**Skills development for software engineers: Systematic literature review**

Context

A good software professional must have technical and non-technical skills, that is, hard and soft skills, to deal with the diverse challenges they will encounter throughout their career. To make this possible, such professional must develop these abilities from the undergraduate.

Objective

This research aims to identify the necessary soft skills for future Software Engineers and the teaching methodologies that contribute to developing such skills from the undergraduate, keeping the students motivated. In addition, this study proposes a framework to help educators conduct a teaching-learning process that includes hard and soft skills during the undergraduate of future Software Engineers.

Methodology

A Systematic Literature Review was performed on six databases, resulting in 56 selected articles identifying the soft skills and the teaching methodologies desired to train Software Engineers. These were the base for the proposed framework.

Results

We proposed a grouping of soft skills found in the literature totaling 33 soft skills. Furthermore, since were found, in the literature, definitions for only 23, this study also defined the other ten soft skills addressed. Regarding the most used and indicated methodologies for developing soft skills in undergraduate students, it was possible to organize them by the principal and auxiliary methodologies. Finally, a framework was proposed to assist in the development of hard and soft skills in undergraduate students, focused on Software Engineering, the FraSSD - Framework for Soft Skills Development.

Conclusion

The proposed framework can contribute to educators’ critical thinking about applying the most effective teaching methodologies for developing hard and soft skills in an undergraduate class, improving the teaching-learning process. This study also evidences the most relevant soft skills for Software Engineers, encouraging the constant search to improve their soft skills aligned with their hard skills since graduation.

**Immersive virtual reality for unintentional injury prevention training with children: A systematic review**

Researchers and educators continue to explore the potential of Immersive Virtual Reality (IVR) technology for safety training in children, as unintentional injuries persist as the leading cause of global mortality among this cohort. In order to implement IVR as a safety training tool, it is important to understand its effectiveness compared to other methods. However, few studies have systematically summarised the use of IVR for unintentional injury prevention training with children. To address this gap, a systematic review was conducted using five databases, following the PRISMA guidelines. Sixteen studies published until March 2024 were identified that evaluated the effectiveness of IVR technology for unintentional injury prevention training with children aged 1–14 years. We evaluated: i) the types of unintentional injury skills taught, ii) research designs, data collection methods and measures used, iii) IVR interface and equipment utilised, and iv) the effectiveness of IVR technologies in comparison to conventional methods of training. The majority of the identified studies focused on road safety, with three on fire safety, and one on water safety. Varied instruments were used to measure outcomes including knowledge, behaviour, immersion, interest, enjoyment, and usability. IVR interventions employed head-mounted displays (N = 13) and Cave Automatic Virtual Environments (N = 3), with either interactive or passive experiences. Overall, the studies suggest a positive role for IVR in unintentional injury prevention training with children. However, only two studies made direct comparisons with other methods, underscoring the need for a cautious interpretation of the findings. Future studies should prioritise evaluating the transfer of learnings from the virtual environment to real-world settings, direct comparisons between IVR and conventional training methods, the relationship between different IVR learning approaches and cognitive and motor skill acquisition, and the correlation between immersion and learning outcomes.

**Classifying games in container terminal logistics field: A systematic review**

Our study generates a review of serious games in the container terminal logistics field. Serious games deliver certain knowledge to the user and improve the user’s understanding of the problem. We analyse 68 games in published research papers and gaming websites and classify them based on the types of container terminal logistics problems, G/P/S (gameplay, purpose, and scope) concept, and the gaming platform. We enrich the existing classification of container terminal logistics problems by adding new fields considered by the listed games. Moreover, further analysis related to user experiences of the games is also conducted. The classification results provide insights regarding the existing studies related to gamification in the container port logistics field. It gives ideas for future developments to support the effectiveness of the learning process in the related area. Our main suggestions are increasing learning stages for game users, a list of required topics for new games, and gaming quality improvements in the existing games. Developing games with a good user interface is as important as considering the complexity of real problems in the games to allow an effective training process for the game users.

**Gamification of motor imagery brain-computer interface training protocols: A systematic review**

Current Motor Imagery Brain-Computer Interfaces (MI-BCI) require a lengthy and monotonous training procedure to train both the system and the user. Considering many users struggle with effective control of MI-BCI systems, a more user-centered approach to training might help motivate users and facilitate learning, alleviating inefficiency of the BCI system. With the increase of BCI-controlled games, researchers have suggested using game principles for BCI training, as games are naturally centered on the player. This review identifies and evaluates the application of game design elements to MI-BCI training, a process known as gamification. Through a systematic literature search, we examined how MI-BCI training protocols have been gamified and how specific game elements impacted the training outcomes. We identified 86 studies that employed gamified MI-BCI protocols in the past decade. The prevalence and reported effects of individual game elements on user experience and performance were extracted and synthesized. Results reveal that MI-BCI training protocols are most often gamified by having users move an avatar in a virtual environment that provides visual feedback. Furthermore, in these virtual environments, users were provided with goals that guided their actions. Using gamification, the reviewed protocols allowed users to reach effective MI-BCI control, with studies reporting positive effects of four individual elements on user performance and experience, namely: feedback, avatars, assistance, and social interaction. Based on these elements, this review makes current and future recommendations for effective gamification, such as the use of virtual reality and adaptation of game difficulty to user skill level.

**Gamified devices for stroke rehabilitation: A systematic review**

Background and Objective:

Rehabilitation after stroke is essential to minimize permanent disability. Gamification, the integration of game elements into non-game environments, has emerged as a promising strategy for increasing motivation and rehabilitation effectiveness. This article systematically reviews the gamified devices used in stroke rehabilitation and evaluates their impact on emotional, social, and personal effects on patients, providing a comprehensive view of gamified rehabilitation.

Methods:

A comprehensive search using the PRISMA 2020 guidelines was conducted using the IEEE Xplore, PubMed, Springer Link, APA PsycInfo, and ScienceDirect databases. Empirical studies published between January 2019 and December 2023 that quantified the effects of gamification in terms of usability, motivation, engagement, and other qualitative patient responses were selected.

Results:

In total, 169 studies involving 6404 patients were included. Gamified devices are categorized into four types: robotic/motorized, non-motorized, virtual reality, and neuromuscular electrical stimulation. The results showed that gamified devices not only improved motor and cognitive function but also had a significant positive impact on patients’ emotional, social and personal levels. Most studies have reported high levels of patient satisfaction and motivation, highlighting the effectiveness of gamification in stroke rehabilitation.

Conclusions:

Gamification in stroke rehabilitation offers significant benefits beyond motor and cognitive recovery by improving patients’ emotional and social well-being. This systematic review provides a comprehensive overview of the most effective gamified technologies and highlights the need for future multidisciplinary research to optimize the design and implementation of gamified solutions in stroke rehabilitation.

**A systematic review and analysis of theory in research on gamification, serious games and game-based learning**

Despite increasing scientific interest in explaining how gamification supports positive affect and motivation, behavior change and learning, there is still a lack of an overview of the current theoretical understanding of the psychological mechanisms of gamification. Previous research has adopted several different angles and remains fragmented. Taking both an observational and explanatory perspective, we examined the theoretical foundations used in research on gamification, serious games and game-based learning through a systematic literature review and then discussed the commonalities of their core assumptions. The overview shows that scientists have used a variety of 118 different theories. Most of them share explicitly formulated or conceptual connections. From their interrelations, we derived basic principles that help explain how gamification works: Gamification can illustrate goals and their relevance, nudge users through guided paths, give users immediate feedback, reinforce good performance and simplify content to manageable tasks. Gamification mechanics can allow users to pursue individual goals and choose between different progress paths, while the system can adapt complexity to the user's abilities. Social gamification elements may enable social comparison and connect users to support each other and work towards a common goal.

**Gamification resources in education: A theoretical approach**

Introduction. The modern education system has undergone significant changes in recent years - the content of educational programs is being revised, electronic, blended, mobile learning is being actively introduced; the practical activities of future specialists are being strengthened. The use of computer networks, web applications, interactive services makes education more accessible, stimulating students' cognitive interests, increasing motivation for education. One of the most significant innovative trends in modern education is gamification, which is most often considered as a system that uses computer game components in non-game situations.

The purpose of this work is to analyze the conceptual foundations of gamification in education, to determine the system of tools that can present unique opportunities for gamification, the features of its promising use for turning it into an innovative experience in the development of higher professional education.

Methodology, methods and techniques of research. The study of the gamification problem involves the analysis of pedagogical and psychological literature of foreign and domestic authors; systematization and generalization of pedagogical concepts, practice-oriented materials, facts. The methodology of gamification includes system, personality-oriented, and activity-based approaches. An attempt was made to determine the components of the gamification system and their role in the organization of modern education. Analysis of gamification resources allows us to reveal approaches to increasing motivation and involvement of students, and, in addition, to find out ways to include elements of game design (definition of tasks, feedback, levels, creativity), computer games in the educational environment.

Based on the personality-oriented approach, the influence of gaming technologies on the development of the personality of students is considered. The activity-based approach allows us to identify the foundations of organizing and managing the initiative of educational entities, to establish the features of using educational technologies, practices, and methodological techniques. The activity-based approach in the context of gamification determines active, ever-more complex activity as a source of personal development of students.

Results. In the course of the study, theoretical foundations for using gamification in modern higher education were formulated, tools for the prospective inclusion of gaming practices in the personnel training system were determined, mechanisms of internal and external motivation of students, and regulation of the behavior of future specialists when using game elements were identified.

Scientific novelty. The concept of gamification of education is part of the concept of the game and reflects modern trends in the development of education based on the strategy and tactics of gaming activities, specially structured taking into account the resources of gaming principles, mechanics, methods and techniques. Gamified learning can become the leading one in the process of training specialists using innovative practices, stimulating motivation, regulating behavior, implementing ideas of friendly competition and creative cooperation in various educational contexts. Practical significance. In the context of determining the promising foundations for the development of modern higher education, ideas for original technological support for training personnel are proposed. The implementation of practical measures to develop the involvement of students in the educational process, regulate motivation, behavior and practical activities of students, emotional self-realization, and the system of relationships will contribute to improving the quality of education in higher education. An important result of the study was the conclusion about the appropriate combination of traditional and innovative options for conducting educational classes with students, the inclusion of various gaming practices in the educational process.

**Uncharted dimensions, gaps, and future trends of serious games in software engineering,**

Objective

Serious Games (SG) are a rising trend in Software Engineering (SE) education, for this reason, and since this topic is still immature and further research was encouraged, it is important to investigate how SGs are integrated into SE education. In this line, this study explores the landscape of SGs in SE) education, focusing on their categorization according to their addressed SWEBOK areas and Bloom's levels, extracted their key elements, mechanics and dynamics, exploring in depth their most portrayed player profiles, finding what makes them successful SGs in this field, and last addressing their resulting challenges in the realm of SE education.

Methodology

A systematic search was conducted across prominent databases: Science Direct, IEEE Xplore, ACM, Scopus, and Wiley. Initially, 125 papers met our initial inclusion criteria, from which 46 remained after rigorous full-text review. Utilizing snowball sampling, we added 28 additional studies, resulting in a total of 74 selected papers for comprehensive analysis.

Results

Among the selected papers, which spanned from the early 2000s to May 2021, a notable increase in publications on SGs in SE was observed, particularly since 2010. The majority of these studies focused on validation research (60 %), followed by solution proposals (17.56 %) and evaluation research (13.51 %). Publication channels predominantly included conferences (79.73 %), underscoring the emerging nature of SGs in SE research, with a smaller proportion appearing in journal articles (20.27 %). Specific focus areas within SE, such as Software Engineering Management (33.78 %) and SE Professional Practice (13.51 %), received significant attention, while others, like SE Models and Methods, showed minimal representation. Furthermore, SGs were found to effectively target higher-order cognitive skills based on Bloom's Taxonomy, with notable implementations of game dynamics such as Teams and Realism to enhance learning experiences. Despite these advancements, there remains a predominant focus on player profiles like Achievers (48.64 %) and Players (47.30 %), suggesting potential gaps in addressing a broader spectrum of learner types within SGs designed for SE education.

Conclusion

This study underscores the evolving role of SGs in SE education, emphasizing the need for diverse approaches to enhance engagement and educational outcomes. Future research should focus on optimizing SG potential across educational and industrial settings by expanding publication visibility, integrating artificial intelligence (AI), and conducting comprehensive evaluations of SGs tailored to SE contexts.

**A bibliometric analysis of digital game-based learning in educational contexts.**

As an emerging topic, digital game-based learning holds great significance as it revolutionizes traditional modes of education by harnessing engagement and enhancing learning outcomes. We bibliometrically analyzed the current studies of digital game-based learning, aiming to explore the key topics and domains of the trend that may inspire further research and innovations. This study employed VOSviewer to explore the top ten authors, sources, organizations, and countries and established a citation network using clustering techniques in CitNetExplorer to visualize the results. Based on the research, it is found that motivation maintenance, in-game feedback, and post-game motivation are important factors impacting sustainable digital learning. This study proposes a framework comprising three elements—Preparation, Process, and Settlement—aligned with different stages of digital gaming. By integrating factors affecting learners with gaming elements, the framework aims to enhance the effectiveness and sustainability of digital learning. Future research could involve implementing game designs based on our proposed framework to evaluate its effectiveness. Additionally, there is potential to integrate AI to promote learner experiences and optimize learning outcomes

**10 Gamification and virtual reality for digital twin learning and training: architecture and challenges,**

Background

Digital Twins are becoming increasingly popular in a variety of industries to manage complex systems. As digital twins become more sophisticated, there is an increased need for effective training and learning systems. Teachers, project leaders, and tool vendors encounter challenges while teaching and training their students, co-workers, and users.

Methods

In this study, we propose a new method for training users in using digital twins by proposing a gamified and virtual environment. We present an overall architecture and discuss its practical realization.

Results

We propose a set of future challenges that we consider critical to enabling a more effective learning/training approach.

**Internet of Things for gaming: A review,**

The Internet of Things (IoT) is an advanced tech that transfers game data such as graphics, text, and other data over real-time networks. Game player surroundings can be sensed, or movement or situation can be observed for wearable devices that use sensors and actuators, this increases sales of wearables from 18 million in 2015 to 533.6 million units by 2021. The information of game players gathered by sensors and actuators is sent for further action in the game engine. In this paper, we survey and analyze the involvement of IoT technology sensors and wearables in serious and social gaming. Further, we reviewed IoT applications for gaming, as well as their challenges and limitations, with open research issues for future development.

**Towards gamification for spatial digital learning environments,**

Digital learning environments exhibiting spatial dimensions, such as VR experiences or virtual labs, have become increasingly common in recent years. At the same time, it is known that gamification, i.e., the application of game-like mechanisms, might support the motivational design of learning environments. However, so far, there seems to be no systematic overview on whether and how spatial dimensions are incorporated into gamification mechanisms. Accordingly, we conducted a systematic literature review to identify gamification mechanisms that use spatial dimensions. Out of 849 articles we finally included 11 articles found in the three databases ScienceDirect, IEEE, and ACM DL that conducted gamification in the context of spatial digital learning environments. For the most part, the gamification mechanisms used in these 11 articles did not relate to any spatial dimension. Conclusively, we state that there have been few approaches to gamification exploiting the spatial dimension. Given the limited findings in the literature, we propose developing a model to bridge existing gaps and support a structured approach to incorporating spatial dimensions into gamification mechanisms. Accordingly, we contribute to enhancing spatial digital learning environments with further motivational cues through spatial gamification mechanics.

**Does using a green gaming system make people more environmentally friendly?,**

In spite of the common disadvantages, including user addiction and so on, the green online gaming system has a potential positive advantage to foster offline pro-environmental behavior through the special online experience. We developed a theoretical framework synthesizing motivation theory, flow theory, dual-system theory, and user engagement theory, aimed at exploring the mechanism between green gaming systems and actual pro-environmental behaviors. Based on the analysis of data from 364 participants utilizing Ant Forest across China, the results showed that motivations generated by using green online gaming systems indirectly promote pro-environmental behavior. The underlying psychological processes include the flow experience, social overload, and green engagement. Especially, user green engagement serves as a critical bridge linking virtual activities to real-world environmental behavior. Furthermore, perceived authenticity significantly facilitates the transition of online experiences into real-world pro-environmental behavior. This research not only advances the theoretical understanding of gamification and pro-environmental behavior but also provides practical references for promoting pro-environmental behavior effectively in managing green gaming systems.

