Proceedings of the 20th Conference on Computer Science and Intelligence Systems (FedCSIS) pp. 489–497
DOI: 10.15439/2025F6951
ISSN 2300-5963 ACSIS, Vol. 43

A Serious Game for Teaching Entrepreneurship and Strategic Management

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***Abstract*—Educational video games have demonstrated significant potential as a modern complement to traditional e-learning in higher education. However, the scarcity of free tools and platforms for creating and customizing educational games impedes their widespread adoption in teaching. This paper introduces an educational video game focused on entrepreneurship, developed using a custom-designed software platform for generating and personalizing learning-based video games through 3D mazes. This platform empowers educators to effortlessly construct hierarchical, personalized 3D mazes for interactive presentation of multimedia educational content. Learners engage with new ideas, concepts, and theories while navigating the 3D maze, and can participate in various embedded mini-games designed to enhance visual and spatial reasoning, psychomotor skills, and context-based reasoning—all of which are vital for successful entrepreneurship. The results obtained from the study are highly promising, particularly regarding the usability and effectiveness of the created 3D video game.**

***Index Terms*—serious game, maze, entrepreneurship, strategic management, GEQ.**

I. Introduction

SINCE the 1970s, computer games have continued to grow, evolving from simple text-based formats into complex, visually rich experiences. Modern computer games make extensive use of two-dimensional (2D) and three-dimensional (3D) video technologies, along with embedded multimedia content, to create immersive and interactive environments. Various genres of video games can now be identified [1], all falling into two main categories: entertainment and serious games. Entertainment games are designed primarily to entertain players [2]. In contrast, serious games (also known as applied games) are created with goals beyond entertainment, integrating entertainment with education, business, healthcare, public order, culture, and other areas [3]. These games have been successfully implemented as educational tools [4], learning environments for social reintegration of marginalized youth [5], rehabilitation platforms for different patient groups [6], and systems for improving cognitive and social activities in the elderly, as well as for telerehabilitation and prevention [7]. The increasing sophistication of serious games demonstrates their potential to engage users in meaningful ways, making learning more interactive, accessible, and effective across disciplines. This sophistication is supported by advanced research in areas such as game AI [8], underlying game theory [9], and even security considerations in game design [10].

This study focuses on innovative approaches to game-based learning in higher education, especially in entrepreneurship education. The target group was chosen due to the growing importance of entrepreneurship education as a key driver of economic growth and social progress [11]. Despite the importance of entrepreneurship education, the availability of educational games in this area remains limited. Furthermore, there is a lack of free software platforms that allow educators without technical expertise to create engaging educational games. This problem is why it is difficult to integrate game-based learning into entrepreneurship courses, as developing such games requires specialized IT knowledge.

If this challenge is met, game-based learning can enhance entrepreneurship courses by helping students develop domain-specific skills, such as critical thinking, problem solving, and innovation. This paper presents STRAMAG, an innovative educational video game designed to bridge this gap. Developed using an open-source, adaptive platform, STRAMAG uses 3D mazes to deliver personalized and hierarchical strategic management training within an entrepreneurship curriculum. Unlike generic educational games, STRAMAG focuses on developing specific skills necessary for entrepreneurial success. Learners navigate the 3D maze, engaging with multimedia content and participating in embedded mini-games designed to improve visual-spatial thinking, psychomotor skills, and context-based decision-making skills directly applicable to real-world entrepreneurial challenges.

The STRAMAG game was created as a customizable video maze using Brainstorm eStudio & API[1] and enabling educators with no IT skills to create engaging, hands-on learning experiences. An experiment with this game was conducted,

[1] https://www.brainstorm3d.com/products/estudio/

and the preliminary results of this study demonstrate the potential of this platform and game.

This paper has two primary objectives:

1. To introduce and describe STRAMAG, a novel adaptive 3D educational game designed specifically for entrepreneurship education;
2. To evaluate the game experience of students playing different mini-games with style-based adaptation of learning content inside a maze using the Game Experience Questionnaire (GEQ).

These objectives lead to the following research question: *How do different video mini-games that adapt educational content to learning styles affect student engagement*?

The paper is organized as follows: Section II reviews relevant literature on serious games, 3D maze games, entrepreneurship education, and game experience evaluation. Section III details the STRAMAG game's design, structure, and content. Section IV describes the experimental setup. Section V presents the results from the game experience evaluation. Section VI discusses the implications of these findings, and Section VII concludes with limitations and directions for future research.

