designers (roles) would result in the creation of action plans that integrate innovative teaching practices in a multidisciplinary approach to e-course design and development. To achieve this, they had to follow the game-flow, which means unlocking several spaces (i.e. classes, laboratories, offices etc.) into the school to reach the exit in a specific order. Step 5 specifies a list of objectives (**Figure 2**). Learning objectives must be aligned with the game objectives, as well as with the puzzles and the learning outcomes. Thus, this step requires clarification of the types and forms of assessment which are related to hints and can affect learners' performance (Fotaris and Mastoras, 2022).

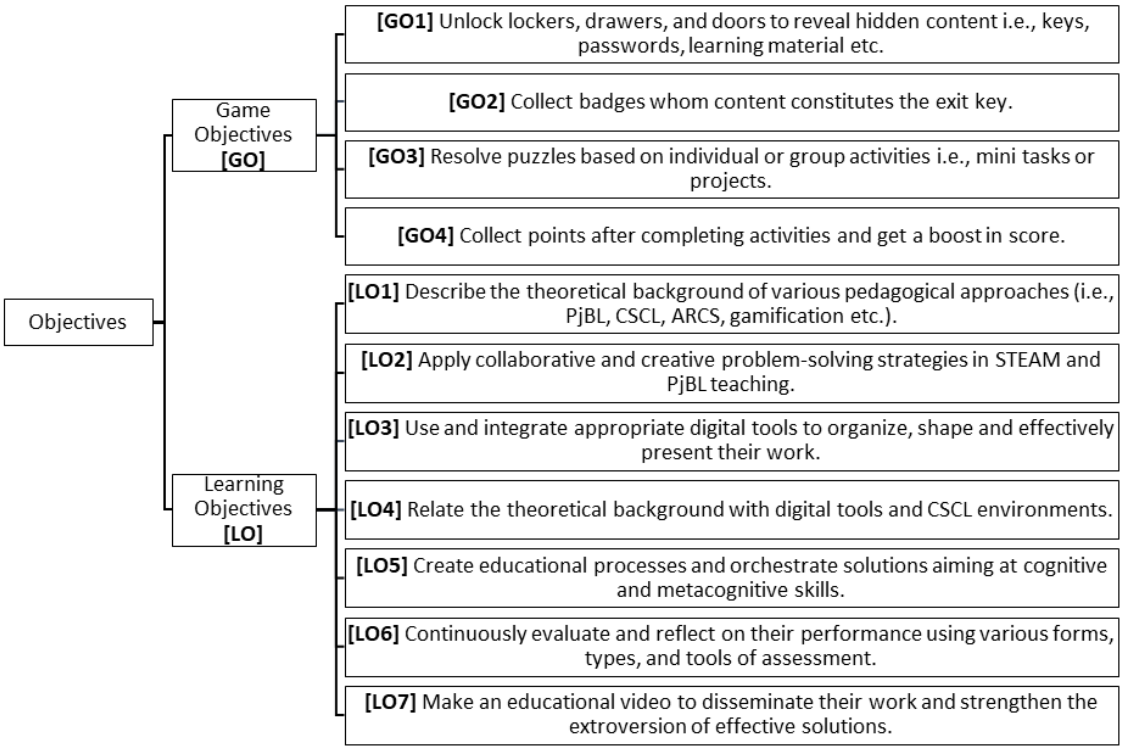

Figure 2: DEER e-course game objectives (GO) and learning objectives (LO)

Design (MD2): D-EER4SmL describes the design process in steps 6-8, where puzzles are incorporated into an SmP-based learning design. As defined by Uskov, Bakken and Aluri (2019), SmP describes the required pedagogy (methods, strategies, techniques, activities, and judgments), enhanced by technology, capable of providing optimal learning processes and environments with corresponding levels of smartness, that is sensing, inferring, adaptation, anticipation, self-learning, and self-organization. To begin with, SmP is equipped with sensing methods, which means that learning data is collected and utilized as part of teaching and learning. This data is then used by SmP to infer information and evidence, which is communicated to students mainly as feedback. Thus, SmP emphasizes self-learning and self-organization in groups and communities through social interaction, so students can learn individually or collectively. Moreover, it helps students predict their future outcomes as well as adapt to the learning process quickly. By tailoring the learning experience to learners' characteristics and preferences such as motivation, skills etc., SmP enables learners to access information more efficiently and

