PAPER

Assessment of Digital Games in Technology Education

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ABSTRACT

The paper contributes to solving the issue of digital games in education. It explains concepts such as gamification and Digital Game-Based Learning; it focuses on the typology of games and the positives and negatives of playing digital games while discussing the aspects of their implementation in education. The case study presented in the paper examines in more detail digital games as a supplement to the learning environment in technically oriented education at the primary level of elementary schools in Slovakia (ISCED 1). The main focus is on an analysis of digital and education aspects of selected digital games. Specifically, based on nine game assessment criteria, such as game content in line with the objectives, application of cross-cutting themes, motivation, way of manipulation, active participation of the pupil, design/graphic processing, playing time, game model and its objective. Each of these criteria can influence the application of selected games in teaching; therefore, we assessed the games individually through these criteria.

KEYWORDS

gamification, digital games, technical education, primary level of elementary schools, ISCED 1

1 INTRODUCTION

The modern era requires that every person be prepared for life in a technological society [1]. For this reason, technical education must become an integral component of general education [2] and reflect the rapidly changing demands of education and technology [3]. Technical education is an issue addressed by the world organisation UNESCO, which, as early as 1974, announced a program with a crucial requirement: the inclusion of technical subjects in general education. It was technical and vocational education that was the main priority of the reforms of the education systems of individual countries, including Slovakia [4]. Technical education aims to prepare pupils for a rapidly changing technological environment, to develop their basic skills based on practical activities, to develop pupils' critical, political, and economic

awareness [5], to develop an understanding of technology and to teach pupils to use critical thinking with the use of technology [6]. Thus, including a subject of this nature in the teaching process is extremely important at all levels of education [7]. As a public education institution, the elementary school plays a crucial role in building the technical literacy of the population. Technical subjects are a tool for building technological literacy, as they are, in their broadest sense, aimed at acquiring knowledge and skills in the technical field, which includes, for example, familiarisation with materials and tools and how to use and handle them. In Slovakia, technical education is carried out at the primary level in Years 1 and 2 only as a cross-curricular subject, and in Years 3 and 4 through the subject of Work education. The State Education Programme (SEP) and the educational area of *Man and the world of work* define the content of this subject (Table 1). The curriculum covers a wide range of work activities and technologies based on creative teamwork. Through technical education, pupils are encouraged to acquire basic user skills in various fields of human activity. The educational content of the Work education subject contributes to the formation of pupils' life and career orientation [8]. The subject focuses on developing practical work skills and complements the whole primary education with an essential component necessary for a person's application in later life and society [9]. According to the SEP, the educational area of Man and the world of work contains five subareas.

Table 1. Overview of the thematic units of the subject work education [9]

Educational Area Man and the World of Work	
3rd Year	4th Year
Man and work	Man and work
Creative use of technical materials	Technical materials
Fundamentals of construction	Fundamentals of construction
Nutrition and preparation of dishes	Preparation of dishes
Folk traditions and crafts	Folk traditions and crafts

Throughout the process of teaching technology at the primary level of education, the ultimate goal of forming a technically, intellectually and emotionally creative person who will navigate the information society must be kept in mind. The *information society* or *digital age* are names for the times we live in, in which technology and innovation are becoming increasingly important not only in society itself [10], but also in education. Recent studies [11] point out that, nowadays, children are in interaction with digital technologies immediately from the moment of their birth [12], [13], literally are growing up in an environment of the Internet and computing devices [14], [15], [16], [17], [18]. They participate more in online games than in direct communication with peers, teachers, and parents in the real world. Professional public calls these children as the net generation [19], generation Z [20], students of the new millennium [21], and digital natives [22]. These digital natives grew up with digital technologies and have different learning styles and higher teaching and learning requirements [11]. As a result, a growing body of arguments supports the reform and integration of gamification and digital game elements into the curriculum for the needs of students and the society in the 21st century, as this century requires very different skills and competencies that games can convey to them [23], [24].

Moreover, the use of gamification in the educational process supports involvement and motivation of the new generations [25] in the education process. It can be seen that with the increase in the variety of digital tools, today's children, who represent the core of the digital natives, actively use these tools, by means of which their creativity and problem solving ability are also supported [26], [27]. That is why teachers are facing new challenges related to adapting the educational process to the individual needs and differences of students, their preferences and requirements to become active participants with a strong motivation, and engagement in their own learning [11]. A problem that has remained and has not been sufficiently addressed so far is the question of the possible difference in influence from introducing gamification into the educational process for children who have grown up with and without technology. Most studies usually so not deal with gamification applications into the selected specific disciplines, or conditions, and do not take into consideration differences in educational areas and gender [28].