II. Background

A. Serious games for education

Serious games are defined as tools that add entertainment elements to learning. These games are considered an alternative to entertainment games, although there is evidence supporting the acquisition of various skills and abilities through the latter, such as spatial thinking, strategic skills, and memory development [12]. Recent meta-analyses indicate that serious games can increase knowledge retention compared to traditional instructional methods [13], with particularly strong effects in applied fields like business and management [14].

The scenarios of serious video games involve problem-solving and decision-making activities, usually through content presented in three-dimensional form. One of the most intriguing challenges in designing serious learning games is how the player can make meaningful and beneficial choices in a serious context. One key approach to address this is through adaptation in these games. Adaptation in serious games operates at multiple levels: content adaptation (adjusting material based on prior knowledge), difficulty adaptation (modifying challenge levels based on performance), and path adaptation (altering the sequence of learning activities [15]. However, Mayer et al. [16] identified significant limitations in current adaptation mechanisms, noting that different player types cannot fully utilize their qualification levels, playing styles, and cognitive abilities when making key decisions. This limitation is particularly relevant to entrepreneurship education, where individual differences in risk tolerance, creativity, and decision-making styles significantly impact learning outcomes [17]. In other words, the personalization and adaptation of games remains an unresolved problem.

A key advantage of serious games in educational contexts is their ability to track a wide range of performance metrics beyond traditional assessments. As Rahimi and Shute [18] observe, these games not only test current knowledge and practical skills but also assess preparation for future learning by tracking collaboration, innovation, design thinking, and entrepreneurial abilities. Recent advances in learning analytics have enhanced this capability, allowing for more sophisticated assessment of complex competencies [19].

B. Adaptive 3D Maze Games for Learning

Many of the latest approaches to learning through games rely on the use of serious maze games for educational purposes [20]. Mazes are widely used in entertainment games and can be represented by graphs, making them very suitable for interactive content presentation, where the player chooses one of several possible actions. Typically, a maze presents part of a course or module, where each position (i.e., a node in the maze's graph) contains information about a concept or situation. For a given position, there are several possible choices (actions) through which the player can continue in the maze. After selecting the desired action, the player moves to the next position (node) of the transition graph and explores the information in that node to decide how to proceed further. In this way, he/she can navigate the entire maze, following his/her strategy for choosing nodes in the transition graph and familiarizing himself/herself with the learning material presented in it. In this way, mazes enhance engagement and promote active learning are a useful tool for educational games.

The 3D virtual environments offer significant potential for engaging and immersive learning, and this extends to maze-based educational tools. While platforms like EcoMUVE [21], which allows students to explore complex ecological systems, and Second Life [22] have demonstrated the capacity of 3D environments for experiential learning, challenges remain in adapting these tools for specific pedagogical needs. Specifically, the authoring and modification of 3D learning content often demand considerable technical expertise from educators, hindering widespread adoption in mainstream education [23]. In contrast, simpler 2D maze creation tools, such as those created with Scratch [24] for basic navigation skills, provide greater accessibility but typically lack the immersive qualities and capacity for sophisticated, scenario-based decision-making that more complex 3D environments can offer [25].

The primary limitations of current maze-based learning tools include:

1. Limited educator control over content without programming knowledge
2. Insufficient adaptation to different learning styles and paces
3. Weak connection between maze structure and pedagogical objectives
4. Inadequate assessment mechanisms for complex competencies.

These limitations are particularly problematic for entrepreneurship education, where rapidly evolving business landscapes require frequent content updates, and diverse student backgrounds necessitate personalized learning paths [17].

C. Teaching technological entrepreneurship through serious games

The application of games in strategic education has a rich history, tracing back to 17th-century war games that simulated complex military decisions [26]. Contemporary computer-based simulations have become increasingly prevalent in entrepreneurship education, with numerous studies demonstrating their effectiveness in developing specific entrepreneurial competencies [27]. The competencies targeted with these games include opportunity recognition and evaluation, resource acquisition and allocation, risk assessment and management [13], business model development and pivoting, and market analysis and competitive positioning. These competencies are crucial parts of all stages of the strategic management process, and their proper implementation increases the chances of success of strategic management.

Neck and Greene [11] argue that entrepreneurship is best taught as a method rather than a process, requiring active practice of entrepreneurial thinking rather than passive learning of concepts. Serious games align perfectly with this pedagogical approach by allowing students to experiment with entrepreneurial decisions in low-risk environments [28].

