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A RULE-BASED SYSTEM FOR RECOMMENDING DIGITAL EDUCATIONAL GAMES FOR STUDENTS WITH INTELLECTUAL DISABILITIES

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ABSTRACT

The motivation for this research arises from the transformative potential of digital educational games (DEG) in supporting students with intellectual disabilities (ID) to develop conceptual, social, and practical skills. Integrating game-based learning into daily education can significantly enhance learning experiences; however, games specifically designed for students with ID are still difficult to find. This research addresses this gap by developing a system that recommends digital educational games based on an ontology tailored to the unique needs of students with ID. The system was evaluated through a two-phase exploratory study. The first phase examined the designed rules and algorithms for game recommendations with input from a panel of experts. The second phase assessed system use and user satisfaction among special education teachers, applying the DeLone and McLean Information System Success Model. Results suggest that the system can effectively recommend DEG aligned with individual learning needs and support teachers in integrating these games into their teaching practices, making the educational process more engaging, inclusive, and impactful. By addressing a gap in tools specifically designed for students with ID, the developed prototype represents a pioneering solution, ensuring personalised educational content and enabling teachers to use digital tools with greater confidence and ease.

Keywords: *digital educational games, D&M model, intellectual disabilities, ontology, rule-based system*

1. INTRODUCTION

The inclusion of digital games in education is a productive and successful endeavour (Karagianni & Drigas, 2022; Feng *et al.*, 2024) because it enhances the development of academic and adaptive skills in a playful manner (Hernandez-Lara *et al.*, 2023). Digital educational games (DEG) are not only entertaining but also often serve as important intervention tools for students with intellectual disabilities (ID), as they enable equitable educational opportunities (Brandio *et al.*, 2010), more equal access to the labour market, better opportunities for independent living and active participation in the community.

DEG can meaningfully support the education of students with ID by enabling frequent task repetition, which is essential for transferring skills to everyday situations and fostering greater independence (Seon-Chil & Hyun-suk, 2021). Despite this potential, DEG remain underutilised in practice (Stančin *et al.*, 2020). This research is motivated by the opportunity to integrate DEG into daily educational processes to facilitate the acquisition of conceptual, social, and practical skills. However, games specifically designed for students with ID are scarce, and their accessibility across professional profiles is limited (Sigh & Agarwal, 2013; Colpani & Homem, 2015; Tsikinas & Xinogalos, 2018). Consequently, teachers often seek general-purpose games that students with ID can use, even when these are not explicitly developed for this population. Identifying such games requires locating relevant DEG repositories, such as iTunes, Google Play, or specialised websites, and then individually assessing each game for suitability, considering the diverse learning difficulties of students. In the absence of a standardised taxonomy of game requirements and functionalities tailored to ID, this evaluation process remains demanding and time-consuming (Stančin *et al.*, 2022). To streamline this process and promote broader use of DEG in classrooms, this research proposes the development of a system that recommends suitable games to support the planning of educational activities for students with ID.

The aim of the research is to develop a system that recommends DEG based on an ontology that considers the individual educational needs of students with ID in order to support special education teachers in improving the educational process. The system development requires identifying both the student characteristics that reflect academic and practical abilities and the DEG attributes that define relevant features and functionalities. The purpose of the research is to support special education teachers in selecting appropriate DEG for their students while encouraging the adoption of modern, innovative, technology-enhanced pedagogical approaches. The contribution of this research lies in the development of a prototype for the recommendation of DEG, which implements and tests the designed evaluation framework for suitable DEG for students with ID in a real environment.

The paper is organised as follows: Section 2 describes the related work and the developed model; Section 3 explains the research methodology; Section 4 analyses the results and discusses the findings collected; Section 5 lists the limitations of the research; and Section 6 concludes the paper.

2. BACKGROUND

2. 1 Related work

Previous research phases have not identified comparable systems that recommend DEG to professionals in the field of special education (Stančin *et al*., 2020). However, several studies have explored methods to improve learning and teaching processes for students with ID. For example, Sarkar (2024) discusses augmented reality applications as tools for enhancing learning among students with ID, highlighting benefits such as increased engagement, personalised learning experiences, and improved social and communication skills, while also addressing challenges like accessibility and educator training. Dandashi *et al*. (2015) present an edutainment system that integrates multimedia technology and physical activity to enhance learning for children with ID, demonstrating positive effects on cognition and motivation, particularly for students with mild disabilities in classroom settings. Similarly, Alja'am *et al*. (2011) introduce an assistive learning system using multimedia tutorials and tangible user interfaces to improve communication, reasoning, and memorisation skills in children with moderate intellectual and learning disabilities, focusing on daily living activities and individualised learning approaches. Bouck, Long, & Jakubow (2023) examine assistive technology systems that support learning for students with ID, covering instructional aids for reading, writing, and mathematics, as well as tools that promote independence and transition, ranging from low-tech to high-tech solutions. Another study aimed to use game-based learning and mobile technology for students with ID to assist them in learning career education knowledge. The results show that game-based learning promotes student involvement and reduces distracting behaviours, while also allowing students to try different strategies to address various challenges (Chang *et al*., 2024).