**Success with Agile Project Management: Looking back and into the future,**

We show what the influential factors and practical strategies are that contribute to agile project management success. The research model comprises three people-related factors (personal characteristics, team capability, and customer involvement), three technological factors (gamification, artificial intelligence, and marketing intelligence), and one dependent variable (agile project management success). Based on 143 questionnaire responses, our findings reaffirm the positive impact of personal characteristics and customer involvement while challenging the roles of gamification and team capability, suggesting that their effects are more context-dependent than previously thought. Our findings also highlight that agile project management success depends on the interplay between remote work and team capability, with strong team skills being highly important for agile methodologies, especially in traditional office settings.

**Multi-modalities in mobile technology for assisted learning performance in higher education in** **China.**

Mobile technology, especially mobile learning, has long been an emerging and thriving field, and remains a main theme in mobile learning applications and systems. The extensive utilization of mobile learning has prompted the invention of many mobile applications. As a result of rapid advances in application technologies, various learning applications can combine different media or multi-modalities, such as video, audio, images, animated graphics, and text, to create multimedia learning resources that engage learners. However, the most favorable modalities in different learning applications that assist performance are worth exploring. This study employed mixed methods to investigate the current multi-modality situation in learning application utilization among 300 university students in China, where a rapid educational technology revolution is occurring. The findings revealed that the verbal modality (M = 3.99, S\*D = 0.79) and the writing modality (M = 3.99, S\*D = 0.75) in the learning applications were less enjoyable and less effective at enhancing learning performance. In exam-based or function-based apps, all five modalities in this research were considered important, especially the visual and aural modes. The results of this study also revealed that a majority of university learners were satisfied with the multi-modalities in different types of applications, except for game-based apps, that assist their learning performance (56.7%, M = 3.87, S\*D = 0.79), which contrasts with the results of several related studies. Overall, college users perceived that multi-modalities were effective in helping them to complete tasks, and all modalities in current applications satisfied most of the users’ needs to assist their learning performance. In the end, the findings indicated a positive and strong linear relationship [r = 0.766, p < 0.05] between multi-modalities and assisted learning performance with the help of more capable (knowledgeable) others with the use of mobile applications.

**University students’ use of mobile technology in self-directed language learning: Using the integrative model of behavior prediction**

Mobile technology offers great potential for university students’ language learning. Numerous studies have been conducted on utilizing mobile technology in language learning classroom. However, using it in self-initiated and self-directed learning outside class remains to be explored. The present study employed the integrative model of behavior prediction to investigate the relationships between attitude, subjective norm, self-efficacy and behavioral intention, as well as the association between intention, facilitating conditions, self-regulation skills and actual use of mobile technology in self-directed language learning. This study also examined whether self-regulation skills moderated intention and actual use. Survey data from 676 language learners in different disciplines from Chinese universities were collected and analyzed using structural equation modeling approach. The results showed that 37.1 percent of respondents indicated that they never used mobile technology for self-directed language learning. Of the other 425 respondents who did indicate that they used mobile technology for this purpose, the majority of them seemed to be extrinsically motivated. Learning activities regarding vocabulary acquisition and translation were far more reported than those in terms of listening, speaking, reading and writing. In addition, attitude and subjective norm significantly explained students’ intention to use mobile technology, but self-efficacy did not have a direct effect on students’ intention. Moreover, students’ self-regulation skills and intention significantly predicted students’ actual use of mobile technology. Through moderation analysis, the results indicated that the relationship between intention and actual behavior would be stronger with any increase in self-regulation skills. These findings are discussed and implications are formulated.

## **Creativity, critical thinking, communication, and collaboration: Assessment, certification, and promotion of 21st century skills for the future of work and education.**

This article addresses educational challenges posed by the future of work, examining “21st century skills”, their conception, assessment, and valorization. It focuses in particular on key soft skill competencies known as the “4Cs”: creativity, critical thinking, collaboration, and communication. In a section on each C, we provide an overview of assessment at the level of individual performance, before focusing on the less common assessment of *systemic support* for the development of the 4Cs that can be measured at the institutional level (i.e., in schools, universities, professional training programs, etc.). We then present the process of official assessment and certification known as “labelization”, suggesting it as a solution both for establishing a publicly trusted assessment of the 4Cs and for promoting their cultural valorization. Next, two variations of the “International Institute for Competency Development’s 21st Century Skills Framework” are presented. The first of these comprehensive systems allows for the assessment and labelization of the extent to which development of the 4Cs is supported by a formal educational program or institution. The second assesses informal educational or training experiences, such as playing a game. We discuss the overlap between the 4Cs and the challenges of teaching and institutionalizing them, both of which may be assisted by adopting a dynamic interactionist model of the 4Cs—playfully entitled “Crea-Critical-Collab-ication”—for pedagogical and policy-promotion purposes. We conclude by briefly discussing opportunities presented by future research and new technologies such as artificial intelligence and virtual reality.

**Game-based adaptive learning in probability education**

Traditional approaches often fall short in effectively teaching complex subjects like probability and dynamic programming, especially in contexts requiring high engagement and individualized learning paths. This paper presents a simulation-based experimental study exploring the potential of an Artificial Intelligence (AI) adaptive learning system through the development of a game-based learning tool. The system utilizes dynamic programming principles and decision tree regressors to adjust the game complexity in real-time, based on simulated student performance. The adaptive dice game provides personalized learning experiences that improve both engagement and comprehension of key mathematical concepts. The experiment evaluates how adaptive difficulty settings influence strategic decision-making and learning outcomes. The results demonstrate that adaptive learning systems can significantly enhance mathematical education by offering customized learning paths that improve understanding of complex concepts. This study contributes to the discussion on the potential of integrating AI with educational technologies to enhance learning outcomes, particularly in disciplines that demand high analytical skills.

**Personalized gamification: A technological approach for student education: A systematic literature review**

Gamification has become an increasingly popular approach in education, applying game elements to increase student motivation and engagement. However, generalized applications often do not consider individual needs, making personalized of gamification important. Personalized aims to tailor game elements to students learning styles and preferences, thereby improving intrinsic motivation and learning outcomes. This research uses the Systematic Literature Review (SLR) method to review gamification personalized trends, methods, framework and provide guidelines for effective implementation in education. This research focuses on several key questions. RQ1: What are the current trends and advancements in personalized gamification. RQ2: Why does student education need personalized gamification. RQ3: How is personalized gamification implemented in student education. This research provides an up-to-date overview of previous research studies related to Personalized Gamification by conducting a Systematic Literature Review (SLR) summarizing 59 relevant journal articles. The research results show that gamification trends in education have steadily increased since 2015, with the adoption of technologies such as Artificial Intelligent (AI), Augmented Reality (AR), mobile, and websites. Personalized gamification has proven effective in enhancing student motivation and engagement by adjusting game elements to individual needs. Various methods such as the Gamification User Type Hexad and Game-Based Learning are employed to support personalized gamification for personalized learning.

**20 Uncovering the theoretical basis of user types: An empirical analysis and critical discussion of user typologies in research on tailored gameful design**

Gamification has become one of the main areas in information systems and human–computer interaction research related to users’ motivations and behaviors. Within this context, a significant research gap is the lack of understanding of how users’ characteristics, especially in terms of their preferences for gameful interaction (i.e., user typologies), moderate the effects of gamification and, furthermore, how gamification could be tailored to individual needs. Despite their prominence in classifying users, current typologies and their use in research and practice have received severe criticism regarding validity and reliability, as well as the application and interpretation of their results. Therefore, it is essential to reconsider the relationships and foundations of common user typologies and establish a sound empirical basis to critically discuss their value and limits for personalized gamification. To address this research gap, this study investigated the psychometric properties of the most popular player types within tailored gamification literature (i.e., Bartle's player types, Yee's motivations to play, BrainHex, and HEXAD) through a survey study (n=877) using their respective measurement instruments, followed by a correlation analysis to understand their empirical relations and an exploratory factor analysis to identify the underlying factors. The results confirm that user typologies, despite their different origins, show considerable overlap, some being consistent whereas others contradicted theoretically assumed relationships. Furthermore, we show that these four user typologies overall factor into five underlying and fundamental dimensions of Socialization, Escapism, Achievement, Reward Pursuit, and Independence, which could be considered common concepts that may essentially reflect key determinants of user motivation in gamification. Our findings imply that future research and practice in tailored gamification design should shift the focus from developing and applying ever more nuanced typologies to understanding and measuring the key underlying determinants of user motivation in gameful systems. Moreover, given the considerable interrelationships between these determinants, we also argue that researchers should favor continuous representations of users’ motivations in specific situations instead of a dichotomous operationalization of user types as static manifestations of their preferences.

**Exploring Recommender Systems for Assisting Teachers in E-Learning Gamification,**

Gamification in e-learning systems implies integrating game elements in non-gaming context to attain the learner’s engagement through pre-defined engagement objectives. These objectives impact the selection of the to-be-applied game elements, which typically influences the learner’s behavior within the learning process. In turn, this behavior is expected to help the teachers in reaching their learning objectives. Therefore, involving teachers in the gamification process as they are in the learning process can ensure the coherence between the learning and engagement objectives. However, since teachers often lack familiarity with gamification, they are rarely involved with the gamification process. Accordingly, recommender systems can play a vital role in assisting teachers through gamification. Therefore, this paper investigates the existing recommender systems from teacher’s perspective to highlight the advancements proposed for assisting teachers and examines the utilization of game elements within gamified e-learning systems to identify their types and explore their practical applications. Based on our research results, this paper proposes a (1) game elements categorization based on their practical applications and (2) a layered recommendation process flow that incorporates the different game elements categories, to assist the teachers in gamifying the learning process.

**Predictive analytics in gamified education: A hybrid model for identifying at-risk students,**

This research proposes a hybrid predictive model designed to identify at-risk students within a gamified education environment accurately. By integrating logistic regression, decision trees, and random forests, we construct a robust ensemble model that leverages the strengths of each algorithm for precise risk assessment. The model analyzes key indicators such as academic performance, participation levels, and task completion rates using data derived from a gamified learning platform. Our approach demonstrates the effectiveness of machine learning in addressing challenges like student disengagement and dropout. The hybrid model outperforms individual classifiers, enabling earlier and more reliable detection of students who may require timely academic interventions. The method is as follows:•Combines logistic regression, decision trees, and random forests•Utilizes gamified education data for at-risk student prediction•Provides educators with a tool for early intervention in student supportThe computational approach converts raw educational data into actionable insights, enabling educators to deliver timely and targeted interventions. Leveraging behavioral data from game-based learning platforms, the project develops a practical student monitoring system powered by machine learning ensembles. This system identifies at-risk students earlier than traditional assessments, allowing for more effective and efficient use of educational resources.

**Analysis of interactive impact and student behavior of teaching online courses based on gamified learning,**

The potential of gamified learning as an emerging force for educational change has been widely recognized, to address the design deficiencies in the automatic recognition methods in traditional gamified learning models and the low accuracy of learning behavior recognition. Based on the improved gamified learning model, this paper jointly proposes an optimal design and recognition model of learning mode based on a deformable convolutional type network. Based on the gamified machine learning theory and interactive feedback theory, it comprehensively analyzes the procedural improvement of the gamified interactive intelligence model to provide a theoretical and practical basis for carrying out the analysis of the interactive impact and student behavior of teaching online courses based on gamified learning. The research results show that: (1) with the increase of the number of gamified learning samples, the value of iterative loss function decreases, the accuracy of recognition improves, and gradually converges and tends to be stable when the number of training times is 500; the 800 training samples setting can fully meet the network training requirements. (2) The deformable convolutional neural learning network constructed with the proposed joint algorithm reduces the network error during the training process and introduces the radical change function to improve the data processing capability. This improved gamified learning model is not only superior in recognition accuracy but also shows great advantages in recognition time.

**EduXgame: Gamified learning for secondary education,**

EduXgame is a gamified mobile application designed to enhance the learning experience of secondary education students. The application integrates AI-driven content generation, gamification features, and interactive learning tools such as quizzes, flipcards, and matching games. It provides educators with a web interface to upload chapters, which are processed by an AI model to generate learning material dynamically. eduXgame transforms traditional learning methods into engaging, competitive, and interactive experiences, making education more accessible and enjoyable for students.

**Design of online teaching interaction mode for vocational education based on gamified-learning,**

Along with the process of building China's modern vocational education system, China's higher vocational education has made great progress. With the development of computer and Internet technology, gamified learning, as a new way of learning, combines the advantages of computer games and online learning, which not only meets the needs of people to learn anytime and anywhere, but also increases the fun of learning activities. In this paper, we developed a gamified learning software with traveler-type problems as the research content, through the interaction with the game, so that students can think in the game and learn knowledge through the game. Through the questionnaire for research and analysis, this game is good game fun and can stimulate learning interest well. In addition, this paper carries out an in-depth study of the game's help system, optimizes the algorithm for the help system, and proposes an improved genetic algorithm. The reverse learning method is adopted to improve the accuracy and convergence speed of the optimal solution; then the Metropolis criterion is used to improve the crossover and mutation operators to enhance the local search ability of the algorithm; finally, the concept of realistic elite learning is introduced to further enhance the local search ability of the algorithm. The simulation results show that the algorithm is effectively improved in convergence performance and solution accuracy, which can significantly improve the response speed of the help system, effectively improve the game's fun, and improve the game's playability.

# Empowering Higher-Order Thinking Skills in Writing through Gamification and Multimodal Learning within PBL

This study explores the integration of gamification and multimodal learning within a Project-Based Learning (PBL) framework to enhance higher-order thinking skills (HOTs) in writing instruction. HOTs—encompassing critical thinking, creativity, and problem-solving—are vital for equipping students to navigate academic and real-world complexities. Employing a mixed-methods approach, the study collected quantitative data through surveys assessing engagement, motivation, and writing proficiency, while qualitative data from focus groups and reflective journals provided deeper insights into student experiences. By incorporating real-world projects, gamified elements (e.g., challenges, rewards), and multimodal resources (visual, auditory, and kinesthetic tools), the intervention created an engaging and inclusive learning environment. Results revealed significant increases in engagement (90%), motivation (87%), and writing proficiency (22%), as well as marked development in critical thinking, creativity, and collaboration skills. This study highlights the effectiveness of combining PBL with gamification and multimodal strategies to empower students in writing tasks through diverse forms of expression. The findings offer actionable insights for designing inclusive writing curricula and underscore the need for further research on the scalability and adaptability of this approach in diverse educational settings.

#### **Development of a Theoretical Framework of MOOCs with Gamification Elements to Enhance Students’ Higher-Order Thinking Skills: A Critical Review of the Literature**

Aim/PurposeThis study aims to develop a theoretical framework for enhancing students’ higher-order thinking skills (HOTS) by integrating massive open online courses (MOOCs) with gamification elements.

BackgroundThere is a growing demand to develop students’ innovative thinking abilities through MOOCs, focusing on higher-order thinking skills (HOTS), which are essential for 21st-century challenges. While gamification has shown potential in enhancing HOTS, its integration within MOOCs to improve these skills remains underexplored. Enhancing students’ HOTS through MOOCs combined with gamification is crucial for developing advanced skills like analysis, evaluation, and creativity. Therefore, there is an urgent need for a robust theoretical framework that effectively merges MOOCs and gamification to enhance students’ HOTS.

MethodologyThis research used a qualitative research approach employing critical analysis techniques. The research procedures were guided by the SALSA framework. A total of 19 articles from the SCOPUS and Google Scholar databases were selected based on specific criteria: articles published between 2013-2023, articles with keywords such as MOOCs, gamification, higher-order thinking, or engagement, and articles written in English. Thematic analysis was conducted to identify common themes in the selected articles. The proposed framework was developed by drawing upon well-established theories in the fields of educational technology, online learning, collaborative learning, connectivism, student engagement, and Bloom’s taxonomy.

ContributionThis study not only synthesizes existing research on MOOCs but also presents a holistic and integrated framework for leveraging learning theories, gamification elements, student engagement dimensions, and HOTS to enhance the effectiveness of MOOC-based education. The proposed framework aims to provide researchers and educators with a comprehensive model for integrating gamification elements into MOOCs to enhance students’ higher-order thinking skills. By utilizing this framework, educators can design more engaging and effective online courses, while researchers can further investigate the impact of gamification on learning outcomes and student engagement.

FindingsThis study proposes a framework that integrates three main components: connectivism, online collaborative learning, and gamification principles. Implementing these components in the MOOC learning environment aims to enhance digital higher-order thinking as proposed by Churches and improve students' feelings and perceptions towards MOOC learning.

Recommendations for PractitionersBy recognizing the unique challenges of maintaining students’ attention in the context of MOOC learning, practitioners can incorporate gamification elements into MOOC learning environments to enhance students’ HOTS.