Several initiatives have emerged to support the development and implementation of serious games in entrepreneurship education:

- The Serious Games Initiative [29] focuses on addressing management and leadership challenges through game-based learning
- The eSG Project [30] aims to stimulate innovation and entrepreneurial mindsets through tailored video games
- ENTRExplorer [31] emphasizes entrepreneurial motivation and risk-taking through gamified learning experiences.

A diverse array of techniques and methodologies for applying serious games in technology entrepreneurship exists [32], including the use of customizable video mazes to teach effectuation through specialized software platforms [33]. However, the potential of style-based adaptive video games remains largely unexplored [12]. Preliminary research among master's students in entrepreneurship indicates a positive reception to these games, particularly regarding their ability to capture student interest [12]. Further investigation, incorporating student interest indicators and adaptive game implementation, alongside detailed student feedback, is essential to comprehensively understand the motivational impact of style-based adaptive video games.

D. The Game Experience Questionnaire (GEQ)

The Game Experience Questionnaire (GEQ) [34] is a widely validated and standardized instrument specifically designed to assess the multifaceted subjective experience of players during gameplay. Beyond simply measuring enjoyment, the GEQ delves into key aspects of engagement that are particularly relevant to the effectiveness of serious games for learning. These aspects include:

- Immersion - the degree to which players feel absorbed in and connected to the game world, a crucial factor in maintaining attention and facilitating engagement with learning content.
- Flow - a state of optimal experience characterized by deep concentration, a sense of control, and intrinsic enjoyment, which can significantly enhance learning and motivation.
- Competence - the player's feeling of mastery and effectiveness within the game, which can positively impact self-efficacy and the willingness to tackle challenging learning tasks.
- Tension/Challenge - The level of pressure and difficulty experienced, which, when appropriately balanced, can drive engagement and critical thinking.
- Negative Affect - feelings such as frustration, boredom, or anxiety, which can hinder learning and should be minimized in effective educational games.
- Positive Affect - emotions like enjoyment, fun, and satisfaction, which can foster a more positive learning attitude and improve retention.

The GEQ provides valuable insights into how players interact with and perceive a game, highlighting elements that contribute to engagement and overall experience. Understanding these aspects is crucial in the context of serious games, as a positive and engaging experience can enhance learning outcomes. By quantifying these subjective dimensions, the GEQ allows researchers to gain a deeper understanding of how game design choices impact player engagement and overall experience, providing essential data for the design and evaluation of serious games aimed at achieving specific learning outcomes.

E. Synthesis and Research Gap

According to the literature review, each of the domains - 3D maze serious games, entrepreneurship education and motivational design - contributes to effective entrepreneurship education. 3D maze serious games provide opportunities for engagement and assessment and offer solution-based learning pathways. Entrepreneurship education defines critical competencies. Understanding the game experience, as measured by instruments like the GEQ, provides a framework for evaluating the effectiveness of these games in engaging learners.

However, significant gaps remain in the effective integration of these elements:

- Most existing entrepreneurship games lack sophisticated adaptation mechanisms to suit individual learning styles and entrepreneurial orientations
- Current 3D learning environments require technical expertise to be modified, which limits their usefulness for entrepreneurship educators
- Few platforms combine immersive 3D environments with teacher-friendly content management systems

The STRAMAG game addresses these gaps by providing an accessible system for creating adaptive 3D maze learning

environments specifically designed for entrepreneurship education. Unlike previous approaches that prioritize either technical complexity or ease of use, STRAMAG offers both and enables non-technical educators to create serious games. By focusing on creating an engaging game experience (assessed using the GEQ) and mapping maze structures to entrepreneurial decision-making processes, STRAMAG represents a new synthesis of the research areas discussed above.

III. THE STRAMAG GAME

A recent research of game-based learning indicated that most serious game studies focus on learning conceptually, with concepts such as general reasoning, creativity, system understanding, and decision making, which do not demand special knowledge of subject areas [2]. This study, however, investigates the use of style-based adaptive video games to enhance learning motivation within a strategic management module of an entrepreneurship program.

The game design and learning content were developed adhering to the Essential Design Criteria for Educational Games [32], which emphasize:

1. Winning should be based on knowledge or skills, not random factors.
2. The game should focus on core curriculum content, not trivial information.
3. The dynamics of the game should be easy to understand and interesting for the players but not obstruct or distort learning.
4. Students should not lose points for wrong answers.
5. Games should not be zero-sum exercises.