2   GAMIFICATION AND DIGITAL GAMES

Gamification is a technique that uses game elements and game design in a non-game context [29]. Its goal is different from the actual playing of the game [30]. The word *gamification* comprises the words game (play) and fixation (implementation). Gamification often appears in education under the term "school through play", which includes the use of games and game elements in different areas of life. It is thus a matter of integrating the pupil into the pedagogical process by integrating individual game elements and game mechanisms. Design of games tries to make the processes involved more exciting and efficient for the player. Game design is crucial, and the game must be designed so that the pupil plays it voluntarily and enjoys returning to it. All this is done not only by leaderboards, points and badges but also by visuals and by setting up different challenges, levels of difficulty and layouts of elements [31]. For this game design to have the correct form, it must also include the so-called "Flow channel," i.e., the difficulty of the task, which cannot be too low so that the player does not get bored, or too high so that the game is not sufficiently challenging for the player [31]. In the field of education, gamification is starting to make significant progress. With success stories such as Classcraft, Class Dojo, and Rezzly, the potential to expand gamification into more and more classrooms is high. Of course, ideas from educators designing their own gamified learning environments are also working in the learning environment [32]. Contemporary education requires an innovative system to engage learners to develop their key 21st century competencies in key subjects (Native Language, World Language, Arts, Geography, History, Mathematics, Science, Government). These skills are divided into three main areas [33]: Learning & Innovation Skills (Creativity & Innovation, Critical Thinking & Problem Solving, Communication & Collaboration), Information, Media & Technology Skills (Information Literacy, Media Literacy, ICT Literacy), Life & Career Skills (Flexibility & Adaptability, Initiative & Self-Direction, Social & Cross-Cultural Skills, Productivity & Accountability, Leadership & Responsibility). Gamification is an innovative technology that is considered a leading trend in education, as it has significant potential in developing some of the above-mentioned skills. Several studies confirm this positive impact on improving task motivation [34], [35] and student behaviour [36], [37] in various topography areas and demographics. Lamrani et al. [38] and Záhorec et al. [39] also confirm this positive impact.

They have observed how gamification can affect learning in mathematics, language, social skills, and even health. The benefits of gamification in many educational areas and stages are unquestionable [40]. Game elements of gamification also support development of other skills and work competencies and thereby increase the motivation of learners within the work or educational contexts [41], teamwork and communication skills, critical thinking and development of social skills and competencies of students [42], [43], [44], [45] as well as their digital skills, too [46], [47], [48], [49]. Application of gamification in education and the classroom is invaluable because it can spark curiosity and promote students' autonomous learning [50], [51]. Applying a gamification educational activity in the framework of teaching can not only encourage students to try new things, but it can help them to overcome their fear of making mistakes [52], [53], [54], [55]. Its use is meaningful and justified. Gamification helps to make the teaching and learning process more interesting, engaging and interactive for students. It affects their behaviour and determination, which leads to the improvement of their knowledge and skills [56]. In addition to competency development, it is also important that students are given an opportunity to apply the newly acquired competencies and skills in practice, in a practical way. This also follows from the framework of the 21st century skills. Gamification is an innovative approach integrated into work, which is focused on social contextual conditions at the workplace and also develops work competencies also means of motivational elements [41].

Gamification supports the conversion of learning materials and activities such as homework, classwork, books, and videos into playful experiences. It brings along behavioural change through playful experiences [57]. However, there is also a need for using innovative methods and means of education.

Therefore, the teacher and his digital competencies play an important role here. However, most teachers have a digital hybrid profile, i.e., they acquire the use of digital tools but in their teaching practice they are not able to give up using the traditional teaching methods [58].

Neither gamification nor digital games can replace teachers, nor or they meant to replace pupils' regular activities. They are tools whose efficient use can benefit both parties involved—teachers as well as the pupils themselves [59]. At this point, it should be stressed that although there are many arguments supporting integration of gamification and digital games into the curriculum, these two terms, while quite often understood as identical—i.e., that gamification is perceived simply as the use of digital games in classroom [29]—are not the same. The creation or use of digital games focuses on learning, also referred to as *game-based learning*, and it is aimed at content and skills [29].

3 DIGITAL GAMES IN EDUCATION

Widespread communication areas (networks); computers, laptops, tablets, and mobile phones (hardware); and a new generation of operating systems, programming languages, and game engines (software) offer new possibilities. They have launched a new field: digital game-based learning [60]. Digital games have become a contemporary phenomenon, especially among children and young people [61], [62], [63]. The reason for their popularity is that they are usually faster and more interactive, provide a variety of scenarios and have a better graphical design. They consist of different difficulty levels and allow players to experience simulated situations that

they would probably not experience in real life [64], [65]. Digital games are software applications that combine features of video and computer games. However, due to multiple digital media designed for gaming, their meaning has become synonymous with a wide range of terms such as computer games, digital games, electronic games, and video games [66]. Digital games simulate tasks so that their execution in the game involves the same cognitive processes required to perform tasks in the real world [67].

Current pedagogical approaches promote the synergy between technology, pedagogy and the implementation of digital play in the learning process [68], [69], [70]. Digital games have become a rapidly developing field. If properly designed and appropriately applied in teaching, they can represent educational tools to improve the effectiveness of the teaching process at all levels of education [66]. The growing popularity of digital games [71] has lead to their widespread use and application [72]. The pedagogical approach to using digital games is called digital game-based learning (DGBL), which we can describe as a fusion of interactive fun and learning through digital games [72], [73], [74], [75], [76], [77]. According to Prensky [78], digital games can be classified as active learning environments [79] if used appropriately within an organized learning framework, i.e., learning objectives and appropriate developmental design and assessment. Of course, this new teaching phenomenon also has to be included in mentor and teacher training, either the pre-service or inservice teacher training [80], [81], [82].

Recent research on digital games [69], [70], [83], [84], [85], [86], [87], [88], [89], [90], [91], [92], [93] emphasizes that these games can improve children's learning and social interactions, behaviour, problem solving, cognitive thinking [94], higher-order thinking, critical-thinking skills, memory and eye-hand coordination skills. In addition, digital games at the primary level represent a dynamic tool that captures children's attention. It can motivate them [95], [96] to explore the boundaries of their competencies, skills and knowledge [97], [98], [75], [99], [100], [78]. Within digital games, learners often take responsibility for their learning style and become more autonomous in their actions and decisions [101].

