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RULES FOR RECOMMENDING DIGITAL EDUCATIONAL GAMES FOR STUDENTS WITH INTELLECTUAL DISABILITIES

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Abstract

The use of digital educational games in the educational process enhances student motivation and engagement, cultivates their mind and spirit, and can thereby increase learning efficiency. Through the use of digital educational games, students can develop problem-solving skills, language proficiency, and concepts such as money or time. They can also develop communication skills (both interpersonal and intrapersonal), socio-emotional growth, judgment, and practical adaptive skills such as independence, self-care, daily living activities, and occupational tasks. For these reasons, digital educational games are essential in the educational process for students with developmental difficulties.

This study presents rules for recommending digital educational games to be integrated into a system designed for recommending games for students with intellectual disabilities. By integrating the defined rules in the form of computer procedures and algorithms, support will be provided to special education teachers to improve the educational process for their students.

The paper outlines initial rules for recommending digital educational games in the areas of academic skills and communication and everyday life, along with the conditions that describe the circumstances under which these rules apply. Since digital educational games in the academic skills domain are proposed in categories such as reading, writing, mathematical skills, time and money management skills, recommendation rules and corresponding educational objectives are defined for each student skill level. Finally, rules are also defined for additional filtering of digital educational games in specific cases, such as when a game requires more complex communication or certain reading skills that the student has not yet acquired. The conclusion of the paper summarizes key findings and provides guidelines for future research.

Keywords: digital games, pedagogical rules, students with disabilities

1 INTRODUCTION

One of the modern methods of using information and communication technology (ICT) in education has proven to be digital educational games. Teaching that incorporates digital educational games as an independent concept and enables the acquisition of conceptual, social and practical skills in a playful way also takes into account an individualised approach for students. In this way, specific educational content can be presented to students in an appropriate and understandable way (Stančin & Hoić-Božić, 2019; Ishak, Hasran, & Din, 2023). The use of digital educational games in the educational process enhances students' motivation and engagement, cultivates their mind and mood, and can thus improve learning efficiency (Woo, 2014). Through the use of digital educational games, skills such as problem solving, language development, the application of concepts such as money or time, communication skills (interpersonal and intrapersonal), socio-emotional development, judgement and practical adaptive skills — such as independence, self-care,

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activities of daily living and vocational tasks — can be developed (Maulik, Mascarenhas, Mathers, Dua, & Saxena, 2011). For these reasons, digital educational games are essential in the educational process for students with special needs.

This study presents rules for recommending digital educational games to be integrated into a system for recommending digital educational games for students with intellectual disabilities. In this sense, the aim of the work is to present the rules for recommending digital educational games that will be used to create algorithms that will be integrated into an ontology-based system that will support professionals in the field of education and rehabilitation in improving the educational process for their students. The system for recommending digital educational games facilitates the process of selecting appropriate digital educational games for students by professionals in the field of education and rehabilitation. Based on the aim and purpose of this study, the following contribution was made: Rules for recommendations were developed according to pedagogical and educational-rehabilitation criteria that take into account the individual needs of students with intellectual disabilities.

2 RECOMMENDING RULES

In earlier phases of the research, a scale for assessing skills in the use of digital educational games by students with intellectual disabilities and a categorisation of the requirements and functionalities of digital educational games were developed (Stančin, Hoić-Božić, & Skočić Mihić, 2022). It is important to mention that the assessment scale was developed using the Delphi method (Fink-Hafner, Dagen, Doušak, Novak, & Hafner-Fink, 2019) based on surveys of professionals in the field of education and rehabilitation who work with students with special needs on a daily basis. The categorisation of requirements and functionalities was obtained through a systematic literature review (Stančin, Hoić-Božić, & Skočić Mihić, 2022). Consequently, these criteria represent pedagogical and educational- rehabilitation criteria as they are based on scientific literature in the field of educational rehabilitation, the DSM-V (American Psychiatric Association, 2013; American Psyhiatric Association, 2000) manual and the expertise of specialists (Stančin, Hoić-Božić, & Skočić Mihić, 2020). On this basis, rules for recommending digital educational games have been developed that take into account the individual needs of students with intellectual disabilities. In order to meet these individual needs, values were identified and categorised into three groups according to the defined ontological model, which describe the student according to Table 1.