One of the biggest challenges in developing learning content for games is the risk that the content in these games is too general and inappropriate for fulfilling existing curricula [3], which leads to an inability to accurately evaluate the applicability of serious games in education. The learning content of this experiment was developed following the educational curricula of the “Strategic management” course within the master's degree program “Technology Entrepreneurship and Innovations in IT” at Sofia University “St. Kliment Ohridski” (Bulgaria). More precisely, the didactic content in the maze game is based on the first two modules of this course, namely “Introduction to Strategic Management” and “Strategic Management Analysis”.

A. Structuring of the learning content

The implementation of a style-based adaptive video game in the educational process of Strategic management required preparation of a specific learning content for the game. This content was designed to:

- Encompass all key syllabus elements;
- Offer well-structured and precise information for each of the elements in the syllabus;
- Offer textual and graphic learning content in format and size, which is supported by the game's design;
- Include learning content suitable for the learning styles of all four basic types - theorists, reflectors, pragmatists, and activists.

The learning content was structured into learning units [11] based on the strategic management process [31], covering the initial stages: Strategic Philosophical Values and Strategic Analysis. An overview of the overall strategic management process is also included at the beginning of the learning content, as it is included in the educational curricula.

The learning content in the game incorporated the following elements:

- Overview of the Strategic Management Process and Stages;
- Strategic Philosophical Values (company values, vision, mission, strategic goals);
- Strategic Analysis (SWOT Analysis, PEST Analysis, Porter’s Five Forces Analysis, VRIO Analysis, USP Analysis).

The learning units, included in the 3D serious educational game STRAMAG, cover the introduction to the Strategic Management Stages. Following the initial structural knowledge on the process stages, a thorough view of the strategic philosophical basics is introduced. These include Strategic Philosophical Values of the company, Vision, Mission, and Strategic goals. These competencies are of crucial importance for the stable strategic management of the company. After introducing the competencies for forming the foundation of strategic management of the company, an introduction to Strategic Analysis is performed. The Strategic Analysis tools included in the game start with SWOT Analysis. This basic micro-environment analysis on the internal strengths and weaknesses, and external opportunities and threats is focused on analyzing all specific factors for the company impacting its strategic choices. This is done through dividing the factors by two scale dimensions – source type (internal/external) and impact type (positive/negative). This tool is applicable in every occasion of changes in the micro-environment and is one of the most widely used strategic management tools. The second Strategic Analysis Tool implemented in the game is PEST Analysis. It is evaluating external political, economic, social, and technological macro-environment factors influencing the company, and it is of very high importance for strategic management when changing the external macro-environment, starting operations in a new market for the company, or facing large changes in the current market. [35] The third Strategic Analysis Tool included in the game is Porter’s Five Forces Analysis. Its goal is to analyze the competitive intensity and attractiveness of an industry, and it is achieving its goal through analyzing the forces that shape them – Competitive Rivals, Potential for New Entrants in an Industry, Supplier Power, Customer Power, and Threat of Substitutes. The fourth Strategic Analysis Tool, which is included in the game, is VRIO Analysis. It is focused on evaluating the availability, type and strength of the company’s competitive advantage. The fifth Strategic Analysis Tool included in the STRAMAG game is USP Analysis. The Unique

Selling Proposition Analysis is a detailed approach to identifying the specific competitive advantages in the company's offers. USP Analysis is a crucial step in defining a strategic advantage for the company's products on the market. It is supporting the development of products and services with higher value for the customers with great precision due to the evaluation of each feature and its level of importance for the customers. [36]

Each learning unit developed in STRAMAG game includes: (1) textual learning content, (2) graphical learning content, (3) additional information (video, textual, graphical, etc.), (4) additional learning tasks and homework. The learning tasks and homework were grouped based on their appropriateness for a specific learning style of Honey and Mumford [37]. Therefore, four groups of tasks were created, appropriate for the learning style of activists, reflectors, theorists, and pragmatists as follows:

- Activists' tasks – include implementation of different activities, aiming to increase the learning motivation of activist players
- Reflectors' tasks – include materials, tasks and puzzles, giving them opportunity for commenting, overviewing and reflecting on the educational materials and practices
- Theorists' tasks – include reading texts and further materials, creating structures and solving logically complex problems
- Pragmatists' tasks – include directions for direct application of the learned theoretic materials, best practices and examples.