Recommendation for ResearchersResearchers can further explore the understanding and measurement of the dynamics of interactions and engagement within MOOCs. Additionally, they should aim to identify which gamification elements effectively capture students’ attention and contribute to their overall engagement.

Impact on SocietyBy focusing on HOTS, especially through gamification, society can anticipate a generation of individuals with improved critical thinking, problem-solving, and innovative capabilities. Furthermore, the implementation of connectivism in MOOCs can promote a global exchange of knowledge, resulting in diverse perspectives and a shared pool of information. This, in turn, will contribute to a more interconnected and collaborative world to address complex challenges.

Future ResearchThe future direction of research in MOOC learning contexts should prioritize guaranteeing and fostering student engagement. It should also involve exploring the potential of gamification within MOOCs and refining instructional designs to specifically enhance higher-order thinking skills. By addressing these critical aspects, researchers can contribute to the ongoing evolution of online education and ensure its effectiveness and relevance in the ever-changing landscape of digital learning.

The use of a personalized learning approach to implementing self-regulated online learning

Nowadays, students are encouraged to learn via online learning systems to promote students' autonomy. Scholars have found that students' self-regulated actions impact their academic success in an online learning environment. However, because traditional online learning systems cannot personalize feedback to the student's personality, most students have less chance to obtain helpful suggestions for enhancing their knowledge linked to their learning problems. This paper incorporated self-regulated online learning in the Physics classroom and used a [personalized learning](https://www.sciencedirect.com/topics/social-sciences/personalized-learning" \o "Learn more about personalized learning from ScienceDirect's AI-generated Topic Pages) approach to help students receive proper learning paths and material corresponding to their learning preferences. This study conducted a quasi-experimental design using a quantitative approach to evaluate the effectiveness of the proposed learning environment in secondary schools. The experimental group of students participated in self-regulated online learning with a personalized learning approach, while the control group participated in conventional self-regulated online learning. The experimental results showed that the experimental group's post-test and the learning-gain score of the experimental group were significantly higher than those of the control group. Moreover, the results also suggested that the student's perceptions about the usefulness of learning suggestions, ease of use, goal setting, learning environmental structuring, task strategies, [time management](https://www.sciencedirect.com/topics/social-sciences/time-management" \o "Learn more about time management from ScienceDirect's AI-generated Topic Pages), self-evaluation, impact on learning, and attitude toward the learning environment are important predictors of behavioral intention to learn with the self-regulated online learning that integrated with the personalized learning approach.

# **Research on the promotion of intelligent entertainment voice robots in personalized English learning based on data mining and gamified teaching experience**

With the development of educational technology and the arrival of the intelligent era, intelligent entertainment voice robots have gradually become a research hotspot in the field of education. This study aims to explore the application of intelligent entertainment voice robots based on data mining in the promotion of personalized English learning, and combine with gamified virtual teaching to improve learners’ learning interest and learning effect. The study uses data mining technology to analyze learners’ learning data, interest preferences and learning performance, and provides learners with targeted learning resources and gamified virtual teaching environment based on personalized recommendation. The study creates a virtual teaching environment presented in the form of games, which contains various interesting tasks, challenges and reward mechanisms. Learners can participate in the virtual teaching environment at the same time, experience the fun and stimulation of games, so as to stimulate the interest and motivation of learning. Learners can engage in interactive speech learning through conversations with intelligent entertainment speech robots. The robot can provide real-time answers to learners’ questions, provide personalized learning suggestions, and provide encouragement and feedback. By interacting with robots, learners can get more flexible and personalized learning support, improving learning effectiveness and satisfaction. Through experiments and data analysis, it is found that intelligent entertainment voice robot based on data mining and gamification teaching experience can effectively improve learners’ learning interest and learning effect. Learners show higher engagement and motivation in personalized recommended learning resources and gamified virtual teaching environments.

# 30 Adapting gamified learning systems using educational data mining techniques

Artificial intelligence (AI) provides opportunities to improve the effectiveness of e-learning by increasing students' engagement. Adaptive e-learning uses AI to support individual learners by responding to their different learning needs which can be determined by analyzing their navigation history of e-learning systems using data mining methods. Educational data mining (EDM) discovers new patterns of learning and teaching to facilitate the process of decision-making to serve education improvement. Gamification is another way of increasing students' engagement by using game elements in a nongame context. In this paper, the gamification technique and EDM methods were used in combination with adaptive learning to increase the students' engagement and learning performance. An adaptive gamified learning system (AGLS) was developed which combines gamification, classification, and adaptation techniques to increase the effectiveness of e-learning. This paper studies the impact of gamification and adaptive gamification on the effectiveness of e-learning through increasing students' engagement and learning performance. AGLS was applied to the data structure course. Results showed that adaptive gamification has a positive effect on students' engagement and learning performance compared to just gamification.

# **Personalized education and Artificial Intelligence in the United States, China, and India: A systematic review using a Human-In-The-Loop model**

The traditional “one size fits all” [education system](https://www.sciencedirect.com/topics/social-sciences/educational-organization" \o "Learn more about education system from ScienceDirect's AI-generated Topic Pages) has been largely criticized in recent years on the ground of its lacking the capacity to meet individual student needs. Global education systems are leaning towards a more personalized, student-centered approach. Innovations like [Big Data](https://www.sciencedirect.com/topics/psychology/big-data" \o "Learn more about Big Data from ScienceDirect's AI-generated Topic Pages), [Machine Learning](https://www.sciencedirect.com/topics/computer-science/machine-learning" \o "Learn more about Machine Learning from ScienceDirect's AI-generated Topic Pages), and [Artificial Intelligence](https://www.sciencedirect.com/topics/computer-science/artificial-intelligence" \o "Learn more about Artificial Intelligence from ScienceDirect's AI-generated Topic Pages) (AI) have given the modern-day technology to accommodate the distinctive features of human beings - smart machines and computers have been built to understand individual-specific needs. This opens an avenue for “personalization” in the education sector. From, mushrooming of [Education Technology](https://www.sciencedirect.com/topics/social-sciences/general-technical-education" \o "Learn more about Education Technology from ScienceDirect's AI-generated Topic Pages) (EdTech) start-ups to government funding in AI research, it is evident that the next generation educational reforms would take a quantum leap forward piloted by Big Data analysis and AI. The objective of this paper is to organize the vast literature on the use of AI for personalization of education and to shed light on the key themes by which an AI-driven approach makes [structural modifications](https://www.sciencedirect.com/topics/social-sciences/structural-modification" \o "Learn more about structural modifications from ScienceDirect's AI-generated Topic Pages) to the existing education system. To this effect, the paper employed a [systematic review](https://www.sciencedirect.com/topics/economics-econometrics-and-finance/systematic-review" \o "Learn more about systematic review from ScienceDirect's AI-generated Topic Pages) using a Human-In-The-Loop [natural language processing](https://www.sciencedirect.com/topics/computer-science/natural-language-processing" \o "Learn more about natural language processing from ScienceDirect's AI-generated Topic Pages) model of past two years' literature (2019–2021) in English language from IEEE Xplore on countries China, [India](https://www.sciencedirect.com/topics/social-sciences/india" \o "Learn more about India from ScienceDirect's AI-generated Topic Pages) and the USA. This process yielded more than 2000 search results at first and these were eventually shortlisted to 353 relevant papers for in-depth analysis. Being the pioneers in [EdTech innovations](https://www.sciencedirect.com/topics/social-sciences/technology-innovation" \o "Learn more about EdTech innovations from ScienceDirect's AI-generated Topic Pages), insights from research done in these three countries provides valuable input for the development of global education systems and research. The findings bring forward AI's success in catering to specific learning requirements, learning habits, and learning abilities of students and guiding them into optimized learning paths across all three countries. Not just that, it is also evident from the literature that AI augments educational content, customizes it for any individual according to their needs, and raises the flag of caution for anticipated learning difficulties. This recalibrates the role of instructors as well as optimizes the teaching-learning environment for a better [learning experience](https://www.sciencedirect.com/topics/social-sciences/learning-experience" \o "Learn more about learning experience from ScienceDirect's AI-generated Topic Pages). The upward trajectory of educational development with AI opens a new horizon of [personalized education](https://www.sciencedirect.com/topics/psychology/personalized-education" \o "Learn more about personalized education from ScienceDirect's AI-generated Topic Pages) for the future generation, but also comes with its challenges. Data privacy issues, availability of digital resources, and [affordability](https://www.sciencedirect.com/topics/economics-econometrics-and-finance/affordability" \o "Learn more about affordability from ScienceDirect's AI-generated Topic Pages) constraints have been reported in the recent literature as impediments in the way of promoting such technologies for day-to-day practice.

## [**Replicated evidence towards a cognitive theory of game-based training.**](https://psycnet.apa.org/record/2019-54904-001?doi=1)

Executive function is the set of cognitive skills needed for goal directed behavior and is a strong predictor of academic success (Best, 2014). The present study examines the effectiveness of a custom video game designed to train the executive function skill of shifting—being able to efficiently shift attention from 1 task to another. In Experiment 1, students who played Alien Game for 4 hr, mostly at home, improved shifting skill more than those who played a word-search control game (d = .40). In Experiment 2, students who played All You Can ET (an updated version of Alien Game) for 2 hr improved shifting skill more than those who played a word-search control game (d = .36), regardless of whether the aliens were designed to portray hot or cool emotions. In addition, playing All You Can ET, which targets shifting skill, did not cause an improvement on inhibition skill, which represents a different kind of executive function. These results extend previous findings (Parong et al., 2017), and highlight a somewhat rare case in which playing a focused computer game for a short duration causes improvements in a targeted executive function skill. Overall, the results support the theory of specific transfer of general skills, which suggests that game-based training of cognitive skills should focus on concentrated practice on a target skill to train the target skill rather than divided practice across multiple different skills in an attempt to improve the mind in general.

# Connecting the dots: Understanding the interrelated impacts of type, quality and children's awareness of design features and the mathematics content learning goals in digital math games and related learning outcomes

This study focused on an examination of how type, quality and children's awareness of design features in digital math games, along with an awareness of the mathematics goals of the game, were related to learning outcomes. We conducted a parallel conversion mixed methods study with 45 students in Grades 3 and 4 (ages 9–10). Students participated in clinical interviews using three digital math games. The results suggest a moderated mediation relationship in which the quality of the design features moderated the mediating impact of children's awareness of the game's design features, specifically when the child was aware of the mathematics content learning goal (MCLG) of the game. These findings show how important it is that design features are of high quality in a digital math game, and how this is intertwined with children's awareness of the features and the MCLG. When these variables intertwined in just the right way, the interactions between the children and the digital math game afforded mathematical learning growth.

**How to improve reading and writing skills in primary schools: A comparison between gamification and pen-and-paper training,**

This research investigates the potential of gamified tools to enhance motivation as well reading and writing skills in pupils, from 8 to 11 years old. The study compares the impact of gamified applications to traditional pen-and-paper activities, utilizing standardized reading and writing tests. The training duration spans 12 h within the school setting, and the sample comprises 113 children with typical development, evenly distributed across two groups. The results indicate significant improvements in reading and writing speed and accuracy for each group, with a slightly higher effect observed in the experimental gamified training group, although this difference was not statistically significant. Although motivation did not directly mediate performance in either group, students in the experimental training groups expressed greater enthusiasm for the activities. These findings emphasize the importance of comprehensive training and pave the way for future investigations into the effects of gamified tools on other real-life skills and motivational aspects. Such studies would prove fundamental to understand the limitations and benefits of gamification, enabling its effective integration into school programs.

# **Towards a new generation of digital games designed with the basics of psychological theories to improve primary school pupils’ psychological and technical skills in learning arithmetic**

Recent studies have shown that pupils learn more effectively through play, which inspired us to design an educational digital game aimed at enhancing their arithmetic performance. This paper addresses various skills, focusing on psychological skills derived from the learning challenges identified by psychologist Jean Piaget. We proposed key skills such as motivation, initiative, engagement, concentration, and behavioral management among pupils. Additionally, we identified technical skills related to arithmetic, including calculation speed, accuracy rate, and overall learning achievement.

We developed ***“GAME-calcul,”*** an innovative digital game for primary school pupils to help them overcome common difficulties in learning arithmetic. The main contribution lies in incorporating Piaget’s cognitive development theory into the game’s design, facilitating various arithmetic operations through an engaging and effective approach.

To investigate the short and long-term impacts of this Piagetian game on both technical and psychological skills, we conducted an experiment using a hybridization between quantitative and qualitative approaches. The quantitative approach aimed to confirm the game’s positive effects on pupils’ technical skills. For this goal, we selected forty-five (45) pupils, dividing them into three groups: a control group that learned arithmetic using traditional methods, a first experimental group that engaged with the ***“Finger Fun Math”*** game designed for first-year pupils, and a second experimental group that used the ***“Sabstracto”*** game intended for second-year pupils. The two proposed games accommodate the characteristics of ***the preoperational*** and ***concrete operational*** stages of a child’s cognitive development identified by psychologist Jean Piaget.

We employed Multivariate Analysis of Variance “MANOVA” and “Post Hoc Levene” tests to analyze the performance of the three groups before and after the game integration in the learning activity. The results indicated that pupils using the ***“Sabstracto”*** game achieved significantly better outcomes compared to those using the ***“Finger Fun Math”*** game and those in ***the control group***.

Equally, the qualitative aspect of the study involved gathering insights from pupils and teachers through interviews and questionnaires, confirming the positive impact of the Piagetian game on pupils’ psychological skills. Overall, the findings demonstrate that integrating these innovative games based on Piaget’s theory positively influences both technical and psychological skills in primary school pupils learning arithmetic.

# **A Historical Text-Based Game Designed to Develop Critical Thinking Skills**

Designing an intervention that can effectively develop critical thinking skills is challenging because of the problems of transfer and domain specificity. The authors describe the design and development of a text-based game that could teach players important critical thinking skills in the domain of history. This was achieved by combining Schon's reflective practitioner model with game-based learning principles. The work contributes to the existing literature because the combination of the models employed allowed the game design to address the problem of transfer, as well as developing critical thinking skills. The instrument used to evaluate the effectiveness of the game was a questionnaire based on the reflective practitioner model. The gathered qualitative data were analysed through affinity diagramming. The results show that the game that was developed has the potential to encourage advanced levels of historical thought, as well as critical thinking skills.

# **Developing an active-learning app to improve critical thinking: item selection and gamification effects**

Critical thinking (CT) is widely recognized as an important skill and attitude in this modern world, but few apps (web-based or installed on devices) have been developed to effectively train it. There is also little research on what kind of content to put into such apps and in what order, if the content is a series of reasoning questions that are intended as CT exercises. Therefore, this research project, consisting of two studies, tries to demonstrate how exercise questions can be presented to learners to sustain their motivation to work on multiple-choice CT questions. In Study 1, question banks were drawn from popular workbooks for CT and verbal reasoning. The questions were ranked in terms of difficulty based on the participation of university students (N = 73).

In Study 2, the questions were loaded onto two types of web-based apps: (1) one that sequentially gives multiple-choice questions with immediate feedback and (2) one with minimum gamification of group/individual competition. The experiment to examine the effect of the gamification was conducted (N = 124). Both groups with and without gamification showed improvements in the scores of the pre-/post-tests using comparable questions, but there was no clear effect of gamification. These findings show that an effective CT app can be developed using existing question banks but that the effect of gamification needs further research.

# **The role of video games in enhancing managers' strategic thinking and cognitive abilities: An experiential survey**

Using gamification and video games is one of the modern approaches to cognitive enhancement and improving the abilities and competencies of managers, including strategic thinking skills. Many organizations use video games in the fields of education, marketing, business, and entrepreneurship. This research aimed to investigate the role of video games in enhancing managers' strategic thinking and their potential contribution to developing cognitive capabilities. The sample included 30 students actively involved in the innovation and entrepreneurship ecosystem. To measure the strategic thinking of the participants, Pisapia’s strategic thinking questionnaire was used, and the CANTAB test was employed to measure their cognitive capabilities. To identify the individuals’ game-playing styles, indicators of micro-management, planning, plan recognition, predictions, gathering resources, partial observability, and damage avoidance were designed. The findings indicated that 53.3 percent of the participants had reflective thinking, 30 percent had systems thinking, and the rest had a reframing thinking style as their strategic thinking dominant dimension. On the other hand, given the identified correlation between the damage avoidance criteria with the thinking and reflective style, as well as the inverse and significant correlation of the gathering resources criteria with the results of the PRM test, it seems that strategic games have the potential to change and even develop some cognitive functions such as attention, reaction, and memory, and can be considered as tools to improve cognitive ability. These games can be used to design tasks to enhance managers' cognitive abilities and subsequently promote their strategic thinking and decision-making skills.