eventually achieve their goals (Lorenzo and Gallon, 2019; Daniela, 2021). Based on previous analyses of DEER e-course specifications, a set of ARCS strategies was selected (Karampa and Paraskeva, 2023) from a variety of tactics (Keller, 2000; Keller, 2010; Keller and Suzuki, 2004; Hodges, 2004) which are strictly related to the factors of Attention (A1-Perception Arousal, A2-Inquiry Arousal, A3-Variability), Relevance (R1-Goal Orientation, R2-Motive Matching, R3-Familiarity), Confidence (C1-Learning Requirements, C2-Success Opportunities, C3-Personal Control) and Satisfaction (S1-Self Reinforcement, S2-Extrinsic Rewards and S3-Equity), as well. Since the e-course is a non-game context that could be transformed into an escape game, the ARCS strategies were aligned with ERs' concepts, gamification elements and game-design techniques (Werbach, Hunter and Dixon, 2012). On the other hand, constructivist approaches reflect SmP concepts, thus Project-Based Learning (PjBL) is considered a suitable methodology for teaching and learning. Besides, PjBL is governed by seven core principles, these of learner-centered environment, collaboration, analytical content, authentic tasks, multiple presentation modes using various ICT tools, time management and innovative assessment (Han and Bhattacharya, 2001), which were found common in (D)EERs (Makri, Vlachopoulos, and Martina, 2021; Markula and Aksela, 2022) and are deeply linked with ARCS. According to Han and Bhattacharya (2001) using PjBL in instruction involves three phases. Two subphases make up the first phase of "Planning", where a collaborative learning environment should be the first subphase in developing the "Overall Climate". The second subphase of "Inquiry" involves selecting themes and topics as well as sharing resources, conducting the study and the investigation.

