

# Key Characteristics of Digital Educational Games for Students With Intellectual Disabilities

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## ABSTRACT

An individual approach to learning is very important for students with disabilities. Teaching based on games enables certain educational content to be introduced to students in a suitable and understandable way. The aim of this paper is to identify important characteristics digital educational games should have to be playable by students with intellectual disabilities. The key characteristics will facilitate special education teachers' selection of digital educational games that their students can play which will enhance the teaching process and enable students with intellectual disabilities to acquire academic and socio-emotional skills necessary to function in everyday life. The research was conducted in two phases. The first phase included a review of the literature that identified 13 characteristics. The second phase of the research was a survey with special education teachers that provided leveling for eight characteristics and defined nine additional characteristics without leveling by which one can assess whether a game can be played by a student with intellectual disabilities.

## KEYWORDS

Assessment Domains, DSM-5, Game Characteristics, Game Genre, Game Type, Learning Outcomes, Marzano's and Kendal's New Taxonomy, User-Specific Characteristics

## INTRODUCTION

Intellectual disability is a neurodevelopmental disorder characterized by a deficit in an individual's intellectual and adaptive functioning present during childhood (American Psychiatric Association, 2013). It affects all fields of early development, including cognitive, motor, auditory, language, and socio-emotional development, and leads to difficulties in conceptual reasoning, social and practical functioning (Maulik, Mascarenhas, Mathers, Dua, & Saxena, 2011; Vuijk, Hartman, Scherder, & Visscher, 2010). Although all students with intellectual disabilities have difficulties in those domains, there are numerous differences in abilities and achievements which are always conditioned by the biological basis, but also by the influences from the environment and the quality of support and incentives in early development. Thus, individual differences in abilities differ across cognitive abilities measured by IQ tests (from 0 to 70(5)), language abilities (from verbal to nonverbal), motoric abilities (from independent motoric functioning to dependent), and socio-emotional abilities (from high to low level of well-being).

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This paper focuses on students with mild and moderate intellectual disabilities or mild intellectual disabilities with comorbidities. The education process of those students operates between student's abilities and needs and society (Biesta, 2014), and curriculum is a bridge between them. The author (Moljord, 2018) pointed out that the educational content is crucial to equip those students with needed skills, while curriculum research for this learner group is sparse. In special school settings, students are educated by adopted curriculum or curriculum for developing life skills. Curriculum content and subject matter (what is taught) are normative and prescriptive (Deng & Luke, 2008), although often argued in the context of the importance of academic versus functional life skills orientated curriculum (Alwell & Cobb, 2009; Shurr & Bouck, 2013). An appropriate curriculum is fundamental for developing cognitive, social, and functional skills of students with mild or moderate intellectual disabilities for future participation and, as much as possible independent living, in society. The curriculum should be aligned with the conceptual, social, and practical abilities and functioning of those students and their motivation and independence skills allowing the development of problem-solving skills, language development, use of concepts such as money or time, communicational (inter and intrapersonal) skills, socio-emotional development as well as judgment, and practical adaptive skills such as independence, self-care, activities of daily living, occupation (Maulik, Mascarenhas, Mathers, Dua, & Saxena, 2011).

For this reason, an individual approach to learning is very important for students with intellectual disabilities. Teaching based on games enables that certain educational content can be introduced to students in a suitable and to them understandable way. The specificity of the education of students with intellectual disabilities is that the focus is on the adaptive skills of students that are necessary for everyday life, and the GDTL (Game-Design Teaching and Learning) approach can help to meet these specificities. This approach, introduced by the author Gee (Gee & Price, 2021), states that it is not only important to use games in the classroom, but to use deep game-based principles of teaching and learning across the curriculum.

Digital educational games specifically designed for students with intellectual disabilities are difficult to find, and existing ones are not always available to the public. A systematic literature review showed that only 21 digital games especially made for students with intellectual disabilities were designed in the period from 2010 to 2019 (according to available references) (Stančin, Hoić-Božić, & Skočić Mihić, 2020). For this reason, teachers who want to improve the teaching process are often in a situation where they have to find games that are not explicitly categorized as games for students with intellectual disabilities, but such students can play them. In order to find such games, special education teachers must first find available game databases such as iTunes, Google play, or some websites. The next step is to search the databases for digital educational games and test each game for special requirements due to the specific difficulties of the students. Since there is no unified list to look for when selecting games for students with intellectual disabilities, the process of finding appropriate games is very time-consuming.