In addition to the concept of digital games, digital educational games are also coming to the fore. These are software applications that combine features of video and computer games [66]. Their goal is to design engaging learning experiences that successfully match specific learning objectives and outcomes [102]. Digital educational games do not have entertainment as their primary goal, but their environments incorporate educational content in a challenging and entertaining way that promotes active learning [103]. Games can encourage learning, develop cognitive skills, or take the form of simulations that allow learners to practice their skills in a virtual environment [104], [105]. Today, we have a variety of video games, digital applications, and adaptive software platforms that we can use in the classroom [106]. However, their design is an unexplored area, especially the area of digital educational games for primary-level technical education.

In the DGBL concept, we can consider three types of digital games that are possible to use to educate students [76]:

1. Leisure games (commercial): not designed with an educational purpose, although it is possible to say that in almost every game, pupils can learn something;
2. Educational games: these sre different from leisure games because they intend to educate pupils, and it is possible to use them in the teaching process;

3. Educational leisure games (commercial-educational): these represent an intersection between the above types. Developers initially created these games commercially, but they have been successfully implemented in the teaching process with an educational aim.

From the above, game-based learning represents an engaging form of education, with the added benefit of increasing the attractiveness of the material, and pupils reinforce their understanding in a fun way [107]. In Slovakia, there has not yet been sufficient pedagogical research on the application, and consequently the impact of digital games on pupils, especially in such a specific subject as technical education, is still being investigated. Mostly we find studies with themes for games and their inclusion in the teaching of science subjects [108]:

- mathematics (e.g., [109], [110], [111]);
- geography (e.g., [112], [113]);
- natural science, biology (e.g., [114]);
- physics (e.g., [115], [116], [117]).

or studies with typologies of games by educational subject [118]:

- Foreign languages (Lingua.ly, Duolingo);
- Czech language (games with Czech localisation);
- History (Kvíz dějepis, American Civil War: Gettysburg, Total War series, Assassin's Creed series);
- Geography (Kvíz zeměpis);
- Mathematics and physics (Portal, Adventures in Math, Physicus);
- Social sciences (Europe 2045, SimCity, Tropico);
- Informatics (Hacker Evolution, Uplink);
- Chemistry (Chemicus);
- Biology (Spore);
- Art and music (Sketch Guru, Guitar Hero, Rocksmith)

However, we have not yet observed the inclusion of digital games in technical education in any study.

4 THE POSITIVES AND NEGATIVES OF IMPLEMENTING DIGITAL GAMES IN EDUCATION

In the context of the multitude of existing games, extensive gaming has many positive and negative impacts on players [119]. The most frequently evaluated negative aspects of games include addiction [120], [121], aggressive behaviour [122], violence and depression [123]. Frequent multiplayer gaming may put youth at higher risk for poor reading performance [124]. There is no evidence of more serious negative consequences of supplemental gaming in instruction [125].

Despite the studies cited above confirming the negative impact of digital games on learners in education, some show the opposite, i.e., that DGBL environments produce positive learning outcomes [126], [127]. In support of the positive implications of digital games, several more extensive studies (see Section 2 of this paper) confirm their positive impact on educational achievement [128]. They also support the

positive correlation between the amount of time spent playing digital games and creativity, regardless of the type of game played [129]. Becker [130] took a slightly different approach to digital games' positive and negative aspects, analysing the advantages and disadvantages of digital games and their use in the educational process. According to her, the benefits of digital games are:

- Elimination of risk: games provide opportunities to try out roles that would not usually be possible in real life.
- Discovery: games allow pupils to discover the answers to questions such as "what if...?", especially concerning behavior not accepted in real life.
- Time: in games, we can speed up or slow down processes and thus allow students to move continuously.
- Continuous evaluation: everything a player does in the game can be tracked, including their decisions, places they go, and how long they stay in the game.
- Feedback: it is usually immediate or at least easily accessible.
- Abstraction: computer games allow for the embodiment of various concepts, processes or relationships while allowing learners to interact with them.

Simkova [131] took a similar approach to Becker, who similarly focused on defining the advantages and disadvantages of computer games in the teaching process. She cites the main positives of computer games education: computer games foster creativity in pupils and are fun for pupils. As a result, pupils often do not even realise that they are learning. Pupils work with computer technology, and they decide when to learn. Learning is interactive, better adapted to the pace and ability of the pupil, and these computer games are more illustrative than traditional forms of learning. On the other hand, according to Simkova, the negatives lie in health problems, the threat of building up an addiction, the diminished motivation to read books and the alienation of pupils from each other.

The different characteristics of games are interpreted differently by various authors, resulting in inconsistent and primarily negative views of parents and teachers about children's and pupils' gaming and, consequently, their noninclusion in the curriculum. The application of games in education depends most on staffing constraints [132]. It is possible to increase the teachers' confidence in digital educational games by having them participate in training programs that provide them with the appropriate skills to evaluate and implement suitable digital games in elementary education [66].

When selecting an appropriate digital game to implement DGBL, there are several factors and continuous steps to consider before implementation. First and foremost, the choice of game needs to be tailored to the nature of the subject matter and the objectives of the specific teaching unit to be achieved. Sandford and Williamson [133] recommend taking into account other factors, such as:

- Age appropriateness: in Europe, the age range at which a game is recommended to be played is categorized using the PEGI system [134].
- Accessibility: there are few games that would be playable by children with motor, hearing or visual impairments, so in this case one needs to look for games from special developers.
- Equality of access: this is related mainly to the social situation of the pupils. Pupils who do not have access to a computer at home or are prohibited from playing

computer games may have a more difficult situation than children with access to them in the use of the games in the educational process.