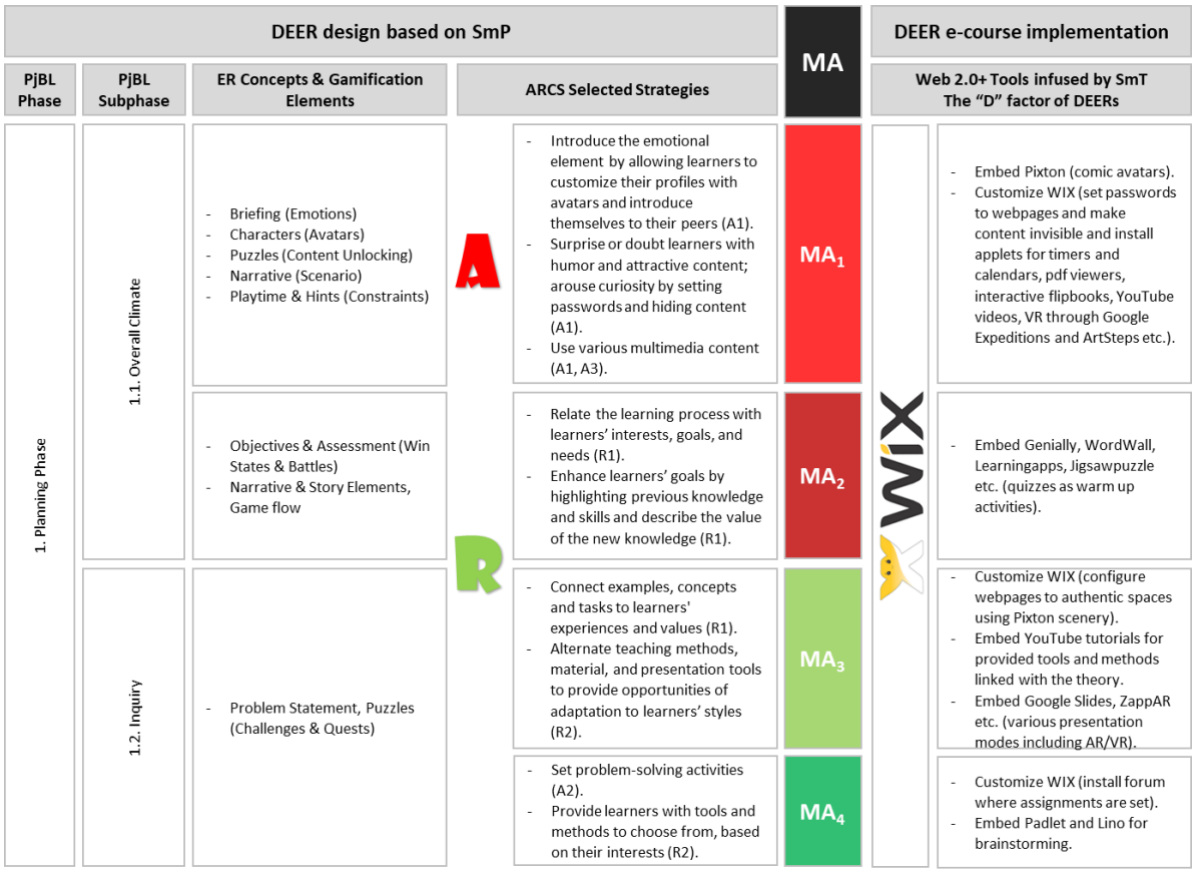

Figure 3: DEER design & e-course implementation – Planning Phase

There are three subphases in the second phase of "Creating". The first subphase is "Analyzing Data", where students make decisions about their projects. The second subphase is "Collaboration" which involves all necessary communications and collaborations to come up with a solution. Furthermore, the third subphase of "Developing Thoughts" involves constructing the artifacts, assembling, and building the final product.