# **An entrepreneurial education game for effectively Tracing the knowledge structure of college students - based on adaptive algorithms**

The application of games in the field of education has brought new developments and updated educational needs to games. To maintain and improve students' learning motivation and interest, and more effectively carry out personalized teaching capabilities, research focuses on students' personalized knowledge structure. Starting from tracking the differences in knowledge structures among different learners, a game model based on entrepreneurial [education theory](https://www.sciencedirect.com/topics/social-sciences/education-theory" \o "Learn more about education theory from ScienceDirect's AI-generated Topic Pages) has been designed. Through modeling learner knowledge using Bayesian network, the research constructs a game framework of entrepreneurial education for adaptive learning. On this basis, a new feature crossover method is proposed to construct a deep knowledge tracking model based on feature embedding and attention mechanism. It was combined with adaptive learning technology to ultimately construct an entrepreneurial education game model that integrates adaptive learning and improved deep knowledge tracking. A total of 379 students participated in the experiment. The experimental results on the ASSISTments09 open data set show that the area value under the receptivity curve of this model is 0.913, which is 8.8% to 26.6% higher than that of advanced models of the same type. The performance of the research model is optimal on different training scale data. Students' adaptability to entrepreneurship education games is higher than classroom teaching, with a difference between 2% and 11%. The experimental data demonstrates the high applicability of this research method and also achieves the goal of game design, which has certain practical teaching application value.

# **40 The Impact of Educational Games on Learning Outcomes: Evidence From a Meta-Analysis**

The objective of this study is to examine and compare the impact of serious games and gamification on learning achievement and motivation. The results of the meta-analysis indicate that gamification has a more positive influence on learning achievement and motivation compared to serious games. The analysis reveals that gamification demonstrates a stronger impact on extrinsic motivation than on intrinsic motivation. Serious games have a more positive effect on intrinsic motivation in comparison to extrinsic motivation. The overall outcome suggests that gamification has relatively stronger effects than serious games. While the impact on extrinsic motivation is more significant with both approaches, serious games excel in fostering intrinsic motivation. However, further research is recommended to investigate the specific mechanisms that drive these effects and to identify optimal strategies for implementing serious games and gamification in diverse educational settings.

# **The Influence of Gamification Elements in Educational Environments**

The use of gamification might offer a partial solution to the decline in students' motivation and engagement the school system is currently facing. Specifically, this study aimed to examine whether gamification elements (perceived collaboration, perceived competition, favorable feedback, unfavorable feedback, self-expression, sense of control) contribute to intrinsic learning motivation. A survey method was used to gather the information from students, and regression analysis was used to examine these results. The results indicated that perceived collaboration, perceived competition, favorable feedback, self-expression, and sense of control are key aspects that impact students' intrinsic motivation. Overall, the findings contribute to a better understanding of learning motivation for research theories and offer concrete suggestions for using gamification to improve teaching.

# **Balancing enjoyment and learning in teaching software project management with game-based learning**

Despite advancements in project management education, project failures remain common, often due to insufficient experience and skills. Games offer a valuable platform for teaching practical project management skills, allowing players to learn from mistakes without significant economic costs. However, many serious games in this field lack focus on engagement and motivation. The "Software Project Management Game" introduced in this article addresses these issues by incorporating motivational game design principles, drawing inspiration from entertainment games like Game Dev Tycoon and The Sims. The game ensures a smooth flow without unnecessary interruptions, putting players in control. Players progress through five projects of increasing complexity, gradually developing their skills and learning soft skills and task dependencies. This article details the design, implementation, and evaluation of the game, focusing on gameflow, intrinsic motivation, perceived learning, and usability. The results indicate that the game successfully balances enjoyment and learning, making it an effective tool for teaching core project management skills.

# Log-Based Analysis of Creativity in the Context of Computational Thinking

Computational thinking (CT) and creativity have been recognized as crucial skills for adapting to the current digital era. However, despite being extensively studied over the last few decades, research on their associations has only emerged recently. We report on a study that examined how creativity is manifested in the context of CT, specifically while solving computational problems in an online game-based learning environment for early programming. We took a learning analytics log-based approach to evaluate measures of CT and creativity. We developed a Python algorithm to automatically analyze the logged solutions across four creativity measures. This allowed for an objective, quantitative, multidimensional analysis of 52,438 submissions of N = 111 primary and secondary school students over 85 tasks. We examined the relationships between measures of creativity, game level, and CT, utilized exploratory analysis to investigate how measures of creativity differ across age groups, and explored how these measures characterize students. Our findings suggest that creativity does not decrease throughout the game despite the increased difficulty and its mechanics that penalize creative solutions. We also point out how various dimensions of creativity play different roles in learning. These findings suggest that educators should foster intrinsic motivation and encourage students to explore multiple solution paths to enhance both CT and creativity skills. Researchers should keep investigating mechanisms to assess and enhance creativity in learning environments and explore the influence of personal and contextual factors.

# Game elements improve affect and motivation in a learning task

Earlier studies repeatedly showed increased learner motivation due to game elements, while overall cognitive effects on learning outcomes were absent. One possible explanation for this discrepancy is provided by theories integrating cognitive and affective learning processes: the beneficial effect on learner motivation eventually balancing simultaneously higher cognitive processing demands associated with game elements. In this paper, we provide results of an empirical test of this theoretical suggestion. In particular, we report results of a value-added online experiment (with n = 61 participants, mostly students; 44 female, 15 male, 2 diverse; median age: 24 years), comparing a more gameful with a less gameful version of a learning task. In agreement with earlier studies, we find similar cognitive learning outcomes (δ < 0.2), but medium (δ = 0.5) and large (δ = 0.9) effects on affective and motivational outcomes, respectively. Furthermore, mediation models show that a small negative direct effect of game elements on cognitive outcomes (β = −0.2) is indeed effectively cancelled by an indirect path through motivational outcomes (β = +0.4). Overall, our results corroborate the tenability of the integrated cognitive affective model of learning with multimedia. This implies its feasibility in purposefully designing learning environments with specific motivational or cognitive aims in mind.

# **Using the E-Learning Gamification Tool Kahoot! to Learn Chemistry Principles in the Classroom**

This study investigated the effectiveness of using the Kahoot! game in developing the cognitive achievement and direction of students of pharmacy at Alasmarya Islamic University, Libya. The study design is based on action research. Kahoot! was implemented once at the end of each of three units. The study sample consisted of 30 female students from the first year of university at the Pharmacy Science College in Libya. The students were selected randomly, and studied using Kahoot! technology. For the quantitative part of the study, data were collected through a 20-item questionnaire on 20 participants and 15 participants to gather information on students’ perceptions about this application by the interview. Results indicate that the students were able to engage actively in the chemistry lessons and learned the unit on molecular weights effectively, leading them to enjoy basic chemistry, and the surveys allow for anonymous classroom participation, which further engages all students. The results hold implications for the development of more efficient, effective in educational process.

# Gamifying Online Training in Management Education to Support Emotional Engagement and Problem-solving Skills

# Online training to improve problem-solving skills has become increasingly important in management learning. In online environments, learners take a more active role which can lead to stressful situations and decreased motivation. Gamification can be applied to support learner motivation and emotionally boost engagement by using game-like elements in a non-game context. However, using gamification does not necessarily result in supporting positive learning outcomes. Our analysis sheds light on these aspects and evaluates the effects of points and badges on engagement and problem-solving outcomes. We used an experimental approach with a fully randomized pre-test/post-test design of a gamified online management training program with 68 participants. The results demonstrate that points and badges do not directly improve problem-solving skills but are mediated by emotional engagement to positively influence problem-solving skills. Additionally, satisfaction with the gamification learning process positively relates to emotional engagement. Thus, when creating online training programs, it is essential to consider how to engage students and to think about the design of the learning environment. By identifying the limitations of gamification elements, the study’s results can provide educators with information about the design implications of online training programs for management learning.

# **Self-reported playing preferences resonate with emotion-related physiological reactions during playing and watching of first-person shooter videogames**

The present aim was to investigate emotion-related physiological responses and subjective ratings of two groups of active gamers (N = 24) in response to both playing and watching a video of a first-person [shooter game](https://www.sciencedirect.com/topics/psychology/shooter-game" \o "Learn more about shooter game from ScienceDirect's AI-generated Topic Pages). Participants of one group had high preferences for game dynamics in first-person shooter games, whereas the other group disliked such dynamics. [Electrodermal activity](https://www.sciencedirect.com/topics/psychology/electrodermal-activity" \o "Learn more about Electrodermal activity from ScienceDirect's AI-generated Topic Pages) (EDA), heart rate (HR), and electromyographic (EMG) activity of the corrugator supercilii (i.e., brow furrowing) and the zygomaticus major (i.e., smiling) muscles were measured while playing and watching a gameplay video. After the playing and watching sessions, the participants rated their experienced level of valence and arousal. The results showed that those who liked the game dynamics showed comparable and stable levels of EDA and HR during both playing and watching. Those who disliked the game dynamics showed overall higher levels of EDA and HR during playing than watching a video, and a rising EDA tendency especially during watching a video. Playing evoked overall higher corrugator supercilii activity than watching in both groups. The group that liked the game dynamics showed a steep EMG increase in the activity of the corrugator supercilii, whereas the group that disliked the game dynamics showed less EMG increase. As for ratings of valence and arousal, both groups reported more positive valence and higher arousal after playing than after watching a video, and there were no differences between the groups. In sum, the results showed that player preferences were associated with players’ emotion-related physiological responses. The results also showed that playing as opposed to watching generated higher autonomic arousal, but only for players who disliked the dynamics of the game.

# **Can gamification help to improve education? Findings from a longitudinal study**

A goal of any educational measure is to improve students' capability to retain teaching content. In this paper, we investigate the potential of [gamification](https://www.sciencedirect.com/topics/social-sciences/gamification" \o "Learn more about gamification from ScienceDirect's AI-generated Topic Pages) to foster knowledge retention using an [action research](https://www.sciencedirect.com/topics/social-sciences/action-research" \o "Learn more about action research from ScienceDirect's AI-generated Topic Pages) approach. We present the results from a [longitudinal study](https://www.sciencedirect.com/topics/social-sciences/longitudinal-analysis" \o "Learn more about longitudinal study from ScienceDirect's AI-generated Topic Pages) including 617 secondary and tertiary education students conducted over a period of two years. Various workshop designs that incorporated numerous [gamification](https://www.sciencedirect.com/topics/computer-science/gamification" \o "Learn more about gamification from ScienceDirect's AI-generated Topic Pages) elements were compared with non-gamified workshop designs, tested and refined over time. The improved workshop designs led to increased levels of knowledge retention that exceeded the benchmark values from educational literature. We found that [gamification](https://www.sciencedirect.com/topics/psychology/gamification" \o "Learn more about gamification from ScienceDirect's AI-generated Topic Pages) exerts a positive impact on knowledge retention. We tested for the moderating [effects of gender](https://www.sciencedirect.com/topics/social-sciences/effect-of-gender" \o "Learn more about effects of gender from ScienceDirect's AI-generated Topic Pages) and age and found no effect of the former and inconsistent results for the latter. The steady increase in students’ [learning performance](https://www.sciencedirect.com/topics/social-sciences/learning-performance" \o "Learn more about learning performance from ScienceDirect's AI-generated Topic Pages) resulting from constant refinement of the workshops demonstrates the usefulness of incorporating [gamification](https://www.sciencedirect.com/topics/social-sciences/gamification" \o "Learn more about gamification from ScienceDirect's AI-generated Topic Pages) principles into educational activities.

# Impact of Gamification on Students’ Learning Outcomes and Academic Performance: A Longitudinal Study Comparing Online, Traditional, and Gamified Learning

This study aims to examine the influence of gamification in students’ learning outcomes and academic performance. A longitudinal study was conducted to compare students’ academic performance in online learning (2020–2021), traditional learning (2021–2022), and gamified learning (2022–2023). The longitudinal study lasted 3 years and a total of 1001 higher education students were involved. Three research questions were set to be explored and students’ viewpoints and experiences were also examined through a questionnaire of 20 questions. This study follows a quantitative research approach. The data refers to students’ academic performance, success rate, excellence rate, withdrawal rate, engagement, motivation, and perspectives. In the laboratory part of the course, gamified learning yielded better outcomes over online learning and traditional learning in success rate (39% and 13%), excellence rate (130% and 23%), average grade (24% and 11%), and retention rate (42% and 36%) respectively. In the theoretical part of the course, gamified learning resulted in better outcomes over online learning and traditional learning in success rate (19% and 14%), in excellence rate (125% and 79%), and in average grade (25% and 12%) respectively. In the overall course, gamified learning yielded better outcomes over online learning and traditional learning in success rate (14% and 14%), in excellence rate (122% and 70%), and in average grade (25% and 17%) respectively. The highest increase was observed in students’ excellence rate. Students highly regarded gamification as an effective educational approach that can increase their learning outcomes, engagement, productivity, and motivation and trigger both their both intrinsic and extrinsic motivation. The learning experience become more enjoyable and students’ basic needs in terms of autonomy, competence and sufficiency, and relatedness and sense of belonging were met. Traditional learning also resulted in better learning outcomes when compared to online learning. Gamification emerged as an effective learning approach which leads to improved learning outcomes and academic performance, learning motivation, engagement, and retention rate over online learning and traditional learning in both theoretical and applied course settings.

# **50 Sustainability science in management education: Cognitive and affective sustainability learning in an MBA course**

[Sustainability](https://www.sciencedirect.com/topics/earth-and-planetary-sciences/environmental-impact-assessment) science is the interdisciplinary study of sustainability that embodies natural sciences, social sciences, and that is actionable in practice. We crafted and deployed an MBA course that integrated natural and social sciences based on two systems of instructional design: the ADDIE conceptual model and Bloom's revised taxonomy. The progression to higher levels of the taxonomy targets higher-level [critical thinking skill](https://www.sciencedirect.com/topics/psychology/critical-thinking-skills" \o "Learn more about critical thinking skill from ScienceDirect's AI-generated Topic Pages) acquisition. Sequencing of instructional design was informed by [construal](https://www.sciencedirect.com/topics/psychology/construal" \o "Learn more about construal from ScienceDirect's AI-generated Topic Pages) level theory (CLT), which posits localized sustainability stimuli are more concretely understood and actionable than distant stimuli. Using a quasi-experimental design, evaluation results indicate that treatment students significantly improved on the cognitive and affective measures of sustainability learning from pre-to post-tests. To assist with curricular adaptation, course-/module-level learning objectives, assignment descriptions, and discussion questions are provided. The study is pedagogically innovative, as the first known to integrate sustainability science to target student cognitive and affective learning about sustainability. Findings suggest the CLT can be utilized to sequence sustainability content from abstract and distant to concrete and local. Research has linked this localized understanding to managerial agency to responsibly respond. The study also provides a robust and replicable research design, including measures for assessing cognitive and affective sustainability learning.

# **The impact of gamification on learning and instruction: A systematic review of empirical evidence**

The adoption of [gamification](https://www.sciencedirect.com/topics/social-sciences/gamification" \o "Learn more about gamification from ScienceDirect's AI-generated Topic Pages) in learning and instruction is perceived to have mass appeal among the learners in stimulating motivation, [learner engagement](https://www.sciencedirect.com/topics/psychology/learner-engagement" \o "Learn more about learner engagement from ScienceDirect's AI-generated Topic Pages) and social influence. This study is an attempt to present a summary of the empirical findings of state-of-the-art literature in the emerging field of [gamification](https://www.sciencedirect.com/topics/psychology/gamification" \o "Learn more about gamification from ScienceDirect's AI-generated Topic Pages) within the educational domain of learning and instruction. It reveals the latest scientific research evidence on the emerging trends of learning technologies and [gamification](https://www.sciencedirect.com/topics/social-sciences/gamification" \o "Learn more about gamification from ScienceDirect's AI-generated Topic Pages) plugins along with extending the possibilities for future research directions in revolutionizing learning and instruction through [gamification](https://www.sciencedirect.com/topics/psychology/gamification" \o "Learn more about gamification from ScienceDirect's AI-generated Topic Pages). A [systematic literature review](https://www.sciencedirect.com/topics/social-sciences/systematic-review" \o "Learn more about systematic literature review from ScienceDirect's AI-generated Topic Pages) examined the thematic and content analysis of 46 empirical research papers published in the Web of Science database between 2016 and 2019. The review critically appraised and evaluated the various contradictions found in the literature along with setting the stage for the significance of future research studies to re-examine the theoretical foundations of gamification, its methodological approaches, theoretical models, gaming platforms and apps, game mechanics and learning outcomes. This study not only attempts to shed light on the novelty of gamified learning perceived as a game-changer and key enabler of motivation, engagement, and user experience but also sought to outline the key challenges and barriers of gamification.