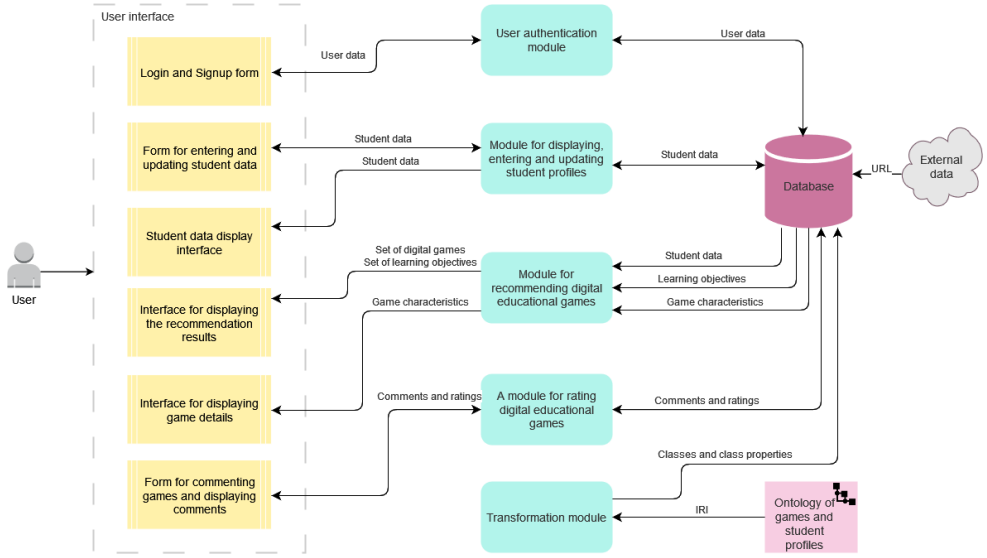
Building on these and previous insights, this research presents a novel approach aligned with the latest guidelines for working with students with ID. By systematically recommending DEG across various domains, the approach offers a comprehensive framework that enhances learning and engagement while addressing diverse educational needs.

2. 2 Model development

A novel rule-based system for recommending DEG was developed to support the design of activities for students with ID. As a rule-based system, it represents expert knowledge through assertions and "if–then" production rules that connect initial facts to corresponding actions and define termination criteria for determining the presence or absence of a solution (Talukdar *et al*., 2023; Ligeza, 2006). The system emulates expert reasoning in special education by applying an evaluation framework that identifies appropriate DEG for students with ID. This framework comprises a skills-assessment scale and a classification of DEG requirements and functionalities, both of which constitute system facts. Recommendation rules were defined according to pedagogical and special-educational criteria, drawing on expert input and current literature (Stancin, 2025), and were implemented as computer procedures and algorithms that address the specific needs of students with ID.

The system architecture (Figure 1) consists of three layers: the user interface, the application layer, and the database layer. The user interface manages communication with the application, while the application layer handles authentication, data display and updates, game commenting, and data transformation. Its central component is the DEG recommendation module, which executes the rule-based algorithms to generate tailored game sets based on each student's skills and needs. The database stores URLs that enable installation or access to DEG via tablets or web browsers. The model employs a scalable multiple-ontology approach grounded in the evaluation framework. Ontology-based implementation provides a formal representation of the DEG domain and student data, making the domain both comprehensive for special-education experts and machine-interpretable. This scalability enables adaptation of the framework to diverse contexts and related applications, including straightforward extension to other languages and educational environments.