- Save-and-quit options: this refers to games with a time commitment of more than one lesson; for such games, it is critical that the game provide these options.
- Teacher expertise: to incorporate the game into the teaching process, the teacher should ideally have a thorough knowledge of the game to be able to clarify any ambiguities for the pupils.
- Assessment: if teachers use computer games in the classroom, they should consider how they will assess pupils' work. It is also worth monitoring whether pupils are actually learning by playing the computer game and, if so, to what extent.
- Cultural representation: gender, nationality and racial differences are often misrepresented; for example, women are generally portrayed as attractive and heroes are mostly white.

Primary education is considered the most suitable of all levels of education for the implementation of digital-learning games. Still, a profound change is fundamental in the extension and support of existing traditional teaching methods with the help of games [66]. The implementation of digital games in education is no longer just a current trend. It is related to the digitalisation of education globally and in Slovakia [135]. Their implementation should not represent a goal, but a means to achieve goals.

5 ANALYSIS OF SELECTED DIGITAL GAMES FOR THE MAN AND WORLD OF WORK EDUCATIONAL AREA

The application of digital games in schools has had a complicated history, mainly because the game design of many digital games did not fit into the curriculum and educational objectives [29]. This situation has led to various approaches to integrating digital games into the curriculum, ranging from commercial off-the-shelf games to educational games to games designed by students or teams of educators and game designers [136]. However, according to some experts, the main shortcoming of commercial games is that they do not take pedagogical considerations or curriculum into account [137], [138]. Equally, however, educational games have been criticised because, although they met the requirements stemming from the curriculum, they lacked motivation and elements of tension to keep students' attention. Božík [139] also highlights this problem of educational games. He argues that educational games rarely positively affect pupils' learning due to inferior design; they simply do not entertain pupils and fail to sustain their interest. For this reason, inconsistent analyses of the evaluation of digital games have emerged. For example, Prensky [64] attempted to specify fourteen different methods of learning and teaching in digital games: practice and feedback; learning by doing; learning from mistakes; goal-oriented learning; discovery learning; guided discovery; task-based learning; question-driven learning; role-playing; coaching; constructivist learning; multisensory learning; choice-based learning from teaching subjects; and intelligent tutoring. Matthias [140] lists three essential criteria in his didactic analysis of digital-learning games: What is it actually and what is to be learned (learning objectives)? What is and what should be the material/topics used to achieve these objectives (learning content)? How should this learning content be learned (learning and teaching methods)?

5.1 Purpose of the research

As mentioned earlier, related to the digital game research there is a lack of studies dealing with digital games for technical education. Therefore, our study aims to map and analyse among the currently available digital games those that are suitable for technical education, specifically for the educational area of Man and the World of Work at the primary level of elementary school. The purpose of the presented analysis is to help teachers to make the right decision when choosing a game among those that are in accordance with curricula (SEP) of the school subject Work education. At the same time, our analysis should also help other researchers dealing with analyses and comparison of the use of digital games in teaching and education.

5.2 Methodology of the research

Within the research, various design and education aspects of the games selected for purposes of technical education at the level of primary education were explored and analysed. That is why it was decided to use a case study, which is commonly used for purposes of more detailed inquiry to obtain multiple understandings in a real context [141]. The games were analysed in terms of content and design. In the context of content, we assessed educational value of the games through analysing the game models, contents, goals and time needed for playing the games in relation to the teaching goals of the Work education subject, total time allocation, and application of cross-cutting themes. Subsequently, the following elements of the design of the games were assessed: graphical elaboration of the game, pupils' activities and motivation, and ways of controlling the game.

5.3 Realisation of the research and its results

The analysis was preceded by a thorough research and selection of freely available games for pupils aged 8–10 years. Subsequently, ten of the games, having a specific technical focus appropriate for the field of Man and the World of Work were selected for the study. In the selection, we focused mainly on games that can also solve frequent problems connected with the practical performance of different activities related to technology. The selected games were properly tested by 46 pupils and then analysed by three experts.

The analysis of the games was done in accordance with predetermined criteria specified by means of literature analysis with regard to the structural and educational aspects of the games. For the analysis, a test sheet was used, in which the experts recorded their assessments of the stated game evaluation criteria. Additionally, observation of pupils playing the games was used, and the experts were asked to try the games too.

- **Game content:** when selecting games, we focused on educational and commercial games whose content is applicable to specific thematic areas of the educational area of Man and the World of Work. The content criterion is the main criterion we used to select the games. Each of the selected digital games is suitable for at least one thematic area within the educational domain. However, we also

investigated the variability of the games, i.e., their application to several thematic areas or cross-cutting topics.