# **Investigating the predictors of adolescent learners’ continuance intention to engage with a gamified e-learning platform about traffic safety in Vietnam**

Introduction: Although e-learning systems are seen as a key part of learning and training activities, many learners stop using them after a period of initial engagement. Prior studies provided insights into e-learning participation, but in the context of traffic safety, little research has been done on learners’ intention to continue using (gamified) e-learning. Objectives: This study aims to investigate whether the following predictors of learners’ continuance intention towards a gamified e-learning platform: satisfaction, attitude, interface design, learning content, learning management and [gamification](https://www.sciencedirect.com/topics/psychology/gamification" \o "Learn more about gamification from ScienceDirect's AI-generated Topic Pages). In addition, the study investigates whether satisfaction mediates the effects of these predictors. Method: A sample of 322 Vietnamese adolescents participated in a study where a gamified e-learning platform was implemented in a sample of high school students. Results: Satisfaction, gamification, interface design and learning content were found to be important predictors of continuance intention. Moreover, satisfaction was a significant mediator of the effects generated by gamification, interface design and learning content on continuance intention. Practical implications: The findings of this study offer useful insights on the successful implementation of a gamified e-learning platform about traffic safety.

# **The role of gamified learning strategies in student's motivation in high school and higher education: A systematic review**

Gamification, defined as the integration of videogame components to promote a gameful experience, is increasingly being implemented in education with the aim of enhancing students' engagement and motivation. Accordingly, since 2010 it has constituted an area of growing interest for researchers and teachers. Following PRISMA 2020's methodology, a systematic review (SR) was conducted in November 2022 seeking to explore the influence of gamification strategies on students' motivation to learn. Having identified 548 articles, 40 studies were chosen based on the selection criteria set and analyzed to reveal that game elements such as points, badges and rankings are widely used to motivate students. From a theoretical perspective, gamification studies focus on the dichotomy of intrinsic and extrinsic motivation. The results suggest a positive influence of gamification strategies on students' motivation, although in the long run, such motivation can decline. Furthermore, the influence of a novelty effect and extrinsic rewards on motivation is identified, which can lead to greater motivation in the short term, followed by a decrease with further exposure to gamification. Future studies should focus on the influence of students' individual traits (e.g., gaming experience, openness to competition and cooperation) on gamification strategies. Moreover, long-term exposure to gamification as well as the novelty effect should be explored.

# **Analyzing the relationships between learners’ motivation and observable engaged behaviors in a gamified learning environment**

Over the last ten years, [gamification](https://www.sciencedirect.com/topics/social-sciences/gamification" \o "Learn more about gamification from ScienceDirect's AI-generated Topic Pages) has been widely integrated in [digital learning](https://www.sciencedirect.com/topics/social-sciences/digital-education" \o "Learn more about digital learning from ScienceDirect's AI-generated Topic Pages) environments as a way to increase learners’ motivation. However, little is known about engaged behaviors adopted by learners when using gamified learning environments. In this paper, we analyze learners’ interactions with a gamified learning environment to study learners’ engagement in this particular context and to identify the factors that influence engaged behaviors. We also analyze the complex relationships that exist between learners’ engagement and motivation. We conducted a large-scale [field study](https://www.sciencedirect.com/topics/psychology/field-study" \o "Learn more about field study from ScienceDirect's AI-generated Topic Pages) in ecological conditions, involving 257 students (13-14 years’ old) in 12 classes, from 4 different middle schools. We identified a model of engagement that distinguishes two types of engaged behaviors: an achievement-oriented engagement for initially intrinsically motivated learners or high achiever learners, and a perfection-oriented engagement for low achiever learners. We show that each type of engaged behavior has a specific impact on the variation in learners’ motivation during the [learning activity](https://www.sciencedirect.com/topics/computer-science/learning-experiences" \o "Learn more about learning activity from ScienceDirect's AI-generated Topic Pages). This model contributes to a better understanding of how [gamification](https://www.sciencedirect.com/topics/computer-science/gamification" \o "Learn more about gamification from ScienceDirect's AI-generated Topic Pages) can affect learners’ engaged behaviors and motivation during the learning activity according to their initial motivation and player profile. These findings open up new perspectives in terms of motivational affordances, as well as the design and dynamic adaptation of [gamification](https://www.sciencedirect.com/topics/psychology/gamification" \o "Learn more about gamification from ScienceDirect's AI-generated Topic Pages) based on learners’ interaction traces with the learning environment.

# **Understanding the postadoption use of gamified learning systems against the conflicting role of the game layer**

[Gamification](https://www.sciencedirect.com/topics/social-sciences/gamification) is driving [widespread application](https://www.sciencedirect.com/topics/computer-science/widespread-application" \o "Learn more about widespread application from ScienceDirect's AI-generated Topic Pages) adoption, with a $70.4 billion projected market by 2030. However, the consequences of gamification on sustained use beyond initial adoption remain largely unclear. This study explores how the game layer may induce psychological fatigue and hinder continued use, particularly in learning systems. Drawing on self-determination theory and [cognitive load theory](https://www.sciencedirect.com/topics/psychology/cognitive-load-theory" \o "Learn more about cognitive load theory from ScienceDirect's AI-generated Topic Pages), we analyzed the perceptions of 307 Duolingo users. The results reveal mixed impacts of the game layer on postadoption usage, influenced by gaming motivation and perceived [learning complexity](https://www.sciencedirect.com/topics/computer-science/learning-complexity" \o "Learn more about learning complexity from ScienceDirect's AI-generated Topic Pages). This research underscores the nuanced effects of gamification and offers insights for improving gamified learning system design.

# **Can online interfaces enhance learning for public decision-making? Eliciting citizens’ preferences for multicriteria decision analysis**

Innovative online interfaces informing and consulting citizens about their preferences for multicriteria decision analysis (MCDA) could make public decision-making more participatory. We propose a three-faceted learning for decision-making framework and used it to test newly-designed online weight elicitation interfaces. We investigated two features meant to enhance learning: fully-fledged gamification with a narrative, interaction with nonplayer characters, and ambient music, and learning loops (LL) using consistency checks of elicited weights and the challenge to resolve inconsistencies. We operationalized our framework with a novel systematic set of measure instruments providing complementary data types. We designed a 2 × 2 between-subject experiment with pre- and postquestionnaires. Answers from 769 respondents, representative of the Swiss population in age and gender, indicated that the interfaces successfully raised awareness about wastewater management. Gamification was helpful: respondents performed better in the factual learning test, and unexpected social learning occurred. However, gamification lowered the perception of process understanding. The LL were beneficial: objectively, respondents performed better in the factual learning test. However, respondents perceived the LL as cognitively demanding and their factual learning as lower. Our structured assessment highlighted the need for further research to investigate, for instance, high interpersonal variability and the disparities between tested and perceived learning. Measuring preference construction remains challenging; and social learning should be added to the assessment framework. Applying such structured assessment of learning outcomes to more traditional operational research interventions would provide a baseline for future comparison.

# **Digital Gaming for Cross-Cultural Learning: Development of a Social Constructivist Game-Based Learning Model at a South African University**

Although game-based learning has gained significant attention in higher education globally, it is difficult to harness its engagement and interactions to improve student success. This paper argues that the use of digital games has the potential to interrupt social practices and increase engagement and interaction, thereby fostering meaningful learning. Using a mixed-method design, a digital game was used in a sport studies programme, involving 106 participants, over a two-year period. Data were collected through surveys, focus group discussions, and reflective blog posts. Structuration theory is considered as the theoretical lens, as it purports that recursive social activities of humans are continually recreated by human agents. The paper concludes that when participants engaged in a cross-cultural game-based learning environment, the social practices acquired through their academic career were interrupted, reshaped, and reproduced into new practices. A social constructivist game-based learning model to foster interaction within multi-cultural higher education classrooms is offered.

**Revolutionizing learning − A journey into educational games with immersive and AI technologies**

Educational games rapidly integrate entertainment technology and learning, engaging individuals in dynamic educational experiences. These games incorporate multimedia content to encourage critical thinking, problem-solving and information retention. Educational games employ immersive technology such as virtual and augmented reality to transfer individuals to simulated worlds, hence improving learning. Furthermore, artificial intelligence (AI) technologies optimize educational experiences by adjusting information to individual learning styles, providing focused feedback as well as encouraging a more effective and entertaining learning technology. The integration of educational games with immersive and AI technology provides great potential for transforming how individuals acquire and apply information sharing. This research determined the creation of significant educational applications that are personalized and adaptive through the use of image, emotional recognition and speech, intelligent agents that replicate the effects of an individual opponent and control over the complexities of game levels along with information. The study evaluated the different tools that educators and learners could utilize to develop immersive and artificial intelligence-based instructional games without a requirement for programming knowledge. The study demonstrates that immersive technology and AI technology could represent beneficial resources for creating educational video games and entertainment technology. The research highlights the novel possibilities of stochastic swing golf optimization (SSGOA) immersive and AI technologies providing an innovative approach to developing effective as well as attractive learning environments.

# From product to process data: Game mechanics for science learning

Game-based learning environments (GBLEs) supplement classroom instruction so students can demonstrate their scientific reasoning abilities and increase knowledge, providing a platform that promotes interest and engagement in science. The goal of this study was to examine the effectiveness of game mechanics for science learning. This study identifies how two types of game mechanics—learning and assessment mechanics—are used by high school participants (N = 137) as they learn about microbiology with Crystal Island, a game-based learning environment for science education. Participants’ learning outcomes were evaluated in two ways: learning gains, which assessed participants’ domain knowledge acquisition, and game completion, which assessed participants’ ability to successfully demonstrate scientific reasoning abilities. Results from this study showed that game completion is not related to learning gains. However, as participants engaged with increasingly more assessment mechanics, learning gains decreased. Further, profiles of learners were extracted to better understand the learning process that best supports greater learning outcomes. Results showed that learners who engaged in less recurrent transitions across assessment mechanics were more likely to successfully demonstrate scientific reasoning abilities. Implications for the design of games which provide scaffolding based on process data of learners’ game mechanic use are provided.

# **60 Adaptive formative assessment system based on computerized adaptive testing and the learning memory cycle for personalized learning**

[Computerized adaptive testing](https://www.sciencedirect.com/topics/social-sciences/computerized-adaptive-testing) (CAT) can effectively facilitate [student assessment](https://www.sciencedirect.com/topics/computer-science/student-assessment" \o "Learn more about student assessment from ScienceDirect's AI-generated Topic Pages) by dynamically selecting questions on the basis of learner knowledge and item difficulty. However, most CAT models are designed for one-time evaluation rather than improving learning through [formative assessment](https://www.sciencedirect.com/topics/social-sciences/formative-assessment" \o "Learn more about formative assessment from ScienceDirect's AI-generated Topic Pages). Since students cannot remember everything, encouraging them to repeatedly evaluate their [knowledge state](https://www.sciencedirect.com/topics/computer-science/knowledge-state" \o "Learn more about knowledge state from ScienceDirect's AI-generated Topic Pages) and identify their weaknesses is critical when developing an adaptive formative assessment system in real educational contexts. This study aims to achieve this goal by proposing an adaptive formative assessment system based on CAT and the learning memory cycle to enable the repeated evaluation of students' knowledge. The CAT model measures student knowledge and item difficulty, and the learning memory cycle component of the system accounts for students’ retention of information learned from each item. The proposed system was compared with an adaptive assessment system based on CAT only and a traditional nonadaptive assessment system. A 7-week experiment was conducted among students in a university [programming course](https://www.sciencedirect.com/topics/computer-science/programming-course" \o "Learn more about programming course from ScienceDirect's AI-generated Topic Pages). The experimental results indicated that the students who used the proposed assessment system outperformed the students who used the other two systems in terms of [learning performance](https://www.sciencedirect.com/topics/social-sciences/learning-performance" \o "Learn more about learning performance from ScienceDirect's AI-generated Topic Pages) and engagement in practice tests and reading materials. The present study provides insights for researchers who wish to develop formative assessment systems that can adaptively generate practice tests.

**Harnessing the power of ChatGPT to develop effective MCQ-based clinical pharmacy exams**

AI has the potential to revolutionize learning and assessments. This research explored ChatGPT’s potential in creating MCQ-based clinical pharmacy exam papers at the Pharm-D level and compared their quality to human-made exams. In this study, three different MCQ-based papers (2 by ChatGPT; AIeasy & AIhard, and 1 by instructor; HUMAN) were set to have 10 MCQs each. We asked ChatGPT to set one exam with a low level of difficulty (AIeasy) and a second exam with specific instructions to achieve a more difficult exam (AIhard). Students attempted these exams as part of their regular assessment and rated them from 1 to 5 for various parameters such as critical thinking involved, difficulty level, and overall experience. Our study shows that students obtained higher marks for AIeasy (7.67 ± 3.92) than for AIhard (7.06 ± 1.32) and HUMAN (5.02 ± 1.70), making the HUMAN exam the most difficult one. Students rated the AIhard and HUMAN exams higher for critical thinking than for AIeasy. The students rated highest for AIeasy for overall experience. Interestingly, most of the students (*n* = 52, 83%) could not correctly identify the exam set by the instructor. Therefore, with clear instructions, ChatGPT can create content-relevant, good-quality exam papers with varying difficulty levels. This is especially useful for students who need to self-study and be ready for several exams to gauge their knowledge.

# Reimagining Flipped Learning via Bloom’s Taxonomy and Student–Teacher–GenAI Interactions

This paper explores how generative artificial intelligence (GenAI) technologies, such as ChatGPT 4o and other AI-based conversational models, can be applied to flipped learning pedagogy to achieve enhanced learning outcomes for students. By applying Bloom’s taxonomy to intentionally align educational objectives to the key phases of flipped learning, our study proposes a model for assigning learning activities to pre-class, in-class, and post-class contexts that can be enhanced by the integration of GenAI. In the pre-class phase, GenAI tools can facilitate personalised content delivery, enabling students to grasp fundamental concepts at their own pace. During class, the interactions between students, teacher, and GenAI encourage collaborative learning and real-time feedback. Post-class activities utilise GenAI to reinforce knowledge, provide instant feedback, and support continuous learning through summarisation and content generation. Furthermore, our model articulates the synergies between the three key actors: interactions between students and teachers, learning support provided by GenAI to students, and use of GenAI by teachers to enhance their teaching strategies. These human–AI interactions fundamentally reshape the flipped learning experience, making it more adaptive, engaging, and supportive of the development of 21st-century skills such as critical thinking, collaboration, communication, and creativity.

# **Artificial intelligence and human behavioral development: A perspective on new skills and competences acquisition for the educational context**

Despite the significant emphasis placed on incorporating [21st century skills](https://www.sciencedirect.com/topics/social-sciences/21st-century-skill" \o "Learn more about 21st century skills from ScienceDirect's AI-generated Topic Pages) into the educational framework, particularly at the primary level, recent scholarly works indicate considerable variation in the implementation of these skills across different countries and regions, suggesting a demand for further research specifically focusing on [primary education](https://www.sciencedirect.com/topics/social-sciences/primary-education" \o "Learn more about primary education from ScienceDirect's AI-generated Topic Pages). The indications of the Digicomp framework and 21st-century skills in Europe have outlined the key competences for lifelong learning needed for all citizens, including teachers and students. In this perspective, Education plays a fundamental role in ensuring that citizens acquire the required skills. The objective in the common European framework is clear: to initiate a transition from the culture of knowledge to the culture of competence. Nowadays, technological advancement allows the researchers to create and combine different frameworks with the perspective of an even more tailored, and engaged education, some examples derived from the implementation of Virtual Reality (VR) and [Augmented Reality](https://www.sciencedirect.com/topics/social-sciences/augmented-reality" \o "Learn more about Augmented Reality from ScienceDirect's AI-generated Topic Pages) (AR), in the combination of [Gamification](https://www.sciencedirect.com/topics/social-sciences/gamification" \o "Learn more about Gamification from ScienceDirect's AI-generated Topic Pages) and AI, or the development of [Intelligent Tutoring Systems](https://www.sciencedirect.com/topics/psychology/intelligent-tutoring-system" \o "Learn more about Intelligent Tutoring Systems from ScienceDirect's AI-generated Topic Pages) (ITS) to foster and create an even more [personalized learning](https://www.sciencedirect.com/topics/social-sciences/personalized-learning" \o "Learn more about personalized learning from ScienceDirect's AI-generated Topic Pages) and teaching. Following these premises, in this paper, we want to point out new research reflections and perspectives that could help researchers, teachers, educators (and consequently students) to reflect on the introduction of new technologies (e.g., artificial intelligence, robot tutors) and on how these can affect on human behavioral development and on the acquisition of new skills and competences (Specifically: Creativity, Critical Thinking, Problem Solving, and Computational Thinking) for the educational context. The analysis carried on, suggests a perspective on how creativity, critical thinking, and problem-solving can be effective in promoting computational thinking, and how Artificial Intelligence (AI) could be an aid instrument to teachers in the fostering of creativity, critical thinking, and problem-solving in schools and educational contexts.