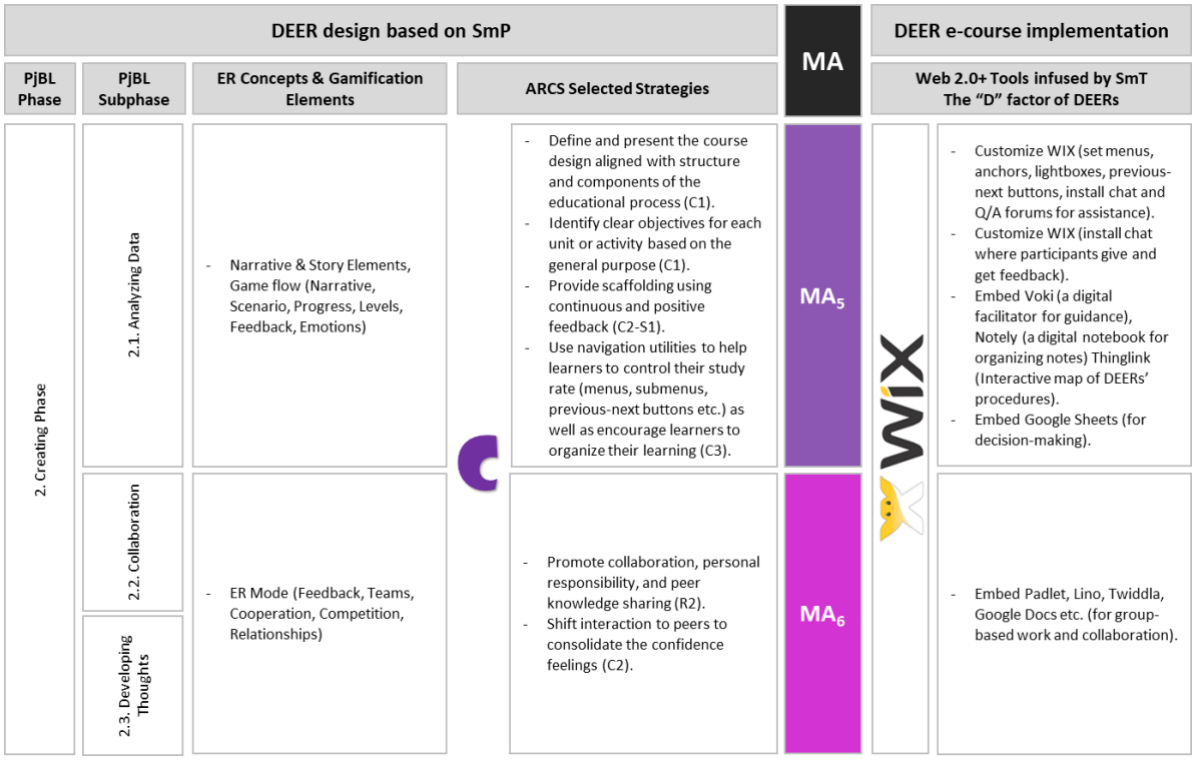

Figure 4: DEER design & e-course implementation – Creating Phase

Two subphases are included in the third and final phase of "Processing". During the first subphase "Presenting Knowledge", the project is presented to the learning community and further disseminated to the society. Reflection and follow-up constitute the second subphase of "Reflection" where students reflect on their and other groups' work, recommending improvements. The described procedures and workflows of PjBL, as well as incorporated strategies and techniques, were further aligned with the educational scenario.

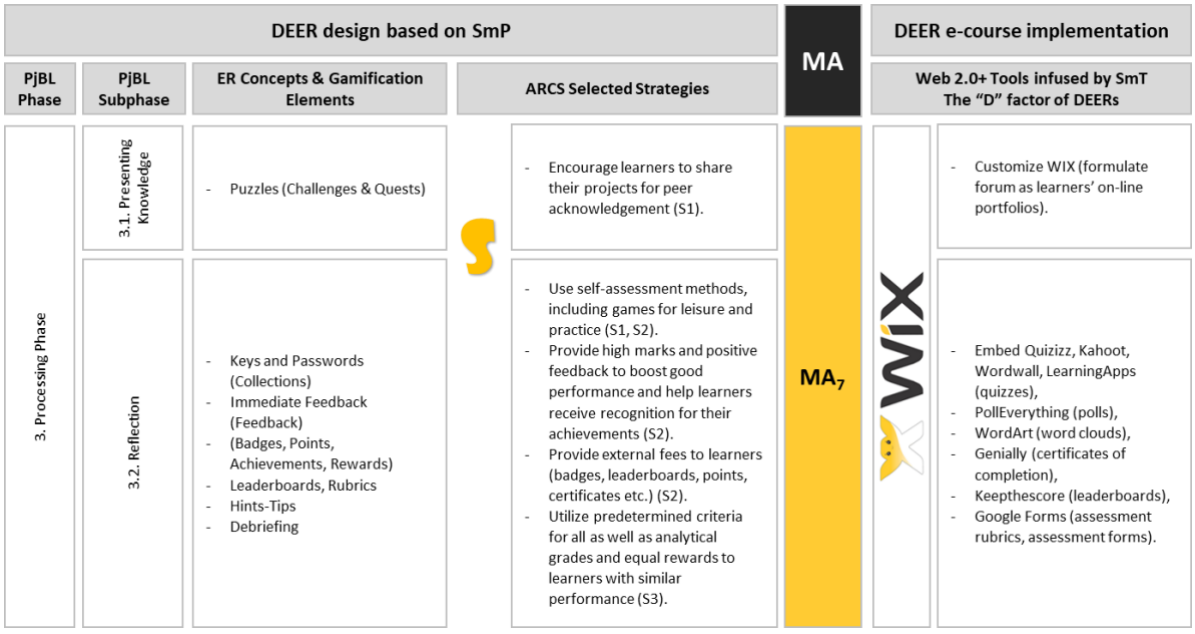

Figure 5: DEER design & e-course implementation – Processing Phase

Therefore, every PjBL subphase was matched to a different space in the school scenery, such as an office, a classroom, or a lab. In terms of puzzles, they were designed as individual or group-based activities. The completion of mini tasks by the students, for example the interaction with web 2.0+ tools that facilitate SmP, could resolve puzzles in a specific order, unlock doors and reach the exit. The design is presented in **Figure 3**,

Figure 4, **Figure 5**. MAs have been aligned with design elements (procedures and workflows, strategies, etc.) from which they emerge to the maximum extent possible.