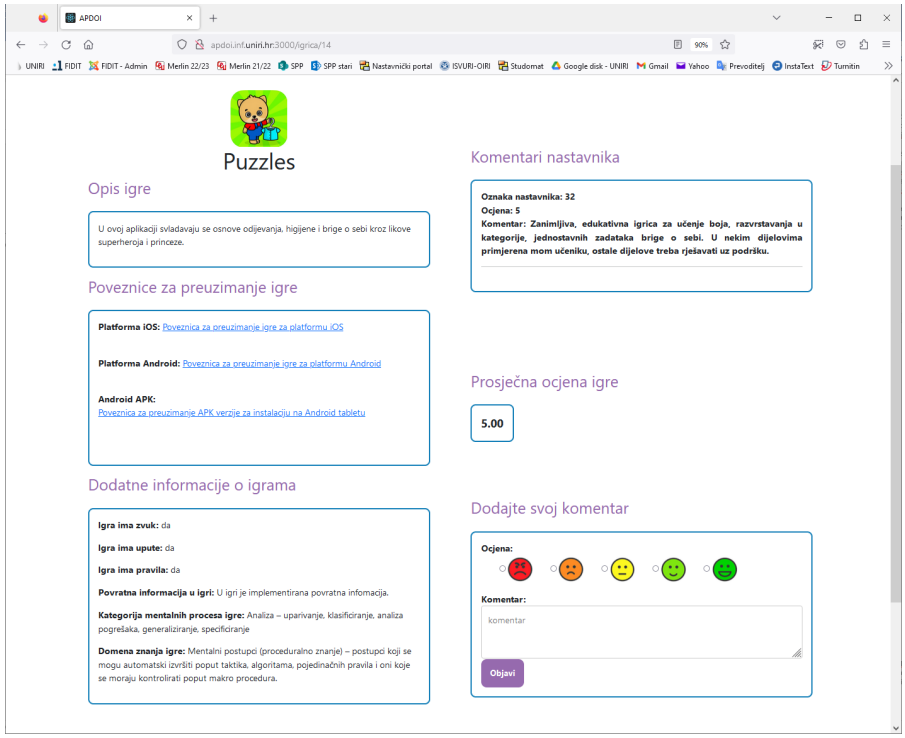
Figure 1. System architecture



Source: Authors

The system is implemented as a web application (Figure 2) accessible via a web browser. It is a responsive application that can be used on various devices, including PC, laptop, tablet, and smart mobile devices. The backend was developed using the ASP.NET Core web framework and the C# programming language, with the code organised in layers according to the application's defined functionalities. The frontend was built using the React JS framework with JavaScript, HTML for markup, and CSS for styling the static part of the application. Microsoft .NET Framework version 4.8 was used for the development of the web application.

Figure 2. Web application



Source: Authors

3. METHODOLOGY

The following hypotheses arise from the aims and purpose of the research:

- H1: The system-recommended DEG are effective in addressing the personalised learning needs of students with ID.
- H2: The use of the system enables special education teachers to effectively incorporate DEG into the learning process of students with ID.

The study on the effectiveness of the system for recommending DEG to support the design of learning activities for students with ID is divided into two phases:

- validation of the developed rules and related algorithms for recommending DEG, which tests hypothesis H1, and
- investigation of the frequency and satisfaction with the use of the system prototype, which tests hypothesis H2.

As this study falls within the scope of specialised domain research, it was not possible to establish a large pool of participants. However, the research was conducted in full accordance with all established principles and recommendations within a highly controlled and rigorous research environment.

In the first phase of the study, an expert group was formed to review the students' initial assessments. These assessments were actual student evaluations obtained from an education centre. The expert group also received a list of digital educational games, each with a short description and a video clip demonstrating its use. The short descriptions were provided to minimise bias in the respondents' categorisation of the games' requirements and functions, encouraging them to focus on the demonstrations and thus provide more objective and independent responses. The expert group's task was to read the students' initial assessments and, using the game list, descriptions, and demonstrations, recommend digital educational games from the list. For each student, the experts determined which games were suitable based on their initial assessment and their professional judgement. The experts' recommendations were then used to compare with the results obtained by running algorithms for the same students whose initial assessments were collected.

Special education teachers and other experts who work with students with ID participated in the second phase of the study. They were presented with the system prototype, its functionality, and instructions for use during an online lecture. Afterwards, the system was made available to them for one month, allowing them to access it at their convenience, mostly while preparing for the educational process, to further encourage the use of modern, innovative teaching methods. After the test phase, respondents completed a questionnaire to evaluate the success of the developed system.