- **Motivation:** in the initial theoretical background, we encountered the most common argument that digital games increase learner motivation. Therefore, we aimed to assess the selected games from that perspective and thus whether the selected games have attributes that positively affect learner motivation. Motivation is determined by, e.g., pupils' involvement in using the content and game elements. It can also depend on friendly competitiveness, fun elements associated with graphics, sound, storytelling, humour, and game characters [84]. For example, encouraging texts or competitive elements associated with comparing results can also be motivating.
- **Game-control method:** to be engaging and hold pupils' attention, the game should include some of the game elements of digital game immersion: story, varying difficulty, outcome and feedback, the possibility of winning, conflict/competition/challenge, and problem solving [78].
- **Active participation of the pupil in the game:** we considered this characteristic as a separate element because it can contain several factors. Active participation represents the opportunity for the player to move freely within the game, the opportunity to change their environment, and the development of creativity, such as designing and creating. Games that do not include these possibilities allow pupils to become more or less passive observers, and they will be acting, more likely, only as "clickers."
- **Game design/graphics:** Game design is also related to the fun aspect of the game. We analysed the graphical quality of the game design, the sound and visual animations in the game, as well as the ability of the digital game to draw the learner into the action. We can assume that the engagement and effectiveness of learning through digital games depend on their game design [142].
- **Playtime:** with the current unfavourable time allocation (1 hour per week in Years 3 and 4) within the educational area of Man and the World of Work in primary education, this criterion is crucial. Teachers frequently cite time as a barrier to applying digital games in education [66]. Therefore, we evaluated the time intensity of each game. We indicate the time required to complete the entire game for short digital games. We analysed whether using any part of the game within one lesson for more complex games was possible.
- **Game model:** teachers lack training on effectively implementing digital-learning games in the classroom [85]. Therefore, we aimed to identify how it is possible to apply the games in question in the classroom, following these models [143]:
  - Model 1: application of the game in one lesson to achieve a specific goal.
  - Model 2: application of the game to several lessons.
  - Model 3: using a separate game element as a supplementary task, which involves using a game element as an additional tool. In this case, the game does not replace the lesson.
  - Model 4: integration of the complete game into the curriculum, where the digital game represents an alternative way of presenting the curriculum, which leads to a reorganisation of the teaching, learning and assessment process, i.e., a redesign of the course.
  - Model 5: use of online games in a blended learning or online course. In this case, pupils do not necessarily meet because the game runs online—synchronously or asynchronously.

○ Model 6: Implementation of a mixed-reality game using elements of the online environment and face-to-face interaction, often involving mobile technologies such as mobile phones or other portable devices.

• **The game's goal:** we will analysed whether the game has a clear goal for the players to achieve or whether the teacher can modify it according to the learning needs.

Results of the digital games analysis, together with their detailed interpretation, are presented in Table 2. For the selected games, we present detailed information, which was obtained by observing the pupils and by a detailed analysis of the games done by the experts, with an emphasis on the content of the subject Work education.

Table 2. Analysis of digital games for the educational domain Man and the World of Work

Name of Game	Sub-Area	Content of the Game	Cross-Cutting Themes	Motivational Elements	Method of Control	Active Participation of the Pupil	Graphic Design	Playing Time (Minutes)	Model of the Game (Whitton)	Goal of the Game
Find the Technology	Man and work	✔	MV	–	✔	–	–	5–10	Model 1	With a goal
What Will I Be?	Man and work	✔	OSR	✔	✔	–	–	5–15	Model 2	With a goal
Recycling	Creative use of technical materials	✔	EV	✔	✔	–	–	5–10	Model 1	With a goal
Woodwork Simulator	Creative use of technical materials	✔	RV	✔	✔	✔	✔	15–30	Model 2, 4	With a goal
3D Models Free Building	Fundamentals of construction	✔	–	–	–	✔	–	1–5	Model 1	Without a goal
Circuit Construction Kit: DC	Fundamentals of construction	✔	OZZ, EV	✔	✔	✔	–	5–8	Model 2	Without a goal
Traffic Education	Fundamentals of construction	✔	–	✔	✔	–	✔	5–10	Model 1, 2, 4	With a goal
Supermarket Sim	Catering and food preparation	✔	OSR, OZZ	✔	✔	✔	✔	5–30	Model 1	With a goal
Cooking Simulator	Catering and food preparation	✔	OSR, OZZ	✔	✔	✔	✔	5–30	Model 1	With a goal
Master of Pottery	Folk crafts and professions	✔	RV	✔	✔	✔	✔	15–30	Model 1, 4	With a goal

Notes: MV, Multimedia Education; OSR, Personal and Social Development; EV, Environmental Education; RV, Regional Education and Folk Culture; OZZ – Protection of Life and Health.

The following section provides a more detailed explanation of the criteria analysed for each game. The organisation of the games corresponds to the thematic units within the Man and the World of Work educational area.

Thematic unit: Man and Work.

Find the Technology. The basis of this digital game (Figure 1) is to find, locate and define objects scattered around the room by clicking on them. In total, there are 21 technologies in the game, such as computers, laptops, smartwatches, data projectors and smartphones, and others.

The game's content is in line with the objectives of the curriculum and the thematic unit, Man and Work. It also provides space for discussions about the positives or negatives of technologies concerning man and work. The aim of the game is in the form of a simple *find* challenge. The game has a motivational element in the feedback on confirming the correctness of the chosen answer to the questions and hidden humorous moments of surprise. The game also features short sound or visual animations when pupils click on particular objects, adding motivation. The game does not allow for the active participation of the pupil. It is conceived more or less staticly in the form of simple mouse clicks on objects. However, it is possible to pass it without thinking, which is detrimental to the game's effectiveness in developing thinking and creativity. Graphically, the game looks interesting, but it takes place in a simple, unchanging environment, which can lead to a rapid loss of attention in the pupil. Among the cross-cutting themes, teachers can apply the game in media education. It is not time consuming, taking 5–10 minutes. It is possible to include this game in the area of games to achieve a specific learning objective of one lesson.