B. Game design and structure

Effective implementation methodologies are crucial for the success of serious games in education [5, 6]. Recent applications have demonstrated the efficacy of maze structures for presenting learning material [7], which are also employed in the "STRAMAG" 3D educational game. Students navigate between learning units situated within "rooms" (nodes) by selecting from connecting "tunnels" (pathways).

Each learning unit is situated within a distinct "room." The "tunnels" connecting these "rooms" incorporate tasks and mini-games tailored to individual student learning styles. Figure 1 illustrates the organization of learning units and their placement within these "rooms," with numerical identifiers (0-9) indicated in red circles.

Both "rooms" and "tunnels" contain learning materials and tasks designed for different learning styles. The game's adaptive algorithm ensures students are presented only with content relevant to their specific style.

The primary objective is to address the unique learning needs of each student and enhance their motivation through the use of a style-based adaptive video game. To illustrate the specific learning content delivered through this maze structure, the following section details the content within each of the ten rooms (or halls) of the maze representing the "STRAMAG" game.

C. Description of the maze rooms with learning content

The maze contains ten rooms (interconnected via tunnels), as follows below.

Room 1: "Strategic Management - Basic stages" – includes information about the basic stages in the strategic management process: Philosophical values - Strategic Analysis - Strategy Formulation - Strategy Implementation - Strategy Execution - Strategy Control and Evaluation. It includes textual material, graphics and diagrams clarifying the concepts, as well as links for further reading.

Room 2: "Strategic Management – Vision" – provides the textual learning content connected with company's vision - definition, basic elements, major directions when formulating the vision and most important questions, which the vision should answer. The learning content also includes practical examples of visions from real companies and links for further reading on the topic.

Room 3: "Strategic Management – Mission" – contains textual content on company mission: definition, differentiation from vision, key questions, examples, video materials, and links for further reading.

Room 4: "Strategic Management - Strategic goals" – focuses on strategic goals and requirements, explaining SMART goals, key questions, graphics, and links for further reading.

Room 5: "Strategic Management - Strategic analysis introduction" – covers the importance and place of strategic analysis in the strategic management process, basic analysis directions, the distinction between strategic analysis in the internal and external environment, basic tools of strategic analysis, examples, and links for further reading.

Room 6: "Strategic Management -Strategic analysis - SWOT Analysis" – focuses on SWOT analysis. It includes textual and graphical learning content describing the tool, all of its elements, the basic questions, and the direction for analysis in each of its sectors, as well as providing a thorough step-by-step guide for implementing the analysis, suitable also for pragmatists and activist learners.

Room 7: "Strategic Management – Strategic analysis - PEST Analysis" – dedicated to PEST analysis. The learning content includes textual and graphical information about the analysis, its application, elements, basic questions, and directions in the implementation of each element of the analysis, as well as an explanation of the other variations of the PEST analysis - PESTLE/PESTEL/PESTLED/STEEPLE/etc.

Room 8: "Strategic Management - Strategic analysis - P5F Analysis" – covers Porter's Five Forces Analysis, its definition, application, content, directions in implementation, and application. It describes all the basic powers in the analysis, their specifics, and influence on the others, as well as information on the key practical points in applying the P5F Analysis in the Strategic Management Process.

Room 9: "Strategic Management - Strategic analysis - VRIO Analysis" – covers VRIO analysis, its definition, textual and graphical presentation, its importance, and a graphical presentation of the methodology of evaluating the type

and durability of the competitive advantage of a company by providing a step-by-step evaluation model for practical application of the analysis.

Room 10: "Strategic Management - Strategic analysis - USP Analysis" – focuses on USP analysis and its importance in the strategic management process for entrepreneurial companies. The room contains the definition of the analysis, its application, and a practical graphical and textual presentation of an example in the application of the analysis.