In the table, the suffix *i* stands for the observed student S_i in the context of the rules and algorithms. It should be emphasised that the values describing the general characteristics of the student (rp_i, m_i, r_i, t_i) are important for a detailed description of the student and his/her abilities. The value jg_i belongs to the general characteristics of the student and is calculated as the arithmetic mean of the values for expressive communication, conversation, language comprehension and language production from the assessment scale in the social domain. Each of these skills is considered equally important in determining the student's general linguistic and communicative characteristics.

The same principle applies to the value po_i which represents the student's behavioural characteristics in the practical domain. This score is calculated as the arithmetic mean of the scores obtained for the student's abilities in the areas of emotion regulation, rule following, transition between activities and behavioural changes in relation to others around them.

Label	Description			
	General characteristics of the students			
rp _i	The level of support required for activities of daily living which can take values ranging from 0 to 4:			
	1 – Occasional support (minimal support only required in certain situations - mild intellectual disability),			
	2 – Limited support (consistent but time-limited support required - moderate intellectual disability),			
	3 – Extensive support (daily care, assistance, and supervision required - severe intellectual disability),			
4 – Complete support (constant, 24-hour support in all aspects of life - profound intellectual disability).				
m _i	Level of the student's motor skills, which can have a value from 0 to 3:			
	0 – significantly inaccurate,			

Table 1 Values used to describe the student in the rules



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	1 – moderately inaccurate).		
	2 – mostly accurate,	1		
	3 – fully accurate.			
r_i	Level of computer usage,	which can have a value fro	om 0 to 2:	
i	0 – does not use a compu	iter,		
	1 – uses a computer with	the help of another person,		
	2 – uses a computer inde	pendently.		
t _i	Level of usage of touch d	evices (tablet, smartphone)	, which can have a value from 0 to 2:	
	0 – does not use touch de	evices,		
	1 – uses touch devices w	th the help of another perso	on,	
	2 – uses touch devices in	dependently.		
jg _i	Language and speech ch	aracteristics of the student,	that take on a value in the range [0,	
	2.5], calculated as the arit	hmetic mean of the determ	ined, equally significant levels of the	
	student's skills:			
	expressive communicatio	n (ranging from 0 to 3 acco	rding to the assessment scale),	
	conversation (ranging from	n U to 2 according to the as	sessment scale),	
	language production (rop)	(langing from 0 to 2 according to	a the assessment apple)	
	language production (rang	dupptional poods of stud	o the assessment scale).	
0	The student's current rea	ding skill lovel, which takes	on values from 0 to 4 according to the	
c_i	defined assessment scale	allig skill level, which lakes	of values from 0 to 4 according to the	
p_i	The current student's wri	ting skill level, which takes	on values from 0 to 5 according to the	
	established assessment s	scale.		
mat _i	The student's current ma	thematical skill level, which	takes on values from 0 to 4 according	
	to the defined assessmen	t scale.		
v_i	The student's current tin	ne management skill level	i, which takes on values from 0 to 8	
	The student's surrent me		al which takes on values from 0 to E	
n_i	i_i The student's current money management skill level, which takes on values from 0 to 5 according to the defined assessment scale			
Adantive skills of students				
no:	The student's behavioral	characteristic, which takes	a value in the range [0,3] is calculated	
po_l	as the arithmetic mean of the determined, equally significant levels of the student's skills.			
	Emotion regulation (rangi	ng from 0 to 3 according to	the assessment scale).	
	Following rules (ranging f	rom 0 to 3 according to the	assessment scale).	
	Transitioning from one ac	tivity to another (ranging fro	om 0 to 3 according to the assessment	
	scale),		ů,	
	Changes in behavior in re	lation to other people in the	e environment (ranging from 0 to 3	
	according to the assessm	ent scale).		
rss _i	The current level of unde	rstanding risky social situat	ions, which takes on values from 0 to 3	
	according to the assessm	ent scale.		
rmd_i	The current level of risk	of manipulation by others	s, which takes on values from 0 to 3	
	according to the assessm	ent scale.		
hr _i	The current level of indep	endence in feeding, which	takes on values from 0 to 3 according	
	to the assessment scale.			
ob_i	The current level of indep	endence in dressing, which	n takes on values from 0 to 3 according	
7	to the assessment scale.	<u> </u>		
oh _i	I ne current level of indep	pendence in personal nygie	ene, which takes on values from 0 to 3	
ck	The surrent level of independence in going to esheel which takes on values from 0 to 2			
sri	according to the assessm	ent scale.	Sol, which takes on values norm o to S	
jp _i	The current level of indep	endence in using public tra	nsportation, which takes on values from	
	0 to 3 according to the as	sessment scale.		
sv_i	The current level of mean	ingful leisure time manager	ment, which takes on values from 0 to 3	
	according to the assessm	ent scale.		
ra _i	a_i The current level of independence in performing daily tasks (cleaning, setting the table,			
	etc.), which takes on values from 0 to 3 according to the assessment scale.			
Source: a	author			