Fig. 1. Screenshot of the digital game Find the Technology [144]

What Will I Be? The game consists of 3 parts:

- Descriptive part: contains 43 textual descriptions of the professions, together with pictures and texts that can also be listened to,
- Fun part: pupils have an opportunity to try out different professions (e.g., firefighter, plumber, painter, make-up artist or designer),
- Practice part: – Designed to repeat the knowledge while performing various activities. Pupils match typical headgear, tools and devices to occupations, recognising occupations by sound. They deal with the matter of who will solve this situation, where, for example, pupils have to match the profession to real-life circumstances.

The game is in line with the objectives of the State Education Programme. Specifically, it allows for the fulfillment of the standards, with a focus on learning about selected professions and occupations, e.g., their job descriptions, justification

of the importance of work for people, awareness of occupations from the environment in which they live, and others. The game includes feedback. It is a mini-game with challenges for the pupils appears while playing the professions. However, it does not involve the active participation of the pupil. Pupils cannot move freely within the game or change the environment. However, it contains several motivational elements, such as helping to put up a house, assembling pipes from a limited number of parts as a plumber, the much-loved memory game, or matching activities (Figure 2). The game includes a small amount of sound and image animations. Its graphic design is relatively simple. It allows the inclusion of cross-cutting themes such as Personal and Social Development. However, occupations are included in almost all thematic units. The game offers a wide range of activities to meet the objectives of several units, and it is possible to use it as an alternative way to present the curriculum, such as types of occupations, personal protective equipment, and occupations. It is not time consuming. It is a short game, manageable in a span of 5–15 minutes.

Fig. 2. Screenshot of the digital game What Will I Be? [145]

Thematic unit: Creative use of technical materials.

Recycling. The digital game consists of three phases. In the first phase, the pupils find themselves in the role of a sorter, putting the rubbish into the correct container. The pupil then plays the role of a specialised sorter, whose task is to determine the type of material and whether it belongs to a given group of waste. After successfully mastering the game, the pupil proceeds to the recycling line. In this part, a product appears on the screen (Figure 3). The pupil has to determine the material of the given product. The game's content is in line with the objectives of the SEP.

The specific standards in the game are waste materials, waste sorting, properties, and secondary uses of waste materials, justifying the use of waste materials, evaluating types of household waste, indicating the possibility of secondary use of waste materials, and others. In terms of content, the game belongs to the games that achieve a specific learning objective in one lesson. The game has a storyline and problem-solving challenges. It provides feedback through the award of badges for the successful completion of each stage. An essential source of motivation is the timer for each task and the fact that if pupils make too many mistakes, they cannot continue the game and have to start again. It is impossible to complete the digital game successfully by clicking without thinking. However, a certain number of mistakes is acceptable. The game does not allow pupils to actively participate in the action or change the environment: they are only passive observers. Recycling is a short digital game handled simply. The game primarily contains static images and

lacks animation elements, either audio or visual. It is not time consuming, in the range of 5–10 minutes. It allows the inclusion of cross-cutting themes, such as environmental education.

Fig. 3. Screenshot of the digital game Recycling [146]

Woodwork Simulator. The digital game provides a set of hand tools with which pupils can simulate different woodworking technologies (Figure 4). The game also allows free creation, i.e., the production of a product according to your imagination with your workflow. It also includes three templates (birdhouse, chair and table), and with their help, pupils can learn to create according to the template, reading and understanding the workflow. From the above, we can conclude that the content of this game also corresponds to the objectives set out in the SEP. The specific standards are wood products, wooden objects, bending, separating, joining, and finishing the wood surface. The game's content is also applicable within the thematic area of Folk traditions and crafts in the simulation of crafts-processing wooden material. The game contains all motivational attributes. It involves the active participation of pupils. The pupil becomes part of the action, moves freely around the workshop, and has an opportunity to turn around and manipulate the tools with which the pupil carries out various technological procedures of woodworking. We also positively evaluate the graphic design. It is of very high quality, and the digital simulation is similar to reality. It effectively manages to keep the pupil's attention. With the help of the game, it is possible to apply cross-cutting regional education. The assignment determines the time intensity of the game. It is possible to play the game within one lesson and for an average of 15–30 minutes. Due to the content and the time needed for playing, it is suitable for fulfilling the objective of one thematic unit. However, the teacher can use some activities as an alternative way of conveying technological practices.
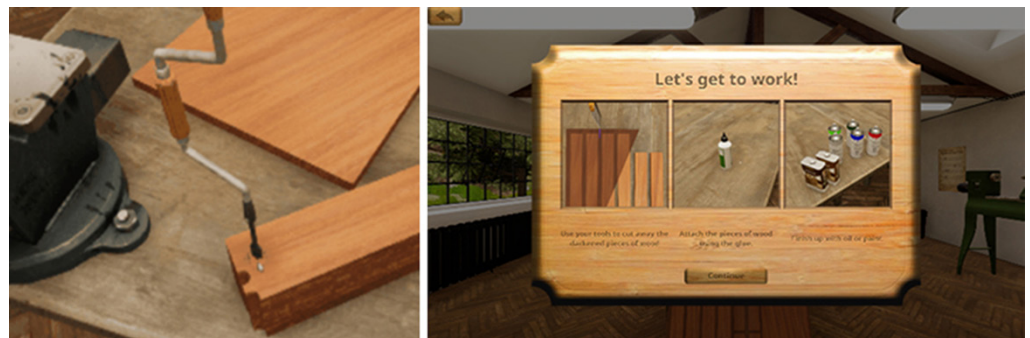

Fig. 4. Screenshot of the digital game Woodwork Simulator [147]

Thematic unit: Basics of Construction.