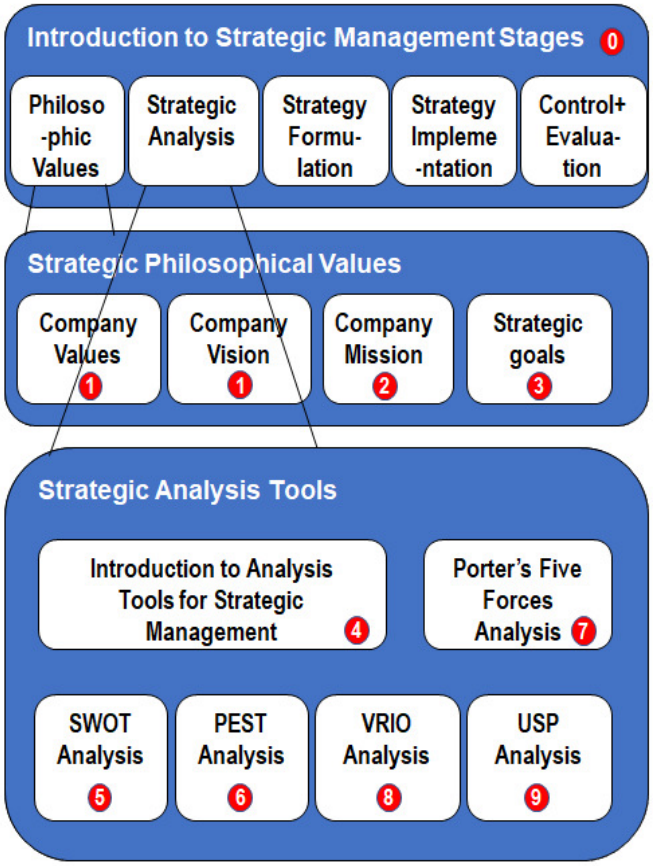

Fig 1. Content distribution across learning units and game rooms

Each room is accessible by "tunnels" and contains tasks and puzzles tailored to individual learning styles, determined during initial gameplay. The "tunnels" feature tasks and activities designed for activist, reflector, theorist, and pragmatist learning styles.

The learning content in every room and the tunnels includes materials and tasks suitable for all learning styles, but all players are shown only the elements suitable for them, according to the learning-style adaptation of the game. The goal is for the learning content to respond to the learning needs of every student in the game, about his/her learning style, and to foster learning motivation during the educational process by using a style-based adaptive video game.

Other mini-games include arranging contextually related images and assembling 3D geometric bodies, which develop associative thinking and spatial imagination. Teachers can customize both the quiz questions and the content of the other mini-games.

Fig. 2. Start screen of the STRAMAG game

The educational content presented in the maze rooms (Fig. 2) encompasses the theory of effectuation, developed by Dr. Saras Sarasvathy [38]. This theory, which has become popular in the last decade, focuses on strategies for achieving entrepreneurial goals under conditions of uncertainty [39].

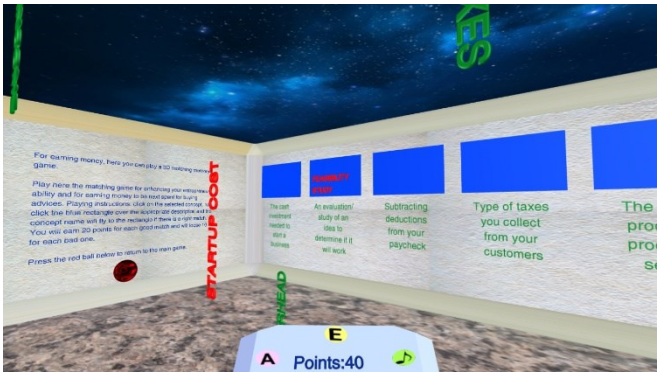

Fig. 3. Inside one of the matching games in the quiz room

Each tunnel passage requires students to use a certain number of points, which adds an element of strategy and planning. To increase their points, students must complete additional tasks integrated into the game.

Fig. 4. Screen of the 3D Zoom game

To prevent monotony and increase the effectiveness of learning, a variety of mini-games are included in the maze. These mini-games are designed to develop fine motor skills, visual-spatial thinking, and context-based decision-making abilities, encouraging entrepreneurial activity and creativity. The mini-games range from entertaining to those with a clear didactic purpose, such as 3D quizzes and games with goal-oriented tasks. For example, a dynamic 3D quiz (Fig. 3) requires students to select from moving text objects containing answers to questions. The speed of movement and rotation of the objects can be adjusted to vary the difficulty. Correct answers are awarded points, allowing the quiz to be used as an assessment tool.