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Table 2 contains the initial rules for recommending digital educational games for the area of academic skills as well as for the area of communication and daily living skills, along with the corresponding conditions that describe the situations in which the rules apply.

Condition	Rules for recommending in the area of academic skills	Learning objectives	Rules for recommending in the area of communication and daily living skills
The student does not use a computer or touch devices. $ri == 0 \land ti == 0$	Digital educational games are not recommended for the area of academic skills.	Learning objectives are not defined.	Digital educational games are not recommended for the area of communication and daily living skills.
The student requires extensive or full support in daily living activities. $rp_i \ge 3$	Digital educational games are not recommended for the area of academic skills.	Learning objectives are not defined.	Digital educational games are recommended according to additional rules.
The student's motor skills are significantly imprecise. $m_i == 0$	Digital educational games are not recommended for the area of academic skills.	Learning objectives are not defined.	Digital educational games are recommended according to additional rules.
The student uses a computer or touch devices independently or with the help of another person, requires occasional or limited support in daily living activities, and their motor skills are either fully precise, mostly precise, or at least moderately imprecise. $r_i > 0 \land t_i > 0 \land$ $rp_i < 3 \land m_i > 0$	Digital educational games are recommended according to additional rules.	Defined according to additional rules.	Digital educational games are recommended according to additional rules.

Table 2 Initial rules for recommending digital educational games

Source: author

Since digital educational games are recommended in the system in the area of academic skills in the categories of reading skills, writing skills, mathematical skills, time management skills and money management skills, rules for the recommendation and corresponding learning objectives have been defined for each student level. The learning objectives serve as a guide for special education teachers when implementing digital educational games into the teaching process. The rules are listed in Tables 3 to 7 for the above categories in the correct order. Along with the student's skill level in each category and the recommendation rules, the learning objectives are also provided, along with the appropriate labels according to the set of learning objectives for the academic skill area.

Table 3 Rules for recommending digital educational games for the area of reading

The current level of the student's reading skill	Rules for recommending	Learning objective
The student does not have developed pre- reading skills. $c_i == 0$	Recommend digital educational games in the field of reading that develop prereading skills.	Develop prereading skills.
The student has developed prereading skills (distinguishes text from images, follows text from left to right, reads globally, identifies the first and last sound in a word, breaks words into syllables, is aware of	Recommend digital educational games in the field of reading that develop prereading skills and the technique of reading letter-by- letter, syllables, words, or	Develop the technique of reading letter-by- letter, syllables, or sentences and acquire/reinforce

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rhyme).	sentences.	prereading skills .
$c_i == 1$		
The student is acquiring the technique of reading: the student reads letter-by-letter and/or reads syllables; the student reads words (shorter and longer); the student reads sentences. $c_i == 21 \lor c_i == 22 \lor c_i == 23$	Recommend digital educational games in the field of reading that develop the technique of reading letter-by-letter, syllables, words, or sentences, or reading with comprehension.	Acquire/reinforce the technique of reading and develop the skill of reading comprehension.
The student has developed the reading technique without comprehension of the text or reads with comprehension. $c_i == 3 \lor c_i == 4$	Recommend digital educational games in the field of reading that develop reading comprehension.	Practice the technique of reading comprehension.