The aim of this paper is to define a set of characteristics by which digital educational games can be described to determine whether a game is suitable for students with intellectual disabilities. In this paper, the game characteristics refer to the attributes by which each digital educational game can be described to assess whether it is suitable for individuals with intellectual disabilities. In this sense, the main contributions of the paper are to a) find a set of existing characteristics of digital games for education through a literature review and b) define new set of characteristics of digital games for education that allow a precise definition of whether a game can be played by students with intellectual disabilities. The identified set of characteristics will be later used in an ontology based system that will facilitate the education process of students with intellectual disabilities for special education teachers.

This paper is organized as follows: section 2 is dealing with related work in the field, section 3 describes how the research was done, and the results of the research. Section 4 discusses the findings, and section 5 concludes the paper and gives insight in the future work.

## BACKGROUND

By reviewing the related work, it was shown that a small number of papers deal with the characteristics of educational games. Since there is no unified classification of games for educational purposes, as there is for the non-educational, commercial game industry, some authors attended to make a taxonomy of games for educational purposes.

For example, the author (Amory, 2007) created a theoretical framework for the development and evaluation of computer video games which can be useful in the learning environment. In the framework, an educational game consists of several components like communication, literacy, memory, and actors space which provides a way to conceptualize digital games for education. This methodology can be used as a checklist of important criteria to design educational games or to evaluate game design specifications, but the author emphasizes the need to evaluate the viability and veracity of the framework in creating complex learning environments.

The authors (An & Cao, 2017) examined the characteristics of digital learning games designed by in-service teachers. In their study, the authors singled out some characteristics of games which teachers design for their students. The characteristics were: level of a game, single-player vs. multiplayer, duration, 2D vs. 3D games, gaming device, estimated length of playing, goals, rules, and context.

Further, the authors (Tsikinas & Xinogalos, 2018) examined important frameworks for designing serious games for people with intellectual disabilities. As part of their study the authors mentioned game attributes as an important part of a conceptual framework that assists the development teams in the design process of educational games. Game attributes assist in the learning process and the engagement of the learner. Besides from attributes, the authors also point out instructional content, intended learning outcomes, learning activity, reflection, game genre, mechanics and achievements as relevant for conceptual framework.

From the before mentioned, and the lack of existing research dealing with game characteristics for students with intellectual disabilities, the authors consider that it is important to identify a set of digital game characteristics that indicate whether a game is appropriate for students with intellectual disabilities. The newly identified set of characteristics will be used to formally describe this domain and create an ontology based system.

## METHODOLOGY

As mentioned in the introduction, the aim of the research is to identify a set of characteristics that games must have in order to be played by students with intellectual disabilities. To this end, a literature review was conducted and several characteristics of games were found. Since the literature review did not find any specific characteristics of games for students with intellectual disabilities, a survey was conducted in which experts in the field of special education gave their opinions on game characteristics which resulted in a set of characteristics of digital educational games important for students with intellectual disabilities.

### Step 1 – Literature Review

#### *Protocol, Databases Searching and Data Extraction*

The first step of the research includes a literature review with the aim of finding a set of existing characteristics of digital educational games. This paper follows a guide to conducting a systematic literature review of information system research by the authors Okoli and Schabram (2010) because it meets the needs of information system researchers who have to combine social science and computing science research methods.

Before conducting the literature review, a prior protocol was made. In the protocol the authors defined that this research should include scientific journals as well as conference proceedings. In order to collect papers, keywords like “classification”, “characteristics”, “taxonomy” and “concepts” were combined with keywords “games”, “educational games”, “education”, “digital educational games”,

and searched in scientific databases Scopus, Web of Science and on the web. Since the queries found a large number of papers (1.415) that meet the keywords, it was necessary to reduce the given set of papers by applying include and exclude criteria defined in the protocol (table 1) in order to single out characteristics that will serve to describe digital games.

After applying include and exclude criteria 1 to 3 listed in table 1 and deleting duplicate studies, there were 215 papers left. In order to find game characteristics, include and exclude criteria 4 was applied by a qualitative review of papers and 12 papers were left for analyzing. By doing that, characteristics that will serve to describe digital games were singled out and grouped into three categories: characteristics of digital games in general, characteristics of digital educational games, and characteristics of digital educational games for students with intellectual disabilities. All papers were exported in the BibTeX format and analyzed in the JabRef tool.