3D Models: Free Building. The digital game consists of a square grid where pupils can build objects in 3D visualisation (Figure 5). The game does not provide pupils with any sketches or templates for construction. Thus, there is no set goal; the teachers can design it by themselves, or the pupils can choose it. However, it allows the development of technical and spatial imagination in modeling objects according to pupil's creativity. The teacher can also use the game to create models, according to which the pupils will construct real objects, e.g., from building blocks. The game does not contain motivational elements. It has a simple graphic design, not very effective, which may lead to a loss of interest of the pupils in the activity. The game can be classified in the area of games to achieve a specific educational objective. The time requirement is in the range of 1–5 minutes, depending on the work assignment.
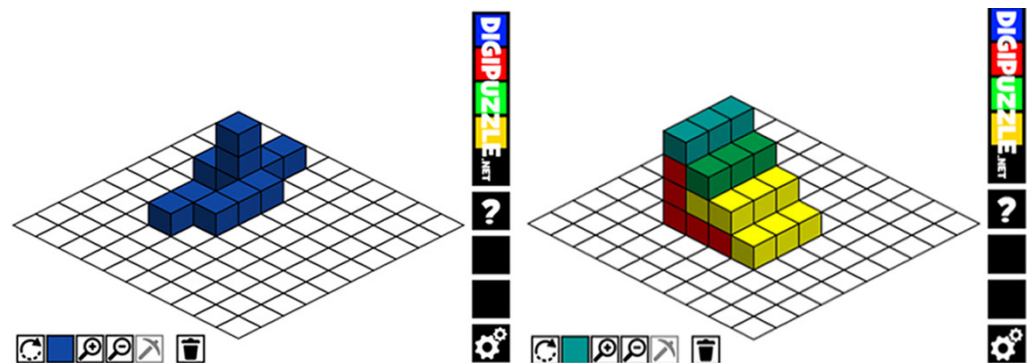

Fig. 5. Screenshot of the digital game 3D Models: Free Building [148]

Circuit Construction Kit: DC. The Circuit Construction Kit is an educational simulation in which pupils have an opportunity to construct electrical circuits using components such as a power source, a wire, a light bulb, a switch, and others (Figure 6). In its content, the game enables acquiring knowledge and skills about electricity and electrical circuits, thus enabling the fulfillment of the objectives of the curriculum. In the simulation, pupils learn to connect a functional electronic circuit, learn about the conductivity and nonconductivity of different materials (e.g., coin, paper clip, banknote) and learn about the function of the ammeter and voltmeter. It is possible to include the above content in the area of games to achieve the learning objective of several thematic units. The pupils become active participants in it, constructing a circuit based on the teacher's requirements or their imagination. Thus, the simulation has no given goal. The game has the light and sound effects triggered when pupils connect the appliances correctly to the circuit as a motivational element. Graphically, the simulation is well designed, clear, transparent, and very good for orientation; for even younger pupils, the graphics are simpler. From the cross-cutting themes, the simulation enables the fulfillment of health and safety objectives and environmental education. It is not time consuming; it takes, on average, 5–8 minutes to build a simple circuit.

Fig. 6. Screenshot of the simulation Circuit Construction Kit: DC [149]

Teaching software: Traffic Education. Traffic education is a teaching programme that includes a fun practice part containing computer games. As the name of the programme suggests, the central theme of the programme is traffic education, including three main thematic areas (Figure 7):

- Rules of the road for pedestrians, cyclists and motor vehicles,
- Traffic signs, police officer's instructions when controlling traffic, traffic lights,
- Rules for safe travel to school and first aid.

The fun practice part works on the principle of games with objectives such as traffic, "Man, don't be angry" test questions, correct naming of traffic signs and their colouring, compulsory bicycle and cyclist's equipment, safe way to school and knowledge of the rules of the intersection. The teaching programme and its games align with the content of the Man and the World of Work educational area. The content allows for the application of games to meet a specific objective within a single lesson, and it is also possible to implement it during several lessons. The treatment of some topics is also suitable as an alternative way of conveying learning. The pupils are motivated by various play elements within the game because they receive feedback, several challenges and competitions. They do not involve the active participation of the pupil, who plays the role of a kind of observer and whose task is usually to click correctly. The game's graphics are attractive, playfully coloured and engaging for the pupil. However, the game lacks any animations or simulations that could better hold the pupil's attention. The game does not allow for cross-cutting themes. It is not time consuming, containing several short 5–10 minute games.

Fig. 7. Screenshot of the tutorial software Traffic Education [150]

Thematic unit: Nutrition and Food preparation.

Supermarket Sim. Supermarket Sim is a simulated game where pupils are free to move around and shop in the store (Figure 8). The game provides the opportunity to go through the entire shopping process, including paying for purchases. Specific standards included in the game are grocery shopping, pricing of purchases, packaging materials and consumer identification. The game can be categorised as a game to achieve the educational objective of one lesson. However, by discussing it with the pupils, the teacher can include other standards such as food storage, advantages and disadvantages of shopping at the supermarket, marketplace, and others. The game has a goal in the form of items to be purchased. It also incorporates changes in difficulty in the manner of shopping within a prescribed time, providing a result

and active participation of pupils because they can move freely around the super-market. The graphic design is of very high quality, and the execution of the products is almost as real. The time difficulty of the game depends on the objective, and it can last from 5 to 30 minutes.