Source: author

Table 4 Rules for recommending digital educational gam	nes for the area of writing
	J

The current level of the student's writing skill	Rules for recommending	Learning objective
The student does not have developed writing skills. $p_i == 0$	Recommend digital educational games in the field of writing that develop the technique of copying from a template.	Copy letters from a template.
The student copies letters from a template. $p_i == 1$	Recommend digital educational games in the field of writing that develop the technique of copying from a template or writing by dictation.	Practice copying letters from a template and develop the technique of writing by dictation.
The student has mastered or is mastering the technique of writing by dictation: the student writes the first letters (vowels, frequent letters); the student writes words; the student writes sentences. $p_i == 21 \lor p_i == 22 \lor$ $p_i == 23$	Recommend digital educational games in the field of writing that develop the technique of writing by dictation and writing in formal handwriting.	Practice the technique of writing by dictation and develop independent writing in formal handwriting.
The student writes independently using formal handwriting (printed letters) or cursive (script letters). $p_i == 3 \lor p_i == 4$	Recommend digital educational games in the field of writing that develop the technique of writing in formal handwriting and cursive.	Practice independent writing in formal handwriting and develop independent writing in cursive.
The student writes on a device (tablet, laptop). $p_i ==5$	-	The student writes on a device, so there are no learning outcomes in this category.

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Table 5 Rules for recommending digital educational games for the area of mathematical skills

The current level of the student's mathematical skill	Rules for recommending	Learning objective
The student has not developed pre- mathematical skills (properties of objects, classification, spatial relationships, relationships between objects, qualitative and quantitative relationships, geometric shapes, quantity, sequence) or is in the process of developing them. $mat_i == 0 \lor mat_i == 1$	Recommend digital educational games in the field of mathematical skills that develop pre-mathematical skills.	Develop and practice pre-mathematical skills.
The student has acquired or is acquiring basic mathematical competencies: has acquired the concept of numbers up to 5 (symbol, quantity, naming, sequence); has acquired the concept of numbers up to 10 (symbol, quantity, naming, sequence); has acquired the concept of numbers up to 20 (symbol, quantity, naming, sequence); has acquired the concept of numbers up to 100 (symbol, quantity, naming, sequence); has acquired the concept of numbers up to 100 (symbol, quantity, naming, sequence); has acquired the concept of numbers over 100 (symbol, quantity, naming, sequence). $mat_i == 21 \lor mat_i == 22 \lor$ $mat_i == 23 \lor mat_i == 24 \lor$ $mat_i == 25$	Recommend digital educational games in the field of mathematical skills that develop: understanding of the concept of numbers up to 5 (symbol, quantity, naming, sequence); understanding of the concept of numbers up to 10 (symbol, quantity, naming, sequence); understanding of the concept of numbers up to 20 (symbol, quantity, naming, sequence); understanding of the concept of numbers up to 100 (symbol, quantity, naming, sequence); understanding of the concept of numbers up to 100 (symbol, quantity, naming, sequence); understanding of the concept of numbers over 100 (symbol, quantity, naming, sequence).	Master the concept of numbers up to 5, 10, 20, or 100, including the symbol, quantity, naming, and number sequence (depending on the student's current level of mathematical competence).
The student understands arithmetic operations of addition and subtraction: calculates with concrete objects/symbols; calculates with the help of a calculator. $mat_i == 31 \lor mat_i == 32$ The student calculates abstractly (solves simple mathematical word problems). $mat_i == 4$	Recommend digital educational games in the field of mathematical skills that develop: arithmetic skills of addition and subtraction with concrete objects/symbols; arithmetic skills of addition and subtraction with the help of a calculator. Recommend digital educational games in the field of mathematical skills that develop: arithmetic skills of addition and subtraction with concrete objects/symbols; arithmetic skills of addition and subtraction with the help of a calculator; abstract calculation skills.	Develop and practice arithmetic operations of addition and subtraction with concrete objects or using a calculator. Practice arithmetic operations of addition and subtraction and develop skills in solving simple math word problems.