**Table 1. Exclude and include criteria**

No.	EXCLUDE CRITERIA	INCLUDE CRITERIA
1	Literature reviews, books, book sections and reports.	Journal and conference articles.
2	Studies not written in English.	Studies written in English.
3	Studies not in the field of computer science and social science.	Studies in the field of computer science and social science.
4	Studies that develop a game but do not mention any game characteristic.	Studies that mention game characteristics in the educational context.

### *Results of the Literature Review*

From the 12 analyzed papers, 13 characteristics were singled out and grouped into three categories: characteristics of digital games in general, characteristics of digital educational games, characteristics of digital educational games for students with intellectual disabilities (table 2).

**Table 2. Number of characteristics by category**

Category	Number of characteristics
Characteristics of digital games in general	7
Characteristics of digital educational games	6
Characteristics of digital educational games for students with intellectual disabilities	0

Table 3 sums up important characteristics of digital games in general and digital educational games. Even though the characteristics of digital games in general were found in educational game taxonomies, they are equal for educational as for non-educational games. Regarding this, the first characteristic refers to the type of game in order to distinguish educational from non-educational games. The other characteristics like audio, narrative, rules, duration, feedback, and prerequisite in the domain are in detail described in table 3. The defined characteristics of digital educational games refer to the game genre, type of learning outcome of the game, category of mental processes which the game address, knowledge domain of the game, complexity and playing style and are in detail described in table 3.

Table 3. Set of characteristics of digital games extracted from the literature

No.	Characteristic	Content	Description	Source
<b>Characteristics of digital games in general</b>				
1	Type of game	Non-educational game, Educational game	Is a game educational or non-educational? It is important to distinguish educational from non-educational games because some characteristics of games apply to all games, while some apply only to educational or non-educational ones.	(O'Brien, Lawless, & Schrader, 2010)
2	Audio	Yes, No	Does the game have audio sound? Audio means any sound – songs, speech...	(Core Game Ontology, 2020)
3	Narrative	Yes, No	Does the game have a narrative? It is examined whether the game has guidance through the game – oral guidance or writing guidance.	
4	Game rules	Yes, No	Does the game have rules or can you freely move through the game? Most games have some rules, but some of them, especially for younger children, enable to move freely through the game (e.g. digital coloring books, games for learning the alphabet...)	(Ghannem, 2014)
5	Duration	Time-limited activities, Free playing	Does the game have time-limited activities or is it a free playing game? This is also important for teachers in order to plan class activities.	
6	Feedback	No feedback, Throughout the game, At the end	Does the game have feedback messages throughout the game or only at the end? Feedback includes messages, points, tips, or instructions for playing.	
7	Prerequisite in the domain	No, Little, Yes	Does the game require previous knowledge in the domain? This is important for the recommendation of games for students.	
<b>Characteristics of digital educational games</b>				
8	Game genre	Linear, Competitive, Strategic, Role-playing	What genre is the game? Linear games – use linear logic but the actions employed in playing may not be linear. They have clear problems, require very little complex problem-solving ability, the rules are very repetitive, and refer to traditional drill-and-practice learning like puzzles, shooting, “jump-and-run” games. Competitive games – include other players (or “robots”) competitively or collaboratively. They vary widely in their aesthetic features, and the player must predict the actions of other players. Strategic games – involve managing a complex system (city, country, business). Players learn domain-specific content knowledge, problem-solving, and fine motor skills become less critical for success. Role-playing games – players create unique characters with some abilities and must succeed at various challenges in order to improve the characters' abilities.	(O'Brien, Lawless, & Schrader, 2010)
9	Gagne's five categories of learning outcomes	Motor skills, Verbal information, Intellectual skills, Cognitive strategies, Attitudes	What is the type of learning outcome of the game? Motor skills – abilities in physical control and expression. Verbal information – the ability to retain, recall and communicate facts. Intellectual skills – ability to manipulate knowledge through cognitive operations. Cognitive strategies – akin to metacognitive abilities, monitoring a learner's behavior. Attitudes – the learner's ability to choose from among a group of options due to personal preference rather than logic.	(Gagne & Briggs, 1974; O'Brien, Lawless, & Schrader, 2010)