IV. Experimental Setup

The 3D Maze game for entrepreneurship education described above was used in a practical experiment together with two included mini-games – a quiz (3D Quiz – Fig. 3) and an arrangement of scattered context-related images (3D Zoom – Fig. 4). The selection of the educational content and mini-games was coordinated with leading experts in the area of entrepreneurial education, who possess many years of experience in entrepreneurship education. The essence of the effectuation theory, its principles, their comparison with those of causal relationships, as well as the process and entrepreneurial method identified by Sarasvathy [39], were described on boards and interactive whiteboards in six rooms of the maze. The test questions in the 3D Quiz referred to both the educational content presented in the halls and to basic concepts in entrepreneurship, such as what a feasibility study is, net profit, initial and overhead costs, etc.

23 students from the master's program in Technological Entrepreneurship at the Faculty of Mathematics and Informatics of Sofia University "St. Kliment Ohridski" participated in the experiment. All participants had excellent computer skills and basic knowledge of entrepreneurship.

The practical experiment consisted of a presentation and demonstration of the 3D maze video game "STRAMAG", followed by individual game sessions, each lasting approximately 10 minutes. After the sessions, participants completed the GEQ [34], which assesses the level of engagement and experience during gameplay.

V. Results

A. Player profiles

23 students enrolled in the master's program in "Technology Entrepreneurship and Innovations in IT" at the Faculty of Mathematics and Informatics of Sofia University "St. Kliment Ohridski" participated in this study. The age of the participants ranged from 20 to 35 years. The mean age was approximately 26.3 years, with a standard deviation of approximately 3.8 years. The gender distribution of the participants was 15 males and 8 females. Before participation, all students self-assessed their computer skills on a 5-point scale (1 = lowest, 5 = highest). The distribution of self-assessments was as follows: 0 participants rated their skills as a 1, 2 as a 2, 2 as a 3, 15 as a 4, and 4 as a 5. This distribution indicates a generally high level of self-perceived computer proficiency within the participant group.

B. GEQ results

Figure 5 and Table I illustrate the responses to the GEQ questions. Overall, students reported a positive experience with the STRAMAG game. High mean scores were observed across several dimensions: Immersion, Positive Affect, Competence, and Flow. These results suggest that students found the game engaging, enjoyable, and provided a strong sense of mastery.

TABLE I.
MEAN VALUES OF GEQ DIMENSIONS AND ASSOCIATED QUESTIONS FOR DIFFERENT MINI-GAMES (3D MAZE, 3D QUIZ, 3D ZOOM)

Dimension	Questions	3D Maze	3D Quiz	3D Zoom
Competence	2, 10, 15, 17, 21	3.91	3.74	4.09
Immersion (sensory & imaginative)	3, 12, 18, 19, 27, 30	4.35	4.13	4.17
Flow	5, 13, 25, 28, 31	3.70	3.96	3.87
Tension/ Annoyance	22, 24, 29	2.32	2.04	2.17
Challenge	11, 23, 26, 32, 33	2.09	2.17	2.26
Negative Affect	7, 8, 9, 16	2.14	2.06	2.36
Positive Affect	1, 4, 6, 14, 20	3.96	3.74	4.09

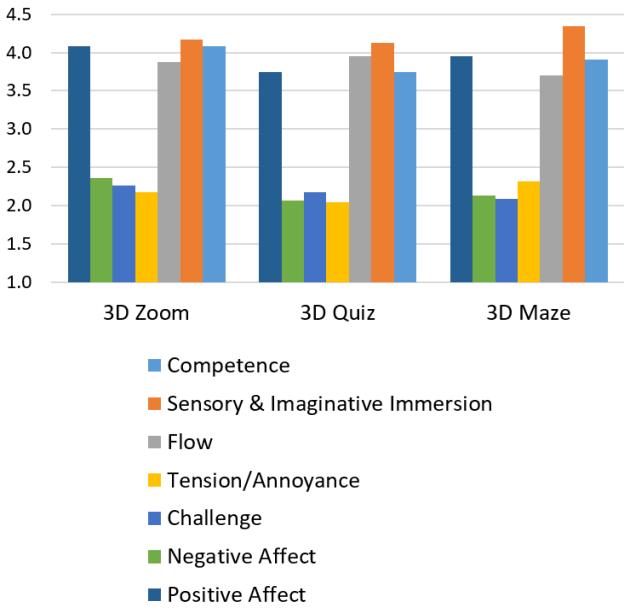

Fig. 5. Responses to the questions from the GEQ

The Negative Affect dimension showed consistently low scores across all game versions (3D Maze: 2.14, 3D Quiz: 2.06, 3D Zoom: 2.36), indicating minimal levels of frustration, boredom, or anxiety. Similarly, the Tension/Annoyance dimension yielded low scores (3D Maze: 2.32, 3D Quiz: 2.04, 3D Zoom: 2.17), suggesting that students experienced little discomfort. The Challenge dimension also showed moderate scores (3D Maze: 2.09, 3D Quiz: 2.17, 3D Zoom: 2.26), reflecting an optimal level of difficulty for maintaining engagement.