3. 1 Sample

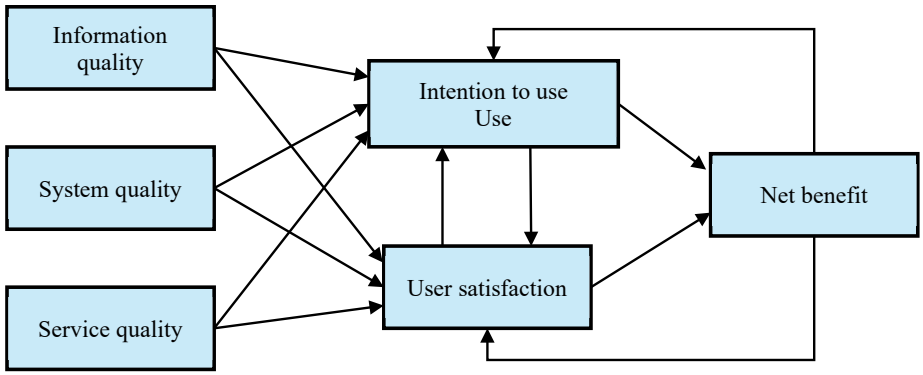
The study was conducted in two phases with two distinct samples. The first phase involved six experts working in the field of intellectual disabilities and using information and communication technologies (ICT) in educational and rehabilitation settings. These experts were employed at five institutions and were selected based on their involvement in workshops, lectures, or projects promoting ICT use for students with ID. The second phase included 38 special education experts, of whom 29 actively tested the system and completed the final questionnaire. Participants were recruited from eight institutions in the Republic of Croatia that educate students with ID. This represents a highly specialised and limited professional population, as special education teachers working exclusively with students with intellectual disabilities form a small group nationally. The modest sample size therefore reflects the targeted nature of the study population rather than recruitment limitations. All necessary ethical approvals were obtained from the Faculty of Informatics and Digital Technologies Institutional Review Board, and informed consent was obtained from all participants in accordance with institutional and international ethical guidelines.

3. 2 Measuring instrument

In line with the research methodology, two instruments were developed. In the first phase, a measurement instrument was used to validate the designed rules and computer algorithms for recommending DEG. This instrument, completed by a group of experts, also included initial student assessments and DEG descriptions.

For the second phase, which examined frequency and satisfaction in prototype use, the DeLone and McLean Information System Success Model (D&M model) was applied (DeLone & McLean, 2003). The updated model comprises six constructs, Information Quality, System Quality, Service Quality, Intention to Use/Use, User Satisfaction, and Net Benefit, which are used to assess information system success. In this model, system evaluation is based on the three quality constructs, which in turn influence intention to use, actual use, and user satisfaction. Use and satisfaction jointly contribute to the net benefit derived from the system, while use and satisfaction also reinforce each other: system use precedes satisfaction, yet a positive user experience increases future use. The Net Benefit construct is context-dependent, reflecting the specific stakeholders and system type involved (DeLone & McLean, 2003; Balaban *et al.*, 2018). This context sensitivity makes the D&M model appropriate for the present study, as it enables evaluation not only of information, service, and system quality but also of the broader consequences and benefits of system use. Figure 3 illustrates the relationships among the model's constructs.

Figure 3. The D&M information system success model



Source: DeLone & McLean (2003)

The D&M information system success model has been used in numerous studies investigating the success of information systems in education. This is supported by a study by Sabeh *et al.* (2021), which identified 92 studies that used this model to examine the performance of information systems in education from 2010 to 2020.

As part of this research, a literature review was conducted to identify questionnaire items from existing studies. All items found were carefully adapted and modified to relate specifically to the context of the system for recommending DEG. Given this context, some items were created from scratch, as the construct of net benefit is entirely dependent on the context for which the information system is developed. In this way, it will be possible to directly assess whether respondents are satisfied with the system based on the quality of the information, the service, and the system itself, whether they intend to continue using it, and whether the system has helped them to integrate DEG into the educational process of students, which constitutes the usefulness of the system.

3. 3 Operationalization of research constructs

The first construct of the D&M model concerns information quality and is used to describe the quality of content in the system (Suliman & Faryadi, 2013). It is often a key dimension of end-user satisfaction instruments (Petter *et al*., 2008). According to Gorla *et al*. (2010), Huh *et al*. (1990) define four measurable dimensions of information quality: accuracy, completeness, consistency, and timeliness. Three existing items were identified to test the quality of information in the created system, examining completeness, relevance, and conciseness. One item was modified to examine the form of information, and one new item was added relating to information about learning objectives and information about DEG. The list of all items for this construct is provided in Table 1.