No.	Characteristic	Content	Description	Source
10	Marzano's and Kendal's New taxonomy – category of mental processes	Retrieval, Comprehension, Analysis, Knowledge utilization, Metacognition, Self-system thinking	Which category of mental processes does the game address? Retrieval – recognizing, recalling, executing Comprehension – integrating, symbolizing Analysis – matching, classifying, analyzing errors, generalizing, specifying Knowledge utilization – decision making, problem-solving, experimenting, investigating Metacognition – specifying goals, process monitoring, monitoring clarity, monitoring accuracy Self-system thinking – examining importance, examining efficacy, examining emotional response, examining motivation	(Marzano & Kendall, 2007)
11	Marzano's and Kendal's New taxonomy –knowledge domain	Information, Mental procedures, Psychomotor procedures	To which knowledge domain belongs the game? Information – (declarative knowledge) vocabulary terms, facts, time sequences, principles, and generalizations Mental procedures – (procedural knowledge) those who can be executed automatically like tactics, algorithms, single rules, and those that must be controlled like macro procedures Psychomotor procedures – foundational procedures, simple combination procedures, complex combination procedures	
12	Complexity of learning	Learning without noticing, Learning by playing, Reality as a game	What is the complexity of the game? Learning without noticing – simple educational tasks, the pedagogical goal is the consolidation of existing knowledge, memorizing concepts and symbols. Learning by playing – requires comprehension of available knowledge, the conditions of the task are set in the game form. Reality as a game – the education material is more complex extensive and directly connected to the real word requiring reflection.	(Bylieva & Sastre, 2018)
13	Playing style	Competitive, Cooperative	Is the game competitive or cooperative? Competitive games have other players and the main goal is to overtake the other players. Cooperative games are single-player games or multiplayer games with the aim of co-creation.	(Ghannem, 2014)

The whole set of defined characteristics will be explained and analyzed in the discussion section. Since characteristics of digital educational games for students with intellectual disabilities were not found in the literature, the second step of this research was made.

## Step 2 – Survey

As the literature review did not find any special characteristics that could fit in the third category and that would indicate the possibility of playing games for students with intellectual disabilities, the step two of the research included the definition of these special characteristics.

## Research Process

In this step, a survey was conducted with the aim of finding a set of characteristics of digital educational games for students with intellectual disabilities.

According to DSM-V (American Psychiatric Association, 2013), which features the most current text updates based on scientific literature with contributions from more than 200 professionals and provides a standard for the diagnosis and manifestations of mental disorders, there are three domains by which the various levels of severity of intellectual disabilities are defined based on the adaptive functioning, and not IQ scores. These three domains (conceptual, social, and practical) describe characteristics that are used to determine the adaptive functioning of each student individually. The characteristics can also provide insight into the limitations of each student and the areas and skills that a student must further develop. This fact can also be used to describe games through the skill levels they satisfy.

Accordingly, the authors first extracted the characteristics from DSM-V according to which the student's adaptive functioning is assessed and the level of intellectual disability is determined. After extracting the characteristics, it was necessary to determine levels for each characteristic in order to describe digital educational games. This was done in collaboration with a specialist in speech and language pathology and specialist in educational rehabilitation. After defining the levels, a questionnaire was made in order to check the defined levels with experts in the field. The questions in the questionnaire were formed to express agreement with the characteristics and defined levels for each characteristic. In case of disagreement participants were asked to suggest their own characteristics/leveling.

### *Participants*

The survey included five participants, two special education teachers from the Center for Education Rijeka, Croatia, and three special education teachers from the Center for Education "Tomislav Špoljar" in Varaždin, Croatia. The teachers are working with students with intellectual disabilities on a daily basis. Two of them are working for 29 years, one for 23 years, and two for 11 years with students with intellectual disabilities. The participants were selected according to the availability of the authors, but taking into account the following criteria: (1) more than 10 years' work experience in education of students with intellectual disabilities; (2) experience in using digital educational games in the teaching process; (3) recommendation of the head of the institution where the expert is working.