Fig. 8. Screenshot of the simulated game Supermarket Sim [151]

Cooking Simulator. In this digital-simulation game, pupils have the opportunity to prepare simple and more complex dishes according to a recipe (the objective of the game). There is a free mode where they have the chance to experiment, prac-tice and learn recipes. They also have the opportunity to move freely around the kitchen (Figure 9). The game's content aligns with the standards included directly in the game, such as knowing the kitchen, its main parts, the layout of tools, appli-ances, their importance, basic safety and hygiene rules and preparing a simple dish. Therefore, it is possible to include the game to achieve the specific learning objective of one lesson. The game contains challenges, simple problems to be solved, and active participation of the pupil. It also has varying difficulty, making it a more engaging version. Graphically, it is exciting, and the simulation is very much in line with reality. It contains a wide range of colours and plenty of animations. Among the cross-cutting themes, it is possible to apply Personal and Social Development, Protection of Life and Health. The time commitment is adaptable to the teacher's requirements. The game can last between 5 and 30 minutes.

Fig. 9. Screenshot of the simulated game Cooking Simulator [152]

Thematic unit: Folk crafts.

Master of Pottery. This is a digital simulation game whose essence is the produc-tion of a ceramic vessel (Figure 10). The pupil gradually goes through all the stages of pottery production, from modeling on the potter's wheel, through drying, firing in the pottery kiln, to glazing with paints.

The game's content is in line with the standards for the Folk Crafts subarea. Pupils have the opportunity to get to know better the ceramic workshop, tools and imple-ments used in clay processing. The game allows pupils to meet the objectives of a

single lesson, but the teacher can also use it to provide alternative ways of conveying techniques that would not otherwise be possible in the classroom. The game contains several motivational elements. Pupils are allowed to create any type of pottery and then have the opportunity to sell their products in an imaginary way. It also contains aspects of competition by motivating pupils to create the most beautiful product possible from the pool of classmates. It is possible to display the individual products made by the pupils as part of the game. As for active participation, this is the main element of this digital game based on creative creation. The game has a high-quality graphic design that is also very close to reality, which positively affects the quality of the knowledge acquired through the digital game. It contains plenty of colour and animation. Its application is also possible in the cross-cutting theme of regional education and folk culture, communicated to pupils through the possibility of making ceramics. The time span of the game is from 15 to 30 min.
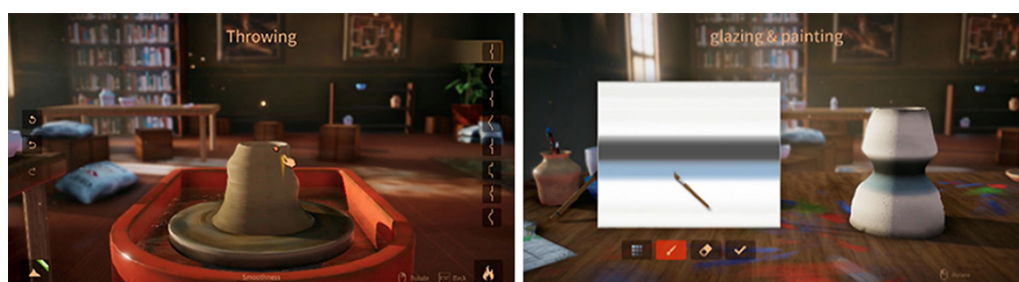

Fig. 10. Screenshots of the simulated game Master of Pottery [153]

6 DISCUSSION AND CONCLUSION

The main objective of this study was to map and analyse the currently available digital games that are suitable for technical education, specifically for the educational area of Man and the World of Work at the primary level of elementary schools. Based on the analysis, we can deduce that there are already several digital games suitable for use in such a specific area as technical education of pupils. We found out that the selected games are well constructed and fulfill both design and education aspects. Most of the games are designed so that they attract the pupils and bring the desired upbringing and learning achievements. They are based on simple and intuitive ways of their use, which for younger learners is an outstanding advantage. We did not record any significant differences between the different games; only minimal differences in motivation, control method, active participation of the pupil, and design, similar to the research by Cheung and Ng [154] or Imlig-Iten and Petko [155]. Concerning pedagogical practice, we see the main problem of some games in the lack of temporal adaptation to the classroom's needs, as they are generally designed for long-term play by players. Some lack a goal, leading pupils to lose attention and motivation. Dedeaux and Hartsell [156] reached similar findings. They note that feedback from participants shows a positive response towards the games, except that some distractions and technicalities have interfered with their learning. Educational and other serious games rarely have the kinds of budgets that AAA games do, so they are not necessarily expensive. Good design is always demanding and applies to all types of learning involving games or game elements [157]. We find the above analysis to be beneficial for practice. It offers a selection of games aligned with the curriculum content of the Work education subject for Years 3 and 4

of primary school. Its theoretical elaboration also contributes to research focusing on assessing the suitability of digital games in education. The above study is only a partial one. It is crucial to verify further the games in practice to get comprehensive results, such as using game sessions as data-collection tools, which should be more frequent to get various data, including game performance score, log value, or reaction time. Future studies may explore the long-term effects of gaming on pupils' knowledge retention and the applicability of the information in other contexts.

7 ACKNOWLEDGEMENTS

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