Development (MD3): Step 9 involves putting the learning design into practice and creating the DEER e-course through the selection and development of materials. Because the WIX platform provides easy drag-and-drop functionality, no budget constraints, and a variety of customization tools, the DEER e-course was developed using this platform. ER equipment was provided via web 2.0+ tools (infused by SmT) in order to facilitate teaching and learning with corresponding features/levels of smartness (Uskov, Bakken and Aluri, 2019). Since digital equipment is less tangible, multimedia content with a high level of interactivity was chosen as props and facilitators in the digital spaces (e.g., AR/VR). A number of pages were tailored to the different locked virtual rooms within the school, while others contained hidden learning material and extra information (e.g., structure, goals, duration, etc.) (**Figure *6***). The "D" factor is described through web 2.0+ technologies in **Figure 3**, **Figure 4**, **Figure 5**, as well.

Pilot – Evaluation (MD4): The final step (step 10) refers to pilot, where learners' reactions as well as their level of satisfaction are determined in order to make revisions (Keller, 2000). Design and development tactics are evaluated for effectiveness, thus, DEERs should undergo several playtests. As mentioned, 108 postgraduate students took part in the DEER e-course and after completing the “playtest”, they conducted assessments at this final step. According to the learning design, they evaluated their projects through self and peer-assessments. In addition, they reflected on the DEER e-course by filling in an improvised questionnaire based on Kellers’ Instructional Materials Motivation Survey – IMMS (Keller, 2010). The questionnaire was provided to learners during the debrief period, where they mainly evaluated the “D” factor of DEERs that facilitates the learning design of the DEER e-course, based on SmP and the MAs that emerge from this combination.

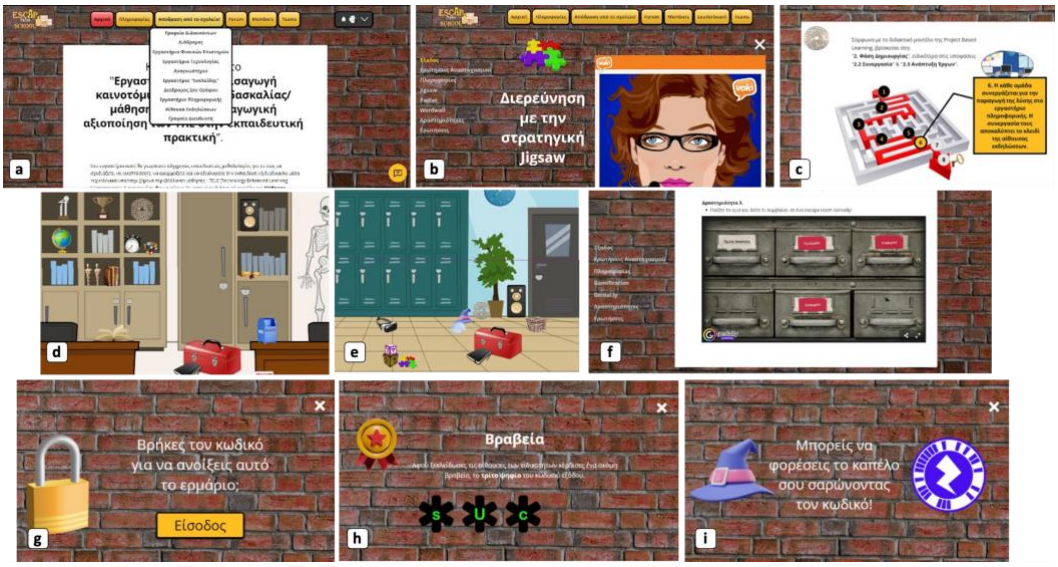

Figure 6: a. DEER e-course homepage – WIX. b. Digital facilitator – Voki. c. Interactive map of the gameflow – Thinglink. d. e. Customized webpages of school spaces – WIX, Pixton. f. Puzzle – Genially. g. Locked locker – WIX lightbox. h. Badges/password element collection – WIX lightbox. i. AR content – ZappAR.