### *Data Collection and Analysis*

In the survey, a questionnaire of 12 yes/no questions was given to participants where they were asked to express their agreement (answer yes) or disagreement (answer no) with the given levels and, in case of disagreement, to suggest changes. An example of the question for the communication characteristic in the social domain is: "In your opinion, is the next leveling for the area of communication right?" This question was repeated for each characteristic with the possibility of commenting on disagreements and proposing own gradations. Taking into account the availability of digital educational games, for the social domain related to emotions and behavior and for the practical domain, no leveling was suggested, so the survey only examined whether these characteristics are considered relevant in the context of digital educational games. The survey was created and analyzed in the survey system Lime Survey Software.

After collecting the answers, the data was analyzed and in places where experts have indicated their disagreement with the current leveling concordance in the leveling was determined and based on that a single leveling was made for each characteristic of the domains. The process was repeated for each characteristic of each domain. Finally, a list of levels of characteristics was obtained which will be explained in the discussion part.

### *Results of the Survey*

The relevance of the levels was tested in the survey where participants were asked to express their agreement or disagreement with the given levels and, in case of disagreement, to suggest changes. All participants agreed that the proposed characteristics are relevant to the field of digital educational games, and all participants agreed with the proposed leveling of characteristics. The final list of characteristic and their leveling is given in Table 4.

## **DISCUSSION**

This chapter presents the discussion of the obtained results from both steps of this research together – the literature review and the survey.

The most important difference between non-educational and educational games is in the well-defined pedagogical aspect of games for educational purposes. With this in mind, it is important to highlight pedagogical characteristics of educational games. Authors (O'Brien, Lawless, & Schrader, 2010) used some pedagogical aspects in order to classify digital games for educational purposes.

Table 4. Set of characteristics of digital educational games for students with intellectual disabilities

No.	Characteristics	Content
<b>Conceptual domain</b>		
1	Reading	0. the game does not develop reading skills 1. the game develops pre-reading skills (distinguishing text from image, tracking text from left to right, global reading ...) 2. the game develops the skill of reading: 2.1. by spelling and/or reading syllables 2.2. shorter and longer words 2.3. whole sentences 3. the game develops the skill of reading with understanding
2	Writing	0. the game does not develop writing skills 1. the game develops the writing of first letters 2. the game develops formal writing 3. the game develops handwriting
3	Mathematics	0. the game does not develop mathematical skills 1. the game develops pre-mathematical skills (relations in space, relations between objects, properties of objects, geometric shapes, quantity) 2. the game develops basic mathematical skills: 2.1. connecting number and quantity 2.2. naming numbers (single-digit, two-digit, three-digit) 3. the game develops the skill of counting 4. the game develops addition and subtraction 4.1. up to 5 4.2. up to 10 4.3. to 100 5. the game develops multiplication with a calculator
4	Time	0. the game does not develop time-related skills 1. the game develops the skill of naming the days of the week and the seasons 2. the game develops the skill of determining the time of day (morning, noon, afternoon, evening, night) 3. the game develops the skill of determining time concepts - today, yesterday, tomorrow 4. the game develops the skill of naming the month of the year 5. the game develops the skill of reading time on the clock
5	Money	0. the game does not develop money recognition and money management skills 1. the game develops the skill of recognizing money as an object 2. the game develops the skill of distinguishing coins from banknotes 3. the game develops the skill of determining the value of money individually 4. the game develops the skill of understanding the use value of money 5. the game develops the skill of making purchases
<b>Social domain</b>		
6	Communication	0. the game does not develop communication skills 1. the game develops non-verbal communication (gesture, image, facial expressions) 2. the game develops poor verbal communication 3. the game develops verbal communication in sentences
7	Conversation	0. the game does not develop conversational skills 1. the game develops a conversation with the student that is related to his usual social situation 2. the game develops a more complex conversation with the student with topics outside of his usual social situation
8	Language	Linguistic comprehension 0. the game does not develop the skill of linguistic comprehension 1. the game develops linguistic comprehension of grammatically substantively simple sentences 2. the game develops linguistic comprehension of grammatically substantively more complex sentences Language production 0. the game does not develop the skill of language production 1. the game develops the skill of using simple utterances 2. the game develops the skill of using complex sentence statements
9	Emotions and behavior *	<ul style="list-style-type: none"> <li>● the game develops the skills of expressing and regulating emotions</li> <li>● the game develops rule-following skills</li> <li>● the game develops skills of understanding risky social situations</li> <li>● the game develops risk recognition skills for manipulation from others</li> </ul>
<b>Practical domain</b>		
10	Transportation *	<ul style="list-style-type: none"> <li>● the game develops the skills of using public transport</li> </ul>
11	Going to school *	<ul style="list-style-type: none"> <li>● the game develops the skills of going to school</li> </ul>
12	Feeding *	<ul style="list-style-type: none"> <li>● the game develops feeding skills</li> </ul>
13	Dressing *	<ul style="list-style-type: none"> <li>● the game develops dressing skills</li> </ul>
14	Personal hygiene *	<ul style="list-style-type: none"> <li>● the game develops personal hygiene skills</li> </ul>