# **A machine learning framework for soft skills assessment: Leveraging serious games in higher education**

This study explores the use of serious games combined with machine learning techniques to evaluate student efficiency and determine appropriate degree programs. The main research question addressed is: How can predictive machine learning algorithms, applied to soft skills data collected through serious games, identify the most suitable study path for each student, thereby improving academic orientation and enhancing the likelihood of educational success? The research involved 211 university students from a single university in Italy, focusing on the application of predictive algorithms based on participants' soft skills and academic performance (GPA). The study employs logistic regression models to classify students into three degree programs: Economic Business Administration (EBA), Sports and Motor Activity Sciences (SMAS), and Modern Literature (ML). Subsequent analysis using ANOVA Kruskal-Wallis identified significant differences in predictive results across various demographic and behavioral subgroups.

As an additional experiment, Data Envelopment Analysis (DEA) was employed to further understand student efficiency. DEA used soft skills as inputs and GPA as the output to calculate efficiency scores, which were then analyzed for all groups. The results highlighted significant differences in efficiency scores among different courses, age groups, and genders, but not among different technology groups or daily screen time.

The findings demonstrate that serious games represent a breakthrough innovation in educational assessment, providing a highly effective platform for capturing soft skills through engaging behavioral scenarios that traditional methods cannot access. This game-based approach, when integrated with machine learning algorithms, successfully classifies students based on comprehensive competency profiles, offering a revolutionary advancement in personalized academic orientation. The serious games methodology proves superior to conventional assessment techniques by enabling real-time collection of rich behavioral data that reveals authentic student capabilities beyond academic performance metrics. Supplementary DEA analysis confirmed these findings. Despite limitations such as sample size and focus on specific devices, this study establishes serious games as a transformative educational technology that fundamentally enhances academic orientation strategies. Future research should explore larger and more diverse samples, integrate advanced technologies, and conduct longitudinal studies to further validate and enhance the serious games approach in educational contexts.

# **Uncurtaining windows of motivation, enjoyment, critical thinking, and autonomy in AI-integrated education: Duolingo Vs. ChatGPT**

Artificial intelligence (AI) has become increasingly integral to second language learning due to its outstanding advantages, such as [personalized learning](https://www.sciencedirect.com/topics/social-sciences/personalized-learning" \o "Learn more about personalized learning from ScienceDirect's AI-generated Topic Pages) experiences, real-time feedback, and increased engagement. Despite the growing popularity of AI-powered platforms like Duolingo and ChatGPT, there is limited empirical research comparing their effectiveness in fostering key educational outcomes. This study addressed this gap by investigating the impact of Duolingo and ChatGPT on the motivation, enjoyment, critical thinking (CT), and [autonomy](https://www.sciencedirect.com/topics/social-sciences/autonomy" \o "Learn more about autonomy from ScienceDirect's AI-generated Topic Pages) of English as a Foreign Language (EFL) learners in China. Employing a true-experimental design, the study involved three groups: two experimental groups (EGs) using Duolingo (n = 81) and ChatGPT (n = 81) and a control group (CG) (n = 82). The outcomes of a one-way [MANOVA](https://www.sciencedirect.com/topics/social-sciences/multivariate-analysis" \o "Learn more about MANOVA from ScienceDirect's AI-generated Topic Pages) indicated that both experimental groups significantly outperformed the control group in terms of motivation, enjoyment, CT, and autonomy. Furthermore, the results demonstrated no significant differences between the Duolingo and ChatGPT groups, suggesting both platforms are equally effective in the constructs under investigation in this study. These findings indicated the potential of AI-driven platforms to transform second language education by providing engaging, personalized, and cognitively enriching experiences.

# Emerging Technology-Based Motivational Strategies: A Systematic Review with Meta-Analysis

To contribute to the design of better teaching strategies mediated by emerging technologies, the aim of this systematic review and meta-analysis was to estimate the effect sizes of the attention, relevance, confidence, and satisfaction (ARCS) motivational model with technologies such as AI and XR regarding academic performance and student motivation. From a sample of 2656 studies obtained from WoS, Scopus, ERIC, and APAPsycNet, 32 primary studies with quasi-experimental designs were selected, where the ARCS model and some types of emerging technology were used. To estimate the possible risks of bias and overestimation, preliminary tests with funnel plots were used. The effect sizes were calculated with Cohen’s d using random-effects models. Moderations were also examined using fixed-effects models and heterogeneity tests. The results showed a moderate effect on academic performance (ES: 0.596, 95% CI: 0.443–0.748) and a strong effect on motivation (ES: 0.886, 95% CI: 0.640–1.133), both with low bias. According to the moderator analysis on academic performance, no significant differences were found between face-to-face and virtual teaching. Furthermore, the greatest effects on academic performance were observed when using AI and XR in subjects like the natural sciences and arts and when combining the motivational model with strategies such as gamification and project-based learning. Finally, gamification and game-based learning proved to be an effective strategy to increase motivation.

# **Game-based learning enhances business decision-making learning for on-the-job MBA students: A case study of dynamic systems-thinking course**

This study examines the impact of game-based learning on business decision-making skills among working MBA students, focusing on dynamic systems thinking application. Integrating flow theory, motivational perspectives, and [immersive experience](https://www.sciencedirect.com/topics/computer-science/immersive-experience" \o "Learn more about immersive experience from ScienceDirect's AI-generated Topic Pages) concepts, the research constructs an innovative theoretical framework to elucidate [learning processes](https://www.sciencedirect.com/topics/economics-econometrics-and-finance/learning-process" \o "Learn more about learning processes from ScienceDirect's AI-generated Topic Pages) in business simulation games. A cross-sectional survey of 245 working MBA students in Taiwan yielded 143 valid responses. Participants engaged in the People Express business simulation game and received systems thinking training. Data analysis using SmartPLS 4.0 tested a 17-hypothesis research model. Findings reveal that intrinsic motivation significantly influences both positive and [negative emotions](https://www.sciencedirect.com/topics/computer-science/negative-emotion" \o "Learn more about negative emotions from ScienceDirect's AI-generated Topic Pages), while extrinsic motivation primarily impacts [positive emotions](https://www.sciencedirect.com/topics/computer-science/positive-emotion" \o "Learn more about positive emotions from ScienceDirect's AI-generated Topic Pages). General abilities exert a stronger effect on emotions than specific abilities. Positive emotions and immersive experiences substantially enhance learning satisfaction and benefits, with immersive experiences playing a crucial mediating role. The study's limitations include its cross-sectional design and geographic scope. Practical implications offer insights for designing business simulation games, emphasizing intrinsic motivation, systems thinking, positive emotions, and immersive experiences. This research contributes an innovative framework for understanding learning mechanisms in business simulation games, deepening the understanding of motivation, emotion, and immersive experience interactions during simulation learning processes, thus providing a theoretical foundation to enhance business decision-making education.

# **Unveiling personalized and gamification-based cybersecurity risks within financial institutions**

Gamification has emerged as a transformative e-business strategy, introducing innovative methods to engage customers and drive sales. This article explores the integration of game design principles into business contexts, termed “gamification,” a subject of increasing interest among both scholars and industry professionals. The discussion systematically addresses key themes, like the role of gamification in marketing strategies, enhancing website functionality, and its application within the financial sector, including e-banking, drawing insights from academic and industry perspectives. By conducting a systematic literature review of 48 academic articles published between 2015 and 2024, this study examines the use of personalized, gamification-based strategies to mitigate cyber threats in the financial domain. The review highlights the growing digitization of financial services and the corresponding rise in sophisticated cyber threats, including traditional attacks and advanced persistent threats (APTs). This article critically assesses the evolving landscape of cyber threats specific to the financial industry, identifying trends, challenges, and innovative solutions to strengthen cybersecurity practices. Of particular interest is the application of AI-enhanced gamification strategies to reinforce cybersecurity protocols, particularly in the face of novel threats in gaming platforms. Furthermore, the review evaluates techniques grounded in user behavior, motivation, and readiness to enhance cybersecurity. The article also offers a comprehensive taxonomy of financial services, categorizing cyber threats into game-based (*e.g*., phishing, malware, APTs) and non-game-based (*e.g*., social engineering, compliance issues) threats. AI-driven measures for prevention and detection emphasize regular security assessments, user training, and system monitoring with incident response plans. This research provides valuable insights into the intersection of gamification and cybersecurity, offering a forward-looking perspective for both academic researchers and industry professionals.

**Optimizing gamification adoption in higher education: An in-depth qualitative case study applying the UTAUT framework**

This qualitative case study aims to enhance the acceptance and adoption of gamification in higher education, focusing on the American University of Bahrain (AUBH) as a unique context. Grounded in the Unified Theory of Acceptance and Use of Technology (UTAUT), this research investigates the integration of gamification in AUBH and its influencing factors. The study employs a purposeful sample of twelve top management and influential faculty members as participants, and utilizes semi-structured interviews to collect data. Thematic analysis of the interview data is conducted, focusing on UTAUT constructs. The findings of this study are expected to contribute to a deeper understanding of gamification adoption in Bahrain's higher education, shedding light on performance expectancy, effort expectancy, social influence, and facilitating conditions. Ultimately, this research intends to inform educational policymakers and practitioners, enriching the literature on educational innovation and technology acceptance within similar contexts.

# 70 Implementation of Game-Based Learning in Educational Contexts: Challenges and Intervention Strategies

In addition to being a fundamental part of human culture, games are also important for social interaction, personal growth, and development. These premises have led to a growing body of research on game-based learning (GBL) as a pedagogical advance in both formal and informal education. Even though GBL has many potential benefits, some challenges need to be taken into account while developing and implementing GBL. In this context, the goal of this study is to accomplish two goals: (a) map the primary barriers encountered when applying GBL approaches in educational settings; and (b) provide an intervention diagram that links each kind of barrier with potential strategies to overcome it. To achieve these aims, a Systematic Literature Review (SLR) was carried out using the PRISMA criteria and methodology. This includes procedures for eligibility and screening that were based on inclusion criteria that were established with the goals of the research. The analysis of the articles obtained for the systematic review reveals four different types of barriers to more regular GBL implementations. These barriers include (1) behavioural and attitudinal barriers; (2) school policy barriers; (3) material and technology barriers; and (4) barriers related to game literacy. Based on these barriers, we propose certain methodological strategies that might help practitioners get beyond the identified barriers. The strategies include: (a) adopting a participatory-driven and co-creation approach; (b) carefully considering whether to use digital, analogue, or hybrid games; (c) using a range of educational actors in the process; and (d) pushing for GBL training in projects. It is possible to argue that attitudinal barriers are related to the other barriers that have been discussed. For example, material barriers affect teachers’ belief that there are currently not enough suitable educational games. Although policy makers’ attitudes can be examined as a part of the macro-level attitudinal barriers, the effectiveness of their measures in the daily educational context is influenced by a separate set of barriers, which will now be investigated. Assessment literacy in GBL refers to teachers’ beliefs about adopting games and how these affect students’ motivation and cognitive development and is similar to an attitudinal aspect. In line with this result, it can be stated the potential strategies are also interrelated. Co-creative processes can be enhanced by integrating a multi-stakeholder approach to GBL, where finalized entertainment works successfully reflect the experiences of all participants. This article corroborates, evaluates, and groups the intervention streams as the basis of a comprehensive program of intervention where existing scientific literature on studies of GBL interventions naturally suggests the solutions.

# A systematic literature review of project-based learning in secondary school physics: theoretical foundations, design principles, and implementation strategies

Project-Based Learning (PjBL) is a widely recognized pedagogical approach that has gained popularity for its capacity to enhance students’ critical thinking, creativity, collaboration, and communication skills. PjBL is characterized by its incorporation of key elements and teaching practices that support and facilitate these outcomes. Despite its increasing use, there remains a limited comprehensive understanding of PjBL’s theoretical foundations, design principles, and implementation in secondary school physics education. This study employed a systematic literature review (SLR) to investigate these aspects within this educational setting. Following the PRISMA 2020 checklist, the review analyzed papers sourced from Scopus and Web of Science. The examination of 27 SLR records indicated that 85% of the studies (23) did not address the theoretical foundations of PjBL. Approximately 48% of the studies (13) incorporated all seven core elements of PjBL. Critique and revision were present in 55.6% of the studies (15), while 29.6% (8) did not include student voice and choice. Additionally, 37% of the studies (10) applied all recommended PjBL teaching practices, with consistent implementation observed in designing and planning, managing activities, and scaffolding student learning. About 96% of the studies (26) utilized various assessment tools throughout the PjBL process, but only 37% (10) included the development of a supportive culture as part of the PjBL strategy. Moreover, 74% of the studies (20) were conducted in face-to-face settings. The implications of this study highlight the potential of PjBL to improve student engagement, curiosity, creativity, critical thinking, and scientific skills in secondary school physics. By developing effective PjBL frameworks and integrating advanced technologies, educators can enhance learning outcomes and conceptual understanding. In light of the global shift towards blended learning due to the COVID-19 pandemic, the review suggests that future applications of PjBL should incorporate blended learning strategies to improve effectiveness.

# Contribution of Microlearning in Basic Education: A Systematic Review

This systematic review analyzed the role of microlearning in basic education, identifying the most widely used Digital Information and Communication Technologies, relevant learning theories, and the role of social technologies from a Science, Technology, Society, and Environment (STSE) perspective. Following PRISMA 2020, searches were conducted in Web of Science, Scopus, ERIC, and IEEE Xplore databases. Studies on microlearning were selected based on previously defined eligibility criteria. The review process in Rayyan involved deduplication, screening, and full-text analysis. Data were qualitatively analyzed using content analysis, and methodological quality was assessed with CASP and the Downs and Black. The findings highlight that microlearning, integrated with digital tools such as online platforms, mobile apps, and short videos, significantly enhances student motivation, performance, and interaction; content in short modules facilitates knowledge retention and connects concepts to real-life situations. Promising trends include mobile technologies and gamification, which foster active, meaningful learning. Grounded in theories like Self-Determination, Constructionism, and Constructivism, microlearning personalizes teaching and promotes engagement, critical thinking, and accessibility, contributing to inclusive and sustainable education. From a STSE perspective, social technologies enhance autonomy, social interaction, and ethical–environmental awareness. In Brazil, further research on digital platforms and gamified strategies is needed to drive innovative educational practices.

# Leveling up Learning: Enhancing Self-Directed Learning in Computer Applications Technology with Classcraft

This study explores how gamification can be incorporated when facilitating theoretical content in Computer Applications Technology (CAT) to promote self-directed learning of Generation Z learners. The CAT curriculum consists of practical and theoretical content, and Generation Z learners tend to perceive theoretical content as less engaging and less stimulating. The dynamic nature of CAT, however, requires CAT learners to be self-directed learners who take ownership of their learning and are motivated and engaged in learning both the practical and theoretical components. A basic interpretive study, within an interpretivist paradigm, was applied as the research design. Purposive sampling was utilized, and 106 CAT learners at a South African high school participated in the research. A traditional teacher-centered approach was first followed to facilitate theoretical content. Thereafter, gamification with Classcraft was applied as an intervention. Data collection was performed by implementing post-open-ended questionnaires and focus group interviews. Results indicate that Generation Z learners crave instant gratification and lack skills such as self-motivation and critical thinking. A teacher-centered approach was found unsuitable for facilitating theoretical content to Generation Z learners. Gamification has the potential to entice Generation Z learners from different socioeconomical and cultural backgrounds to experience theoretical content in a more engaging and enjoyable manner and foster self-directed learning.