2.3 Research Model

The research model employed in this study investigates the provision of MAs of a DEER e-course when it is designed and developed based on the D-EER4SmL framework. Within this model, the variables are differentiated based on their representation before and after the implementation of the DEER e-course, at the phases of briefing and debriefing, respectively. A baseline assessment of the DEER e-course's MAs was based on learners’ previous experience with e-courses, including DEER e-courses. Through D-EER4SmL processes, these pre-intervention variables serve as benchmarks for comparing post-intervention assessments. Following the D-EER4SmL processes, post-intervention variables are measured to capture the participants' perceived MAs. Pre-post survey models are used to discern potential statistically significant differences between constructs of the model before and after the DEER e-course implementation based on D-EER4SmL. This analytical approach helps to investigate how D-EER4SmL could achieve SmL through the lens of MAs.

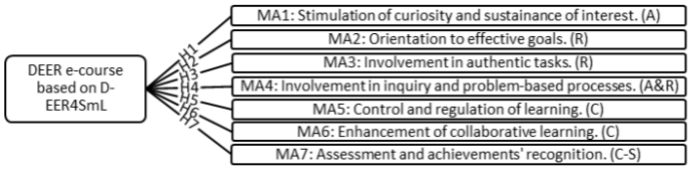

Figure 7: The proposed research model

2.4 Data Analysis and Results

The survey procedure utilized a 5-point Likert scale (from 1 – Strongly Disagree to 5 – Strongly Agree) to ask 35 questions about motivational content adapted to the context of the DEER e-course (**Figure 3**, **Figure 4**, **Figure 5**). Data analysis and statistical tests were conducted using IBM SPSS version 29. Seven factors (MA1 – MA7) were formulated for pre, and post data and for these factors reliability check was conducted. Using Cronbach's alpha (indices for MAPRE= 0,747 and MAPOST= 0,774), it was determined that the reliability of factors before and after the DEER e-course implementation ranged from acceptable to good (Mallery and George, 2000). Furthermore, paired sample statistics were computed to reveal the average response across participants (mean) and to gauge dispersion or variation in responses (Std. D) before and after the DEER e-course implementation (**Table 1**).

Table 1: Paired samples statistics

Paired Samples			PRE		POST	
		N	Mean	Std. D	Mean	Std. D
Pair1	MA1PRE – MA1POST	108	3,5119	,39117	4,1733	,56134
Pair2	MA2PRE – MA2POST	108	3,7185	,44008	4,2074	,56630
Pair3	MA3PRE – MA3POST	108	3,4877	,54196	3,9228	,57030
Pair4	MA4PRE – MA4POST	108	3,2245	,71282	3,9444	,51534
Pair5	MA5PRE – MA5POST	108	3,3161	,43500	3,6402	,50799
Pair6	MA6PRE – MA6POST	108	2,8642	,57290	3,7870	,51852
Pair7	MA7PRE – MA7POST	108	3,6543	,43753	4,1327	,52495

According to paired samples statistics, the mean values for the seven factors (MA1 – MA7) improved before and after the implementation of the DEER e-course. A paired samples t test was also conducted (**Table 2**). Since all mean values of MA1 – MA7 factors after the DEER e-course implementation were significantly higher than before, and the level of significance corresponding to all differences was 0,000 < 0,001, there was a statistically significant improvement.