\* No levels were defined. It is only necessary to indicate the existence of different characteristics in games.



They proposed a taxonomy that outlines four game genres that depend on the cognitive functions and skills the games engage. In the first linear game genre, success requires linear logic, in the second competitive game genre, success requires anticipating actions of other players besides linear logic. In the third, strategic game genre, success requires strategic planning and management of a complex system, and in the last, role-playing game genre success requires developing and maintaining a profile of probabilities within a complex environment. Accordingly, these genres are included as one of the important characteristics of digital educational games (characteristic 9 in table 3).

All before mentioned game genres are associated with the five categories of learning outcomes (Gagne & Briggs, 1974) which is also included as a characteristic (characteristic 10 in table 3), Bloom's taxonomy of educational objectives (Bloom & Krathwohl, 1956), and Jonassen's typology of problem-solving (Jonassen, 2004). Although Jonassen's Problem Solving Types (Dilemma, Case analysis, Design, Strategic performance, Diagnosis-solution, Troubleshooting, Decision-making, Rule-using, Story, Algorithmic, Logical) fit good into the linking pattern of the educational games taxonomy, it was not included in the final list of characteristics due to the greatest focus on the problem domain which is in the higher levels of the taxonomy (Jonassen, 2004; O'Brien, Lawless, & Schrader, 2010), and therefore not adequate for students with intellectual disabilities.

Also, the Bloom taxonomy is not included in the set of characteristics because it has some flaws. The taxonomy complements traditional learning with academic procedures of step-by-step learning, but the digital environment enables the learner to engage the content first and then modify their approach through iterative failure/feedback (reverse order of Bloom's hierarchy) (Cao & Hill, 2009). Bloom's taxonomy also oversimplifies the nature of thought and its relationship to learning (Furst, 1994). For that reason, authors Anderson, Krathwohl et al. (Anderson, et al., 2001) made a revision of Bloom's taxonomy, but that revision also attempted to use degrees of difficulty as the basis of the difference between levels of the taxonomy. So, any attempt to design a taxonomy based on the difficulty of mental processing is not recommended because of the psychological principle that even the most complex processes can be learned at the level at which it is performed with little or no conscious effort (La Berge, 1995; Marzano & Kendall, 2007) which can be significantly observed in students with intellectual disabilities. For that reason, the authors Marzano and Kendall introduced the New Taxonomy of educational objectives (Marzano & Kendall, 2007) which is a two-dimensional model with six categories of mental processes and three domains of knowledge. The model is based on the three systems of thought – the self-system, the metacognitive system, and the cognitive system (Marzano & Kendall, 2007, p. 19). Also, the New taxonomy includes psychomotor procedures as a type of knowledge which is very important for educational games that seek to enhance the fine motor skills of students. For these reasons, the New Taxonomy is included in the set of the characteristics – as characteristic 11 (category of mental processes) in table 3, and characteristic 12 (domain knowledge) in the same table.

Authors (Bylieva & Sastre, 2018) classified games into three levels depending on their educational complexity. In doing so, they took into account whether training can take place in the game completely or if a certain level of knowledge is required to participate in the game. The first level – learning without noticing includes games with simple educational tasks and the pedagogical goal is the consolidation of existing knowledge, memorization of symbols, and simple skills. The second level – learning by playing requires comprehension processing of available information, and the third level – reality as a game has a more complex educational material and is connected to the real world. As this classification corresponds to the needs of students with intellectual disabilities, it was also included in the set of characteristics (characteristic 13 in table 3).

To make the set of characteristics complete for the needs of ontology based system development, the authors have added several characteristics of digital educational games that will facilitate the process of ontology development. The new set of characteristics are listed in table 5. The first 6 characteristics refer to digital games in general and include the used platform, language of the game, appropriate age for playing, game name, description and URL.