Source: author



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Table 6 Rules for recommending digital educational games for the area of time management

The current level of the student's	Rules for recommending	Learning objective
time management skill		
The student does not have developed time management skills or he independently or with assistance identifies and understands parts of the day (morning, forenoon, noon, afternoon, evening, night). $v_i == 0 \lor v_i == 1$	Recommend digital educational games in the area of time management skills that develop the ability to identify and understand parts of the day (morning, forenoon, noon, afternoon, evening, night).	Develop and practice determining and understanding parts of the day.
The student independently or with assistance names and understands the seasons. $v_i == 2$	Recommend digital educational games in the area of time management skills that develop the ability to name and understand the seasons.	Develop and practice determining and understanding the seasons.
The student independently or with assistance names and understands the days of the week. $v_i == 3$	Recommend digital educational games in the area of time management skills that develop the ability to name and understand the days of the week.	Develop and practice determining and understanding the days of the week.
The student independently or with assistance identifies and understands the time concepts today, yesterday, tomorrow (before/after). $v_i == 4$	Recommend digital educational games in the area of time management skills that develop the ability to identify and understand time concepts today, yesterday, tomorrow (before/after).	Develop and practice determining and understanding time concepts yesterday, today, and tomorrow.
The student independently or with assistance names and understands the months of the year. $v_i == 5$	Recommend digital educational games in the area of time management skills that develop the ability to name and understand the months of the year.	Develop and practice determining and understanding the months of the year.
The student independently or with assistance reads time on an analog clock (clock with hands). $v_i == 6$	Recommend digital educational games in the area of time management skills that develop the ability to read time on an analog clock (clock with hands).	Develop and practice the ability to read time on an analog clock.
The student independently or with assistance identifies and understands the date on a calendar or has developed all the listed time management skills. $v_i == 7 \lor v_i == 8$	Recommend digital educational games in the area of time management skills that develop the ability to identify and understand the date on a calendar.	Develop and practice the ability to determine and know the date on a calendar.

Source: author

Table 7 Rules for recommending digital educational games for the area of money management

The current level of the student's money management skill	Rules for recommending	Learning objective
The student does not have developed money management skills. $n_i == 0$	Recommend digital educational games in the area of money management skills that develop the ability to recognize money as an object.	Develop the skill of recognizing money as an object.
The student recognizes money as an object. $n_i == 1$	Recommend digital educational games in the area of money management skills that develop the ability to recognize money as an object and/or differentiate coins from banknotes.	Practice recognizing money as an object and develop the skill of distinguishing coins from banknotes.

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The student distinguishes coins from banknotes. $n_i == 2$	Recommend digital educational games in the area of money management skills that develop the ability to differentiate coins from banknotes and determine the value of money individually.		Practice the skill of distinguishing coins from banknotes and develop the skill of determining the value of money individually.	
The student determines the value of money individually. $n_i == 3$	Recommend digital educational games in the area of money management skills that develop the ability to determine the value of money individually and understand its practical value.			Practice the skill of determining the value of money individually and develop the skill of understanding the practical value of money.
The student understands the practical value of money or independently or with minimal help makes a purchase. $n_i == 4 \lor n_i == 5$	Recom in the a that de practic purcha	amend digital educational ga area of money management velop the ability to understa al value of money and perfo sing tasks.	ames t skills and the orm	Practice the skill of understanding the practical value of money and develop the skills for making purchases.