VI. Discussion

The findings of this study provide strong evidence for the usability and effectiveness of the STRAMAG game as an educational tool for entrepreneurship and strategic management. The game's 3D environment, combined with embedded mini-games, offers a dynamic and interactive learning experience that traditional methods often lack. Moreover, the novelty of the STRAMAG game consists in introducing an adaptation of learning content based on the learning style of the individual player. The results presented in Fig. 5 show that different video mini-games that adapt educational content to learning styles affect student engagement in a slightly different way.

The positive responses observed in the GEQ indicate that the game effectively engaged the students. The high scores for Immersion, positive effect, Flow, and Competence can be attributed to the design of the 3D maze environment and the integration of relevant entrepreneurial concepts within the maze structure and the embedded mini-games.

The Negative Affect dimension showed consistently low scores across all mini games (3D Maze: 2.14, 3D Quiz: 2.06, 3D Zoom: 2.36), indicating a minimal level of frustration, boredom, or anxiety. Similarly, the Tension/Annoyance dimension yielded low scores (3D Maze: 2.32, 3D Quiz: 2.04, 3D Zoom: 2.17), suggesting that students experienced little discomfort. The Challenge dimension also showed moderate scores (3D Maze: 2.09, 3D Quiz: 2.17, 3D Zoom: 2.26), reflecting an optimal level of difficulty for maintaining engagement.

It is important to acknowledge the limitations of this study. The sample size of 23 master's students, while sufficient for preliminary analysis, may limit the generalizability of the findings. Future research should aim to include larger and more diverse student populations. Additionally, longitudinal studies could investigate the long-term impact of the STRAMAG game on students' entrepreneurial skills and career trajectories. Further refinement of the game's adaptive mechanisms and exploration of additional game-based learning strategies are also warranted.

VII. Conclusions

The use of educational video games in higher education has the potential to significantly enhance the outcomes of traditional e-learning by making it more engaging and effective. Video games offer innovative ways to acquire knowledge and practical skills through informal and often implicit problem-solving.

This research was motivated by the existing lack of customizable and free video games for educating young people in entrepreneurship and strategic management [40]. The developed software system for declarative description, personalization, and generation of 3D video mazes, or such that offer a free solution for mass game-based learning, not only in entrepreneurship. It allows teachers to construct mazes presenting content from a given subject area in a personalized and interactive way, where the learner chooses how to continue navigating the maze. In addition to becoming acquainted with new ideas, concepts, and theories in a 3D maze, learners can play entertaining embedded mini-games with didactic value that develop motor skills, visual and spatial thinking, and context-based reasoning. The positive results from the Game Experience Questionnaire indicate that students found the STRAMAG game to be highly immersive and perceived the learning content as useful, suggesting the potential of this game for engaging and effective entrepreneurship education.

Future research and development should focus on several key areas. Firstly, expanding the learning content within STRAMAG to encompass a broader range of entrepreneurship topics would increase its applicability. Secondly, implementing more nuanced adaptive learning mechanisms that dynamically adjust difficulty and content based on individual student progress and learning styles could further enhance its effectiveness and foster a greater sense of competence. To further capture and maintain student attention, future iterations could explore incorporating more dynamic visual elements and unexpected challenges. Additionally, enhancing the perceived relevance of the content through personalized pathways and real-world scenarios, and integrating a more robust reward system to increase learner satisfaction, are important avenues for future development. The authors plan to compare the knowledge acquisition of students who played the game with those who did not by conducting a controlled experiment with a larger sample size, dividing participants into experimental and control groups. Finally, exploring the integration of collaborative gameplay features could foster social learning and engagement among students.

Acknowledgment

The research leading to these results has received funding from the MOTIVATE project, funded by the Bulgarian National Science Fund, Grant Agreement No. КП-06-Н85/2 dated 05/12/2024, and from the EU ESI Funds by the European Union-NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project SUMMIT, No. BG-RRP-2.004-0008.

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