Except for the importance to pointing out major characteristics which are generally important for the use of digital games in education, it is crucial to mark off the characteristics that are specific and should be especially taken into account for students with intellectual disabilities because the advancement of those students is relatively slow (it all depends on the severity of intellectual and adjacent disabilities) which demands frequent repeating of instructions and actions (Stančín & Hoić-Božić, 2019). As seen from the above mentioned, the most important thing in the process of education of an intellectually disabled student is the awareness of individual differences between students, and taking into consideration obstacles that appear as a consequence of difficulties and that could lead to digital exclusion (Rocha, et al., 2012). Those difficulties can be slower learning, low level of reading comprehension, limited fine motoric, lowered spatial perception, poor eyesight, as well as hand or eye coordination, poor finger dexterity, and lowered threshold of information overload (Friedman & Bryen, 2007; Rocha, Bessa, Melo, Barroso, & Cabral, 2016).

Takin this into account, the remaining 4 characteristics in table 5 belong to the characteristics of digital educational games for students with intellectual disabilities. First, it is necessary to associate the game with a particular school/center subject so that teachers know, without prior game testing, with which subject the game correlates (educational area). Also, it is important to know if a game has a virtual assistant, or a teacher takes on that role in the game. This is followed by the ICT requirements of the game because some students are not independent technology users, so the teacher is needed for each subsequent step of a game. Furthermore, students with intellectual disabilities have lowered threshold of information overload, so it is necessary to determine the level of information that appears in a game. Detail descriptions are presented in table 5.

To get a better insight into the whole set of digital educational game characteristics, a game example is given in Table 6. The game is described by all the defined characteristics, and based on this, special education teachers can assess which of their students can play the given game. The Math Kids game is a game for learning counting, addition and subtraction. Because of that the most important thing is to define the mathematics level of the game – it fits in the level 4.2 (the game develops addition and subtraction up to 10) which indicates the teacher which students can play this game. Of course, it is not enough to look only at the level of mathematics, because students with intellectual disabilities also have other obstacles which are before mentioned in the paper. Accordingly, there are also a number of other characteristics of games such as reading, writing, time, money, adaptive skills and the theoretical background of learning through the Gagne's five categories of learning outcomes and Marzano's and Kendal's New taxonomy.

## **LIMITATIONS**

As in most research studies, it is necessary to point out certain limitations of this study. Due to the limited access to specific digital databases, it can be presumed that the access to a larger number of digital databases would give different results. Also, using more or different keywords may have resulted in a larger number of articles because different authors interpret the same terms in a different way. It is also important to mention the narrow regional characteristic and number of participants of the study because it was conducted in two special education centers and involving more schools or special education centers with more experts in the field could give different level of agreement with the proposed levels. Because of that, it is necessary to limit the possibility of generalizing and it cannot be claimed that the study results are representative of the entire population of special education teachers.

## **CONCLUSION AND FUTURE WORK**

Through this work, important characteristics of digital educational games were identified, and a set of characteristics by which each game could be described was defined. The research was made in two phases. The first phase of the research was to review the literature by which 13 characteristics

Table 5. New set of characteristics of digital educational games

No.	Characteristic	Content	Description
<b>Characteristics of digital games in general</b>			
1	Used platform	iOS, Android, Windows, Not platform dependent	Where is the game available? This is important for the teachers in order to know on which platform they can download the game.
2	Language	No language, Croatian, English	Does the game use language or only signs? It is important to point out if the game supports the Croatian language because the system will be tested in Croatian schools.
3	Appropriate age	0-3, 4-7, 8-11, 12-15, 16-19, 20+	Which is the appropriate range of age for playing? The creators of a game often indicate the appropriate age in the description of a game.
4	Game name	String	What is the name of a game? The name serves as an identifier for the game.
5	Game description	String	What is the aim of the game? Description of a game is useful for special education teachers to get familiar with the game.
6	URL	String	Where is the game available? The URL of a game facilitates the game search.
<b>Characteristics of digital educational games for students with intellectual disabilities</b>			
7	Educational Area	Introduction to school and surrounding, Self-care, Communication, Socialization, Creativity, Training in performing activities, Sports, Organized free time spending	To which subject in school/center can the game be associated? This is important information for special education teachers because in that way they can plan their educational activities and use games in the appropriate school subject.
8	Virtual assistant	Yes, No	Does the game have a virtual assistant/tutor? A virtual assistant/tutor is a character in a game who explains how the game works.
9	ICT requirements	Low, Medium, High	What are the ICT requirements of the game? Low – the game is very intuitive, each step of the game is demonstrated Medium – some steps are demonstrated, and some steps are only described High – less intuitive interface, steps of the game are not described nor demonstrated
10	Amount of information	Low, Medium, High	How many new information is presented in the game? Low – one or two new information per screen Medium – three or four new information per screen High – more than for new information per screen