Source: author

Since digital educational games are also recommended in the system for the area of communication and daily life, rules for recommending games for this area have been made in Table 8.

Table 8 Rules for recommending digital educational games for the area of communication and daily living skills

Condition	Rules for recommending
The arithmetic mean of the student's behavioral characteristics is less than or equal to 1. $po_i \le 1$	Recommend digital educational games that address emotion regulation, following rules, transitioning from one activity to another, and behavior based on interactions with others in the environment.
The student frequently or moderately struggles to understand risky social situations. $rss_i \leq 1$	Recommend digital educational games that address understanding risky social situations.
The student is often or moderately inclined to follow suggested peer behavior without considering their own well-being. $rmd_i \leq 1$	Recommend digital educational games that address recognizing the risk of manipulation by others.
The student is completely, largely, or moderately dependent on support during feeding. $hr_i \leq 1$	Recommend digital educational games that address independence in feeding.
The student is completely, largely, or moderately dependent on support during dressing. $ob_i \leq 1$	Recommend digital educational games that address independence in dressing.
The student is completely, largely, or moderately dependent on support during personal hygiene. $oh_i \leq 1$	Recommend digital educational games that address independence in personal hygiene.

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The student is completely, largely, or moderately dependent on support when going to school. $sk_i \leq 1$		Recommend digital educational games that address independence when going to school.		
The student is completely, largely, or moderately dependent on support when using public transportation. $in_i < 1$		Recommend digital educational games that address independence when using public transportation.		
The student has significant difficulties in planning leisure activities or frequently needs support in this area. $sv_i \leq 1$		Recommend digital educational games that help in planning leisure activities.		
The student is completely, largely, or moderately dependent on support when performing daily work activities. $ra_i \leq 1$		Recommend digital educational games that address independence in performing daily activities.		
The arithmetic mean of the student's language and speech skill levels ranges from 1 to 2.5. $jg_i \leq [1,2.5]$		Recomme language	and digital educational games that address and speech skills.	

Source: author

Finally, rules for additional filtering of digital educational games were defined in special cases when a game requires more complex communication or acquired reading skills, and the student does not possess the specified skills. The recommendation rules are found in Table 9.

Table 9 Additional filte	ering rules fo	r digital edu	cational games
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Condition	Rules for recommending in the area of academic skills	Rules for recommending in the area of communication and daily living skills
The arithmetic mean of the established levels of the student's language and speech skills is less than 1. $jg_i < 1$	Remove from the set of recommended games those that require skills in optimal verbal communication, more complex conversations on topics outside the student's usual social situation, linguistic understanding of grammatically and content-wise more complex sentences and instructions, as well as linguistic production of complex sentence statements.	Remove from the set of recommended games those that require skills in optimal verbal communication, more complex conversations on topics outside the student's usual social situation, linguistic understanding of grammatically and content-wise more complex sentences and instructions, as well as linguistic production of complex sentence statements.
The student has not developed pre- reading skills. $c_i == 0$	-	Remove from the set of recommended games those that require pre-reading skills, the technique of reading by spelling and/or syllables, words, sentences, and reading with comprehension.
The student has developed pre- reading skills. $c_i == 1$	-	Remove from the set of recommended games those that require the technique of reading by spelling and/or syllables, words, sentences, and reading with comprehension.

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The student is acquiring the technique of reading by spelling, reading words, or reading sentences. $c_i == 21 \lor$ $c_i == 22 \lor$ $c_i == 23$	-		Remove from the set of recommended games those that require skills in reading with comprehension.	

Source: author

3 CONCLUSION AND FUTURE WORK

This paper defines the rules for recommending digital educational games based on pedagogical and educational-rehabilitation criteria, taking into account the individual needs of students with intellectual disabilities. Further research activities will focus on creating appropriate algorithms to be implemented in the system. In accordance with the defined rules, two algorithms will be developed: one that recommends digital educational games and defines the corresponding learning outcomes for academic skills, and the other that recommends digital educational games for the area of daily living skills.

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