Table 2: Paired samples t test

Paired samples t test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. D	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	MA1PRE - MA1POST	-,66138	,55607	,05351	-,76745	-,55530	-12,360	107	,000
Pair 2	MA2PRE - MA2POST	-,48889	,57247	,05509	-,59809	-,37969	-8,875	107	,000
Pair 3	MA3PRE - MA3POST	-,43519	,68731	,06614	-,56629	-,30408	-6,580	107	,000
Pair 4	MA4PRE - MA4POST	-,71991	,45565	,04384	-,80682	-,63299	-16,420	107	,000
Pair 5	MA5PRE - MA5POST	-,32407	,54638	,05258	-,42830	-,21985	-6,164	107	,000
Pair 6	MA6PRE - MA6POST	-,92284	,55367	,05328	-1,02846	-,81722	-17,321	107	,000
Pair 7	MA7PRE - MA7POST	-,47840	,57919	,05573	-,58888	-,36791	-8,584	107	,000

3. Discussion and Conclusion

Initial research on MAs proved the D-EER4SmL framework effective. The DEER e-course appears to increase collaborative learning more than any of the other MAs among learners (MA6). As part of the playtest, learners demonstrated personal responsibility, shared knowledge, and assisted peers by using communication and collaboration tools. A higher MA4 was observed as well, which refers to learners' involvement in inquiry and problem-based processes. In conjunction with their own pre-existing knowledge, learners constructed their digital artifacts by studying material using various methods (pedagogical approaches) and tools (digital technologies). During this study, they even investigated external resources, made critical decisions regarding the actual problems of the hypothetical teachers they represented, and ultimately solved a multitude of puzzles to progress. Learners were also intrigued during the playtest, owing to the attractive comic school scenery, humorous narratives of authentic situations, avatars, varied means, and high interactivity of multimedia content (MA1). Through ARCS goal orientation strategies, MA2 aimed to guide learners to effective goals, whereas MA7 aimed to assess and reflect on learners' experiences throughout the DEER e-course using self-assessment (quizzes), peer-assessment (forums, leaderboards, badges, word clouds, etc.). Increased MA3 issued learners' involvement in authentic tasks, such as using ICT to implement well-designed e-learning solutions. Additionally, increased MA5 indicated that learners managed their learning through clear course design, organized content, study management information, and easy navigation, usability, and accessibility. Reflecting on D-EER4SmL framework processes, several factors may explain the positive results. First, the DEER e-course was tailored to learners' profiles, an essential part of SmP. A theme that was authentic, relevant to their backgrounds, skills, motivations, and personal goals was chosen, along with a game story that featured hypothetical teachers from STEAM fields mixed and matched in groups to work in a common hypothetical workplace. Emphasis was placed on the skills they wished to enhance (4Cs and pedagogical use of ICT in their learning environments). A comprehensive educational solution was orchestrated based on a suitable and documented methodology of PjBL, aligned with SmP principles. Goals and motivations for the e-course as well as their future careers were also considered. In no way did they want to give up the effort; so, emphasis had to be placed on the selected ARCS tactics during the design process, not only to complete the e-course achieving high grades, but also to highlight the value of knowledge by potentially facing problems in their future careers as potential educators in e-learning environments. Learning objectives and assessments were set in this direction. Furthermore, gamification elements and ER concepts were incorporated to develop the DEER e-course in a game format and align the game objectives to the learning objectives. Reflecting on the development processes it is necessary to illustrate the "D" factor of the DEER e-course. Assuming that the framework integrates SmP effectively based on the previous thoughts on the design processes, the web technologies enhanced learners' motivation. The customization of the WIX platform and the integration of various Web 2.0+ tools were not only used to structure and implement the DEER e-course, but also to integrate digital props according to the learning design. In comparison to other advancements in education like AI, robotics, big data analytics, etc., web technologies appear outdated and less intelligent. However, education technology is already on this pathway, and web technologies now leverage many of these smart features; what is lacking is the orchestration of frameworks (including DEERs), in which SmP and SmT interoperate effectively towards SmL, providing learners with a wide range of learning affordances. The present study investigates this perspective only through the lens of MAs. The interfunctionality of SmT within the learning environment will certainly need to be improved to achieve higher levels of smartness, so as to increase even more the provided MAs, i.e., MA3, MA5, MA7, by developing DEERs that are more immersive, reflective, and self-regulating. As SmL encompasses a wider set of smart learning affordances than MAs, further research is necessary to confirm the effectiveness of the D-EER4SmL framework in this broader context.

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