# **Gamification in mobile applications: techniques, benefits and challenges**

Gamification, the integration of game-design elements into non-game contexts, has gained significant traction in the development of mobile applications across various sectors, including health, education, commerce, and environmental sustainability. This article explores the effectiveness, benefits, challenges, and future directions of Gamification in mobile apps. By enhancing user engagement, motivation, and loyalty, Gamification has demonstrated substantial benefits, as evidenced by successful applications like Duolingo, Nike+ Run Club, and mHealth solutions. However, the approach is not without its challenges, including ethical concerns, privacy issues, and the potential for negative outcomes like excessive competition and stress. The article highlights the need for continuous innovation and thoughtful design to address these challenges and maximize the potential of Gamification. Future research should focus on incorporating advanced technologies, personalized elements, and data-driven strategies to ensure that Gamification continues to provide meaningful value in mobile app development. The findings suggest that, with careful implementation, Gamification can be a powerful tool for transforming user experiences and achieving positive outcomes in a variety of contexts.

# **Human–computer interaction tools with gameful design for critical thinking the media ecosystem: a classification framework**

In response to the ever-increasing spread of online disinformation and misinformation, several human–computer interaction tools to enhance data literacy have been developed. Among them, many employ elements of gamification to increase user engagement and reach out to a broader audience. However, there are no systematic criteria to analyze their relevance and impact for building fake news resilience, partly due to the lack of a common understanding of data literacy. In this paper we put forward an operationalizable definition of data literacy as a form of multidimensional critical thinking. We then survey 22 existing tools and classify them according to a framework of 10 criteria pointing to their gameful design and educational features. Through a comparative/contrastive analysis informed by a focus group, we provide a principled set of guidelines to develop more efficient human–computer interaction tools to teach how to critically think in the current media ecosystem.

# Improving the Cybersecurity Awareness of Young Adults through a Game-Based Informal Learning Strategy

Knowing about a danger is not enough to avoid it. Our daily lives offer countless examples of occasions in which we act imprudently for various reasons, even though we know we are taking risks. Nevertheless, circumstances in which we lack the necessary knowledge can lead us to run into unpleasant or harmful situations without being aware of it. In cybersecurity, knowledge of the dangers (as well as the mechanics of a possible attack) makes a huge difference. This is why specific training is provided in organizations, along with awareness campaigns. However, security training is often generic, boring, and a mere fulfillment of obligations rather than a tool for behavioral change. Today, we can deliver content through various devices and platforms that people access for both work and leisure, so that learning can happen incidentally and with almost no effort. Distributing knowledge in small, dedicated units creates the conditions for lasting, effective learning and is more effective than teaching through traditional courses (whether delivered in-person or online). In this article, we present an ongoing project on cybersecurity informal learning, including the design of a small video game. The intervention is aimed at helping young adults (18–25 years) to understand the mechanics of cookies and their role in the dynamics of cyberattacks. Consistent with the idea that a comprehensive course may be unsuitable for delivering cybersecurity training, the game covers and deliberately limits itself to that topic only. We also provide detailed considerations related to the evaluation of its effectiveness, although this is outside the scope of the present paper.

# **Metaverse Applications: Challenges, Limitations and Opportunities - A Systematic Literature Review**

### **Context:**

The [metaverse](https://www.sciencedirect.com/topics/social-sciences/metaverse), an emerging concept at the intersection of digital technology and society, is gaining relevance in multiple domains, including education, entertainment and healthcare. Shared [virtual spaces](https://www.sciencedirect.com/topics/computer-science/virtual-spaces) allow users to interact in innovative ways, but the design and development of these environments pose significant challenges for [software engineering teams](https://www.sciencedirect.com/topics/computer-science/software-engineering-team) as well as users.

### **Objective:**

The objective of this study is to provide a comprehensive [systematic literature review](https://www.sciencedirect.com/topics/social-sciences/systematic-review) of metaverse applications over the past decade. The review aims to identify key areas of application, technologies employed, virtualized elements, and economic aspects, as well as to explore the objectives, motivations, scope, challenges, and limitations faced in [Software Engineering](https://www.sciencedirect.com/topics/computer-science/software-engineering) when conceptualizing metaverse environments. Additionally, the study examines the nature, knowledge area, type, and validation of the studies included in the review.

### **Methods:**

This study was conducted using the Kitchenham methodology for systematic literature reviews (SLR). A total of 35 primary studies were selected from major scientific databases, including IEEE, ACM Digital Library, PubMed, ScienceDirect, and Scopus. These studies were evaluated to extract relevant data.

### **Results:**

We have identified [application areas](https://www.sciencedirect.com/topics/computer-science/application-area), technologies used, virtualized elements and economic aspects used, as well as the objectives, motivations, scope, challenges and limitations in Software Engineering related to the conceptualization of environments and non-functional characteristics of the metaverse. The nature, area of knowledge, type and validation of the studies chosen in this review are also analyzed.

### **Conclusion:**

The study concludes that while the metaverse presents huge opportunities across multiple domains, its development faces significant challenges, particularly in software engineering related to the non-functional aspects of these environments. To address these challenges, future research should focus on the application of the [Model Driven Engineering](https://www.sciencedirect.com/topics/computer-science/model-driven-engineering) (MDE) paradigm, which could optimize [development processes](https://www.sciencedirect.com/topics/computer-science/development-process) and better manage the complexities of the metaverse.

# Identifying factors influencing study skills engagement and participation for online learners in higher education during COVID-19

The COVID-19 pandemic disrupted education across the world as campuses closed to restrict the spread of the virus. UK universities swiftly migrated to online delivery. The experiences of students and staff during this transition can inform our return to campus and our ability to deal with future disruption. This study draws on Moore's theory of transactional distance to understand factors influencing student study skills engagement and participation in online learning during this period. We surveyed students (*n* = 178) in a computing school at a UK university. A partial least squares (PLS) analysis was used to explore the influence of transactional distance (between students/teachers and between students/students), access to e-learning capital, and perceived usefulness on two measures: study skills engagement and participation in online collaborative activity. Results show that transactional distance influences participation, and e-learning capital influences study skills engagement. Our findings suggest that if universities continue with aspects of online learning for previously on-campus students they should provide access to infrastructure and training on utilising the online ecosystem to avoid disadvantaging students. Further investment in students' e-learning capital, such as signposting and adapting existing resources, is also necessary to support this key influence in study skills engagement.

### **Gamification Effect of Team Games Tournament in Game-Based Learning on Student Motivation**

This study examines the impact of gamification elements, specifically the duration of use and level of collaboration, on student motivation in online learning environments. Using the Team Games Tournament model, which combines elements of both competition and collaboration, a web-based Game-Based Learning application was developed to enhance student motivation. The study employed a motivation survey based on the model Attention, Relevance, Confidence, Satisfaction, which was administered to participants before and after using the application. In addition to the survey, interaction data, such as the duration of application use, frequency of participation, points earned, and the level of collaboration, were collected to assess the relationship between these factors and student motivation. The study involved 20 fifth-semester students (12 male, 8 female) enrolled in a digital games course, many of whom had prior gaming experience, which could influence their response to the gamified learning experience. The data collected was analyzed using Decision Tree algorithms, Pearson correlation, and simple linear regression to understand the impact of various gamification elements on motivation. The results showed that both the duration of application use and the level of collaboration were significant factors in increasing student motivation. Specifically, motivation increased by an average of 0.72 points for every 10 minutes of application use, as measured by the difference between pre-test and post-test survey scores. These findings underscore the importance of balancing competitive and collaborative elements within game-based learning environments. By incorporating features that promote collaboration and encouraging sustained application use, educators can significantly enhance student engagement and motivation. The study provides valuable insights for the development of future game-based learning applications, highlighting the need for optimal design in terms of collaboration and duration to create an effective and engaging digital learning experience.

# A Gamified Method for Teaching Version Control Concepts in Programming Courses Using the Git Education Game

Using version control tools is an indispensable skill for engineers in the software industry. This study introduces a gamification approach together with a serious game called the Git Education Game (GEG) to teach Git concepts and usage, intending to improve students’ motivation and learning performance compared to traditional lectures. An experiment was designed with two classes of the same course to compare the effect of GEG. A post-test was designed to verify whether the game could help students achieve better learning outcomes and higher motivation. The results show that our approach had a positive effect on students’ motivation, so the experimental group had a higher pass rate than the control group for most items in the post-test. Based on this study’s results, we emphasize the impact of interactive learning environments in software engineering education.

# Enhancing Student Active Engagement in Class through Game-Based Learning: A Case of Civil Engineering Education

Students are rapidly losing interest in STEM education due to the minimal incorporation of media into learning and the complexity of teaching methods, which ultimately results in a lack of motivation. However, despite these challenges, incorporating active learning methods in STEM can ultimately reignite students’ interest in STEM education. This paper reports a case study presenting the effects of simulation games on enhancing the learning experiences of civil engineering students through an intervention method. It develops a framework for enhancing learning through game-based learning. Intervention included the following two groups: a control group exposed to conventional teaching methods and an experimental group introduced to the simulation game. Following the learning sessions, a survey was conducted to gauge students’ perceptions about the proposed framework. Results indicated a strong positive response from students toward the game-based learning approach. They expressed satisfaction with its effectiveness in improving their understanding. Independent *t*-tests found that the mean score (4.13) for entertainment via the game exceeded that of traditional teaching methods (3.72). Furthermore, 85% of students acknowledged the game’s utility in reinforcing civil engineering concepts, compared to 67% for traditional methods. Many students suggested expanding the game to cover a wider range of topics in future versions to enable a more comprehensive learning experience.

# **Optipharm: Enhancing pharmacological management skills in healthcare students for geriatric care through gamified e-learning**

### **Background**

Complexities in older patient care and frequent [polypharmacy](https://www.sciencedirect.com/topics/medicine-and-dentistry/polypharmacy) requires tailored tools, specific skills and interdisciplinary collaborations. Traditional disease-centered education often overlooks these issues. Despite digital gamification’s relevance in health education, limited exploration exists for gamified platforms addressing [polypharmacy](https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/polypharmacy), especially within comprehensive geriatric assessment (CGA).

### **Objective**

This study outlines Optipharm’s design, a gamified e-learning tool designed to enhance health students’ education in managing polypharmacy among older adults. It also assesses its usability using a validated scale.

### **Methods**

Optipharm development utilized gamification techniques guided by pedagogical principles. Learning objectives addressed clinical and educational gaps in older adult care. Hosted on a Moodle system, the platform housed a structured clinical case as a SCORM file, a usability scale, a certificate of achievement, and a literature library. Optipharm was assessed by 304 medical students from the University of Navarre, Spain, using the SUS-G-Sp scale.

### **Results**

An immersive gamified e-learning tool simulating clinical practice settings was developed, requiring users to assume the role of healthcare professionals in multidisciplinary outpatient consultations. The interface, with a 2D cartoon-style aesthetic, aligns with learning objectives, integrating engaging storytelling and clear instructions for CGA in Phase 1 and pharmacological optimization in Phase 2. The evaluation of Optipharm’s usability revealed very positive perceptions among users, with high agreement rates on usability items.

### **Conclusion**

Optipharm represents a pioneering gamified tool designed to simulate clinical scenarios, allowing users to engage as healthcare professionals within multidisciplinary teams and address medication-related challenges in older patients with polypharmacy. It provides a secure, interactive learning environment with clear educational objectives and seamless integration of gamification elements, enhancing users’ knowledge and skills in managing complex medication regimens. As a platform for experiential learning and knowledge exchange, Optipharm contributes to shaping the future of health education and fostering a culture of patient-centred care among future healthcare professionals.

# **Integrating technology in physical classrooms: The impact of game-based response systems on student learning experience**

This study examines the impact of game-based student response systems (GSRSs) on students’ [learning experiences](https://www.sciencedirect.com/topics/computer-science/learning-experiences) in face-to-face education. Building on technology-mediated learning and active learning, we demonstrate the positive impact of GSRS use on learning outcomes and learning processes (student motivation, concentration, and enjoyment) in a field experiment in a Dutch [secondary school](https://www.sciencedirect.com/topics/computer-science/secondary-school). Our study expands [information systems](https://www.sciencedirect.com/topics/computer-science/information-system) research by showing the educational and social impact of technology integration in physical classrooms and its equalizing role in bridging the performance disparity between underperforming and overperforming students while promoting an inclusive learning environment for all students.

# Transforming Science Education in Elementary Schools: The Power of PhET Simulations in Enhancing Student Learning

In recent years, the integration of technology into education has significantly transformed teaching methods, especially in science education. Tools like PhET simulations have proven highly effective in enhancing student engagement and comprehension. Research has highlighted the value of simulation-based learning in fostering critical thinking and problem-solving skills. This study aimed to explore the impact of simulations, with a focus on PhET, on improving elementary students’ learning outcomes, an area that remains under-researched. The study compared the performance of two groups of third-grade students: one group learned about solubility using PhET simulations, while the other relied on traditional textbook instruction. Each group comprised fifty students. The study lasted for a two-month period. The instructional approach was investigative learning. Data were gathered through student responses to materials science questions aligned with Bloom’s Taxonomy, allowing for a detailed evaluation of their understanding and application of scientific concepts. Responses were assessed for accuracy and scored accordingly. We ran an independent-sample *t*-test to decide whether the difference in the mean score in science achievement between the two research groups was significant. The results showed that students using PhET simulations not only achieved significantly higher scores but also demonstrated their ability to explain their reasoning during problem-solving tasks. These findings emphasize the substantial advantages of incorporating digital tools like PhET simulations into elementary science education, as they enhance conceptual understanding and better equip students to tackle future scientific challenges. The present research results complement the previous research on using technology in the chemistry elementary classroom and add the issue of simulations to this research. The results of this study are centered on the topic of solubility. To broaden the generalizability of these findings, future research should examine the effects of simulations on student achievement in a wider range of elementary science topics.

# **Optimizing experiential learning in science education: The role of two-tier testing in digital game-based learning**

Science education aims to cultivate students’ scientific literacy, problem-solving abilities, and critical thinking skills through engaging and effective instructional approaches. However, traditional teaching methods often struggle to foster deep conceptual understanding and sustained interest in scientific learning. To address these challenges, digital game-based learning (DGBL) has emerged as a promising approach, providing an enjoyable, interactive, and immersive environment that enables students to experience and apply scientific knowledge in authentic contexts. Building upon this foundation, this study explores the effectiveness of two-tier test-based digital game-based learning (TT-DGBL), which integrates diagnostic assessments within a game environment to identify and correct students’ misconceptions through adaptive feedback. A quasi-experimental design was employed to compare the impact of TT-DGBL and conventional DGBL on academic performance and flow experience among sixth-grade students. Additionally, lag sequential analysis was conducted to examine students’ behavioral patterns in the game-based learning process. The findings indicate that TT-DGBL significantly enhances students’ academic performance and flow experience, while also promoting positive and sustained learning behaviors more effectively than conventional DGBL. These results suggest that incorporating two-tier testing into DGBL can serve as an effective strategy for fostering deeper engagement and conceptual understanding in science education.

# **Design Sprint: Enhancing STEAM and engineering education through agile prototyping and testing ideas**

Creating project-based learning experiences in the classroom where students learn in a team to solve complex problems and to develop creative and critical thinking is a challenge. Design Sprint (DS) is an agile methodology (implemented in 5 days) with the goal of creating innovative design based on user needs (User Experience). The objective of this work was to develop an Engineering Drawing classroom experience linked to the context of the current COVID-19 pandemic with the Design Sprint methodology. The experience had to involve the integration of theory and practice, the application of knowledge, the development of both hard and soft skills, and the empowerment of students to conduct research. 56 first-year students following three STEAM degrees at the University of A Coruña participated in this experience. The activities were designed for both face-to-face and remote learning. Microsoft Teams and Moodle were used for tutoring and for monitoring student progress. The Moodle Workshop tool was used for the evaluation of the prototypes that were developed and the projects were evaluated by video. The students defended their projects through a presentation in lightning talk format (Ignite). Evaluation rubrics were used following a triple approach: co-evaluation, hetero-evaluation and self-evaluation. The 3D design of the projects was developed with Autodesk software. A total of 18 projects were developed. Once the projects were completed, a survey was administered to evaluate the levels of student satisfaction. The survey results were very positive. The Design Sprint projects also showed positive effects on grades. The Design Sprint method has promoted an interactive learning environment. In addition to its simplicity, a further advantage of DS method is that all student dedication is planned. Students were therefore less likely to feel overloaded, all of which helps with better time management. The DS methodology is multipurpose, so it can be applied to various fields and subjects.