of games were found and grouped into three categories. The second phase of the research included the extraction of game characteristics from the DSM-V (14 characteristics) by which one can assess whether a game can be played by a student with intellectual disabilities. The survey served to evaluate the extracted characteristics and to provide leveling for 9 of the 14 characteristics.

Thus, the set of game characteristics created in this paper has a scientific basis, as it was extracted from existing scientific papers – partly from a systematic literature review, and partly from the DSM-V.

Table 6. Example of describing the game Math Kids with the defined set of characteristics

	Characteristic	Example of a game
<b>Characteristics of digital games in general</b>	Game name	<i>Math Kids</i>
	Game description	<i>Math Kids is the perfect introduction to the basics of counting, addition, and subtraction. It will teach children sorting and logical skills along with early mathematics, giving them the perfect foundation for a lifetime of learning.</i>
	URL	<a href="https://apps.apple.com/us/app/math-kids-add-subtract-count/id1272098657">https://apps.apple.com/us/app/math-kids-add-subtract-count/id1272098657</a>
	Type of game	<i>Educational game</i>
	Audio	<i>Yes</i>
	Narrative	<i>Yes</i>
	Game rules	<i>Yes</i>
	Duration	<i>Free playing</i>
	Feedback	<i>Throughout the game</i>
	Prerequisite in the domain	<i>Little</i>
	Used platform	<i>iOS, Android</i>
	Language	<i>Croatian</i>
	Appropriate age	<i>8-11</i>
<b>Characteristics of digital educational games</b>	Game genre	<i>Linear</i>
	Gagne's five categories of learning outcomes	<i>Intellectual skills</i>
	Marzano's and Kendal's New taxonomy – category of mental processes	<i>Analysis</i>
	Marzano's and Kendal's New taxonomy –knowledge domain	<i>Mental procedures</i>
	Complexity of learning	<i>Learning without noticing</i>
	Playing style	<i>Cooperative</i>
<b>Characteristics of digital educational games for students with intellectual disabilities</b>	Reading	<i>Level 0: the game does not develop reading skills</i>
	Writing	<i>Level 0: the game does not develop writing skills</i>
	Mathematics	<i>Level 4.2: the game develops addition and subtraction up to 10</i>
	Time	<i>Level 0: the game does not develop time-related skills</i>
	Money	<i>Level 0: the game does not develop money recognition and money management skills</i>
	Communication	<i>Level 0: the game does not develop communication skills</i>
	Conversation	<i>Level 0: the game does not develop conversational skills</i>
	Language	<i>Linguistic comprehension – level 1: the game develops linguistic comprehension of grammatically substantively simple sentences Language production – level 0: the game does not develop the skill of language production</i>
	Emotions and behavior	<i>No</i>
	Transportation	<i>No</i>
	Going to school	<i>No</i>
	Feeding	<i>No</i>
	Dressing	<i>No</i>
	Personal hygiene	<i>No</i>
	Educational Area	<i>Training in performing activities</i>
	Virtual assistant	<i>Yes</i>
ICT requirements	<i>Low</i>	
Amount of information	<i>Low</i>	

Accordingly, the contributions of the paper allow for a precise definition of whether a game can be played by students with intellectual disabilities. The defined set of characteristics will serve to create an ontology based system that will provide special education teachers with recommendations which will help them to implement digital games in the teaching process. This will address the student's individual needs with the goal of developing intellectual and adaptive skills of those students. The idea of the ontology is to describe game characteristics, relations, and users in a formal and machine-readable way. Also, by defining semantic data models and combining them with the associated domain knowledge, the individual needs of students can be more formally described which will make it easier for the system to make recommendations.

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