# Enhancing Early Childhood Cognitive Development via Mobile Game-Based Learning Applications: Insights and Practical Experiences

Early childhood cognitive development is foundational for future academic and personal success. While traditional teaching approaches often overlook technology’s potential, gamebased learning applications offer an innovative solution to enhance cognitive abilities in young children. This study evaluates the feasibility and effectiveness of a game-based learning (GBL) application for enhancing early childhood cognitive abilities. Using Research and Development (R&D) methodology, 40 children aged 5–6 were randomly assigned to experimental and control groups for an eight-week intervention. The application was developed through systematic needs analysis, design, development, implementation, and evaluation. ANCOVA analysis of pre- and post-test assessments demonstrated highly significant effects (F = 2154.89, p < 0.001, partial η2 = 0.966), explaining 96.6% of score variations. Expert validation scores exceeded 4.6 out of 5.0, confirming the application’s quality. Qualitative feedback from teachers and parents noted substantial improvements in children’s problem-solving skills, memory retention, and critical thinking. These findings suggest that integrating GBL applications could enhance educational equity and improve cognitive development outcomes across diverse educational settings.

# **Systematic mapping of computational thinking in preschool children**

This study characterizes the literature on teaching computational thinking (CT) to preschoolers aged 4 to 5 years. Previous research and published systematic studies have provided important contributions about CT teaching to elementary and high school children. However, to date, there is no [systematic overview](https://www.sciencedirect.com/topics/computer-science/systematic-overview) of CT education for preschoolers. For this reason, this [systematic mapping](https://www.sciencedirect.com/topics/computer-science/systematic-mapping) synthesizes 82 studies on CT teaching, through the implementation and evaluation of tools and activities to teach, improve or measure the CT knowledge acquired by children. Furthermore, studies on courses or training offered to preschool teachers related to the teaching of CT were also considered. From the selected studies, the following information was collected: year of publication; recovery sources and databases; vehicles and places of publication; temporal [delimitation](https://www.sciencedirect.com/topics/social-sciences/delimitation) of research, research approach, nature and research method; CT teaching approaches; tools used to teach CT and how they are classified according to their physical characteristics and, finally, participants and individuals responsible for the research. The results suggest an increase in the number of publications in recent years, revealing the interest of researchers in the topic. Furthermore, we observed a trend towards the use of physical artifacts and the use of the disconnected computing approach to teaching CT skills to [preschool children](https://www.sciencedirect.com/topics/psychology/preschooler). The results also exposed that preschool teachers have little [autonomy](https://www.sciencedirect.com/topics/social-sciences/autonomy) in implementing CT teaching activities because those are mostly implemented by computer professionals (researchers, teachers, etc.). This is because preschool teachers are still discouraged from teaching computer and technology-related content to children, considering them complex and disconnected from basic curricula. However, when teachers are trained to teach CT, they become interested in the content and become more active during the teaching process. We argue for integrating CT-related content into education curricula and supporting preschool teachers to implement it autonomously in their classrooms.

# **Improved socio-emotional skills in students with autism spectrum disorder (ASD) following an intervention supported by an augmented gamified environment**

This study examines the impact of an intervention using an Augmented Gamified Environment (AGE) to stimulate socio-emotional skills in a sample of 54 subjects with [Autism Spectrum Disorder](https://www.sciencedirect.com/topics/psychology/autism-spectrum-disorder) (ASD) aged between 3 and 17 years old. The study used a quantitative, exploratory, analytical methodology. Socio-emotional skills were evaluated before and after intervention (pre-posttest) using the DiagnosticApp instrument, supported by a fun app. The study specifically analyzed their ability to identify primary and secondary emotions and emotional states, as well as the cause-effect relationship linked to a context. The results show that socio-emotional skills improved after the intervention, regardless of gender, age, degree of ASD, comorbidity, or type of language. Overall, the greatest improvement was in identifying both primary and secondary emotions through recognizing facial expressions. Additionally, as expected, older students, and those with less severe ASD and more functional language exhibited higher scores in their socio-emotional skills. In conclusion, the extrinsic motivation associated with the mix of game mechanics, dynamics, and aesthetics, along with the [augmented reality](https://www.sciencedirect.com/topics/social-sciences/augmented-reality) resources making up the AGE, are key contributing elements in improving these students’ socio-emotional skills.

# **Narrative alchemy: Co-creating a game-based extensive reading framework for adult language learners**

Contextual analysis is an important skill for language acquisition. It involves deciphering complex linguistic relationships and patterns. This way, unknown vocabulary can be learned if presented within understandable contexts. Extensive reading is a common method for developing this skill but requires learner participation. This paper presents a game-based extensive reading framework designed to encourage participation through a co-created visual novel. The project’s key features are its feasibility and role as a language course supplement. The short-term goal is to increase participation, with the long-term aim of promoting habitual reading and fostering language curiosity. The study was conducted in two parts: first, educational experts (n = 5) tested the framework for acceptance and feasibility; second, it was implemented at a language school (n = 13). Results indicate high acceptance from educators and enjoyment from learners. Although there was no significant increase in test scores, students’ willingness to participate in homework activities improved significantly.

# **Taboo Talks: Enhancing ESL Speaking Skills through Language Model Integration in Interactive Games**

Achieving fluency in a foreign language is challenging, often because of limited opportunities for speaking practice. Speaking in a different language can be difficult and sometimes embarrassing. This study introduces a tool designed to prioritize language-speaking practice by integrating the ”Taboo” game with speech recognition technology and a large language model (LLM). This game involves players conveying a target word to an AI-based agent without using specific ”Taboo” words. Our contribution focuses on proposing a meticulously designed taboo game for speaking practice that incorporates engaging interactions with the LLM. This methodology offers a novel and beneficial alternative for English as a Second Language (ESL) learners. Initial experimental trials were conducted, and user feedback highlighted a positive experience with reduced anxiety compared to conventional, human-based speaking practice. However, challenges have emerged, particularly in terms of pronunciation and the expression of certain words. In response to this valuable feedback, we presented a design proposal aimed at addressing these challenges to improve the overall learning experience and ensure effective language practice.

# The Design and Implementation of an Innovative Course on the Creation of Cultural Landscape Images: A Case Study of Dalin Township in Taiwan

Innovative design-based education is a student-centered approach that aims to nurture students’ proactivity, creativity, and interdisciplinary integrated skills. The curriculum planning of a course in this study incorporated design-based learning with the 4D design process. Three units were planned: field exploration and concept development, 3D wearable creations, and cultural landscape shaping. Each unit was co-taught by an interdisciplinary teacher. By means of teamwork, the students explored agricultural spaces and cultural stories, then used paper materials and mixed media to create wearable creations. Afterward, they visually recorded their unique views of traditional spaces and created cultural landscape images. To elucidate their learning outcomes and creative expression, this study adopted a mixed-methods approach. The results are as follows: (1) The students experienced positive growth in their five core competencies. Their “field-based knowledge” and “skills and technological value” were significantly improved. (2) The five major perspectives of the students pointed out that creativity stems from multicultural symbols, the learning outside-the-classroom approach reinvigorated motivation, more confidence is gained through learning by doing, teamwork can create more possibilities, and discovering one’s other interests is possible through diverse exploratory approaches. (3) The teacher summarized the feasibility of designing and implementing innovative courses under three themes: conversing with methods, conversing with cultures, and conversing with teams.

# Discussing the Protagonist Role of Students in Game-Based Learning

In the ongoing process of the digital transformation of society, corresponding competencies are required from children more than ever. The concept of computational empowerment (CE) promotes confident and reflective engagement with digital technology, which often falls short in formal education. This work outlines how both entertainment and serious games can be used to support the cause of CE and what opportunities they offer for more empowering learning in school settings. The use of digital games appears to be a promising way to connect with the lifeworld of young people and thus offering a low-threshold and differentiated starting point. In this context, the focus should be placed on a stronger establishment of the protagonist role to empower students to engage with digital technologies in depth.

In the *Serious Game Changers* project, students created their own educational modules on specific Sustainable Development Goals (SDGs) using digital games and creating new artifacts as learning objects through remixing game elements. In this project, students should be empowered to become active participants by designing with the help of commercial and serious games. Thus giving them their own voice in future (formal) educational settings and promoting future skills in order to make them self-confident 'protagonists' of their surroundings.

# **Gamification in technology and design areas: A teaching innovation project in a fully online environment**

Gallifantes and motivation’ is a teaching innovation project intended to foster students to participate in the university online campus of UNIR, a fully online university. Although students at UNIR are used to studying in an online independent way, it is well known that having a learning community and a confident-based relationship with mates enhance learning results. Intended to promote a lively interaction between students, both in the forums and in synchronous lessons, this teaching innovation project proposes gallifantes-rewarded actions during the semester in a competitive run. The 4 students with the highest numbers of gallifantes obtain 0.25, 0.5, 0.75 and 1 additional points in the final grade. In this paper, we present the different approaches followed in 3 subjects in the areas of technology and design, having a total number of 114 active students and 1164 gallifantes rewarded. The students answered a survey at the end of the process. As a conclusion, most of them supports the initiative, obtaining good results in satisfaction, motivation and engagement, while also suggesting improvement opportunities.

# **Exploring student engagement in technology-based education in relation to gamification, online/distance learning, and other factors: A systematic literature review**

Engaging students in learning activities is the primary duty of the teacher. It is also important to see the methods of engagement in teaching and learning for both students and teachers. Students at all age levels, from elementary schools to graduate students, must have specific engagement methods in a virtual learning environment. In addition, learners encounter differences when engaging in lessons that might be more severe in a virtual environment than in a conventional classroom. The purpose of this study is to identify how students engage with different [educational technologies](https://www.sciencedirect.com/topics/social-sciences/educational-technology). To achieve this purpose, a [systematic literature review](https://www.sciencedirect.com/topics/social-sciences/systematic-review) was conducted using articles published in Scopus and PubMed databases during the 2018–2022 period. A research question developed using the PICO framework and the [PRISMA](https://www.sciencedirect.com/topics/psychology/systematic-review) framework was used for article selection, and 33 articles were used for the analyses. Analysis of the literature is divided into three sections: [gamification](https://www.sciencedirect.com/topics/social-sciences/gamification) and student engagement, online/distance learning and student engagement, and technology and student engagement. The keyword co-occurrence network visualisation map indicates the gap between the conducted studies during this period. The study provided insightful guidance on advancing learning outcomes and student engagement in the digital age. Additionally, future research areas are highlighted at the end.

# Impact of Serious Games on Teacher Training: An Analysis of Competence, Immersion, and Positive Emotions

In recent times, the use of serious games has significantly advanced in science education, with notable contributions in the design and implementation of game mechanics in immersive environments. This research aims to assess the usability and experience of the serious game ABCCI, identifying both the positive and negative effects generated by its interaction from the perspective of pre-service teachers, considering levels of competence, immersion, tension, flow, and challenge. To evaluate usability, the System Usability Scale (SUS) was adapted, and the Game Experience Questionnaire (GEQ) was used to assess the overall experience. The results indicate a moderate positive correlation between the experience and usability of the serious game. Most pre-service teachers expressed positive views about the frequent use of the ABCCI serious game in science education, which successfully created an engaging and positive experience characterized by a sense of competence, immersion, and positive emotions, with an appropriate level of challenge and low levels of negative affect. Further studies are needed to develop a framework for designing games in science education. ABCCI proves to be a promising tool for managing learning.

# **Deep learning inspired game-based cognitive assessment for early dementia detection**

This paper introduces a gaming approach inspired by [deep learning](https://www.sciencedirect.com/topics/computer-science/deep-learning) for the early detection of dementia. This research employs a convolutional [neural network](https://www.sciencedirect.com/topics/computer-science/neural-network) (CNN) model to analyze health metrics and [facial images](https://www.sciencedirect.com/topics/computer-science/facial-image) via a cognitive assessment gaming application. We have collected 1000 samples of health metric data from Apollo Diagnostic Center and hospitals, labeled “demented” or “nondemented,” to train a modified 1-dimensional [convolutional neural network](https://www.sciencedirect.com/topics/engineering/convolutional-neural-network) (MOD-1D-CNN) for game level 1. Additionally, a dataset of 1800 facial images, also labeled “demented” or “non-demented,” is collected in our work to train a modified 2-dimensional [convolutional neural network](https://www.sciencedirect.com/topics/computer-science/convolutional-neural-network) (MOD-2D-CNN) for game level 2. The MOD-1D-CNN has achieved a loss of 0.2692 and an accuracy of 70.50% in identifying dementia traits via health metric data; in comparison, the MOD-2D-CNN has achieved a loss of 0.1755 and an accuracy of 95.72% in distinguishing dementia from facial images. A rule-based linear weightage method combines these models and provides a final decision. In addition, a better fusion [neural network](https://www.sciencedirect.com/topics/chemical-engineering/neural-network) strategy is also explored in the results analysis with an ablation study. The proposed models are computationally efficient alternatives with significantly fewer parameters than other state-of-the-art models. The performance and parameter counts of these models are compared with those of existing [deep learning](https://www.sciencedirect.com/topics/engineering/deep-learning) models, emphasizing the role of [AI](https://www.sciencedirect.com/topics/computer-science/artificial-intelligence) in enhancing early dementia.

# **Interweaving gaming and educational technologies: Clustering and forecasting the trends of game-based learning research by bibliometric and visual analysis**

This study aimed to highlight the applications and trends in game-based learning (GBL) by conducting a [systematic review](https://www.sciencedirect.com/topics/social-sciences/systematic-review) as well as bibliometric mapping analysis of the studies published in seven SSCI (Social Science Citation Index) educational journals from 1990 to 2019. A total of 743 journal papers were included in this study. The results revealed that most publications and citations for GBL research were from Taiwan and the United States. The author who contributed the most is Gwo-Jen Hwang, while Computers & Education is the journal with the most publications and the most citations. The most frequently studied keywords are interactive learning environments, followed by game-based learning and teaching/learning strategies. Based on reviewing the literature, this study provides a comprehensive summary overview of the existing research, integrating the available information on the research hot topics, and visualizing and identifying the main GBL trends. In addition, the roles of gaming in educational technology research were investigated. Accordingly, some suggestions regarding the application and research directions of GBL are provided based on the study’s findings, which could be a reference for researchers conducting related research in the future.

# A Gamified Active-Learning Proposal for Higher-Education Heterogeneous STEM Courses

Both industry and academia have recently highlighted the need to provide students with 21st-century abilities that involve soft skills and flexible technical competencies. To this end, active learning (AL) helps scholars to be more autonomous, proactive, self-regulated, sociable and creative. A full AL implementation typically requires costly resources and institutional support. However, it is possible to maintain a traditional teaching structure and include low-cost AL activities that enhance the students’ performance and satisfaction. This proposal suggests a methodology where lectures become more dynamic, the practical teaching is student-centered, the lab teaching is fully open, and the learner’s progress is gamified. A full subject design is presented in a comprehensive manner aiming for satisfying courses with a heterogeneous students’ profile. All activities are carefully selected with a social constructivist approach in order to promote critical thinking, social interaction and students’ engagement. The assessment of the course design implementation is performed considering multiple aspects, such as satisfaction, performance, social relationships and self-regulation. Results confirm the adequacy of the proposal to develop technical skills, excite non-technical competences and motivate scholars with an inclusive approach.

# Evaluation of Problem Based Gamification Learning (PBGL) Model on Critical Thinking Ability with Artificial Intelligence Approach Integrated with ChatGPT API: An Experimental Study

This research evaluates the effectiveness of the PBGL model integrated with Artificial Intelligence (A.I) using the ChatGPT API to improve students' critical thinking skills. The main problems faced are the limited time of the lecturer in delivering the material, the lack of reference material, and the low motivation of students. This research used an experimental method involving 520 students from Timor Leste (Cova-Lima and Dili districts) and Indonesia (East Java and East Nusa Tenggara provinces) studying Python, Java, and Web programming. Participants were divided into control (n=260) and experimental (n=260) groups. Key challenges included integration of the ChatGPT API, implementation of A.I-based automated feedback, and maintaining consistency and fairness in testing. The evaluation results showed significant improvement in critical thinking skills in the experimental group across all topics. For the Python topic, the experimental group had an average improvement of 20.75 points, compared to 8.20 points in the control group, with an average difference of 12.55 points. On the Java topic, the experimental group increased by an average of 25.58 points, while the control group only 7.86 points, with an average difference of 17.72 points. In the Web Programming Languages topic, the experimental group showed an average increase of 23.74 points, compared to 8.58 points in the control group, with an average difference of 15.16 points. These findings confirm that the contribution of A.I and ChatGPT integration in the PBGL model can improve critical thinking, provide automatic feedback, and increase student motivation. This research has the potential to be a reference in digital curriculum design with generative A.I approaches such as ChatGPT API, showing that A.I can enrich learning materials, personalized materials and provide flexibility for students and teachers in the digital era.