Table 1. Items of the construct Information quality

ID	Item	Source
IQ1	The information provided by the system is complete.	Existing: (Fraser & Salter, 1997)
IQ2	The information provided by the system is relevant.	Existing: (Barnes & Vidgen, 2005)
IQ3	The information provided by the system is concise (contains only the necessary data).	Existing: (Gable *et al*., 2008)
IQ4	The information provided by the system is well formatted (legible and easy to understand).	Existing: (Gable *et al*., 2008)
IQ5	The information provided by the system (learning objectives, recommended games) is in accordance with the needs and abilities of the individual student.	New

Source: Authors

This construct represents system quality and measures the desirable characteristics of an information system based on technical specifications such as data processing, ease of use, reliability, and response time (Balaban *et al*., 2013). In the context of the system for recommending DEG, four existing items were used to investigate usability, reliability, and response time, and one item was modified to investigate technical functionalities. The list of items for this construct is provided in Table 2.

Table 2. Items of the construct System quality

ID	Item	Source
SQ1	It's easy to learn to use the system.	Existing: (Gable *et al*., 2008)
SQ2	The system contains the necessary features and functions for the recommendation of DEG.	Existing: (Balaban *et al*., 2013)
SQ3	The system is always available and works on demand.	Existing: (Gable *et al*., 2008)
SQ4	Access to the system is possible with the usual web browser without much preparation.	Existing: (Balaban *et al*., 2013)

Source: Authors

Support for the end user in working with the system is crucial to the success of the information system. Therefore, the construct of service quality was included in the updated D&M model (DeLone & McLean, 2003) and analyses the quality of the accompanying service provided alongside the developed information system. Accordingly, two existing items were used for the developed system to test the support provided when working with the system, and one item was modified to examine the quality of the lecture given to participants and the instructions available for working with the system. The items are listed in Table 3.

Table 3. Items of the construct Service quality

ID	Item	Source
SEQ1	E-mail and other forms of online assistance are available in case of problems with the use of the system.	Existing: (Kim *et al.*, 2006)
SEQ2	The system managers respond quickly to enquiries (within 24 hours).	Existing: (Parasuraman *et al.*, 1988)
SEQ3	The use of the system is well described through instructions and lectures (e.g. entering and updating student data, checking DEG...).	Modified: (Balaban *et al.*, 2013)

Source: Authors

The following construct refers to the use of the system and/or the intention to use the system. In most cases, system use is an appropriate measure of success because it is a complex variable that requires consideration of the nature, extent, quality, and appropriateness of system use (DeLone & McLean, 2003). The intention to use the system alone can be a good indicator of system utilisation, as Venkatesh *et al.* (2003) found a significant correlation between intention to use and actual use. In the context of the developed system, three existing items were used to test system use, with item SU3 in the questionnaire reorganised to correspond to the period of prototype testing: "During the time the prototype was tested, I accessed the web application more than once." In addition to the existing items, two new ones were added to investigate whether it is easy to enter data about students and what the intention is to use the system. Details of the items can be found in Table 4.

Table 4. Items of the construct Intention to use/Use

ID	Item	Source
SU1	I have the necessary knowledge to use the system.	Existing: (Venkatesh *et al.*, 2003)
SU2	I was able to complete the task in the system even if there was no one there to tell me what to do.	Existing: (Venkatesh *et al.*, 2003)
SU3	I use the system a lot.	Existing: (Freeze *et al.*, 2010)
SU4	I use the system to get information about DEG that my students can play.	New
SU5	I entered the information about the student without much difficulty.	New

Source: Authors

The user satisfaction construct is closely related to the previous construct – intention to use/use. As DeLone and McLean argue (2003, p. 23), "use must precede user satisfaction in a process sense," meaning that the system must first be used in order to assess satisfaction based on the experience of using the system. Accordingly, a positive experience leads to higher satisfaction, while a negative experience leads to lower satisfaction. Two existing items were used for the system, and two were modified to suit the educational and special educational context. The items are listed in Table 5.

Table 5. Items of the construct "User satisfaction"

ID	Item	Source
US1	I love working with the system.	Existing: (Venkatesh *et al.*, 2003)
US2	The system makes the education and rehabilitation process more interesting.	Modified: (Venkatesh *et al.*, 2003)
US3	Using the system is a good idea.	Existing: (Venkatesh *et al.*, 2003)
US4	I find the system useful for the educational and rehabilitation process of my students.	Modified: (Venkatesh *et al.*, 2003)

Source: Authors

The final construct represents the benefit of the system and results from the constructs of intention to use/use and user satisfaction. This construct is highly specific in each case, meaning it depends entirely on the type of information system developed. Consequently, there are many methods for measuring system benefits, with perceived usefulness and impact on work being the most common measures (Balaban *et al.*, 2018). Accordingly, six items were created for the developed system to examine the perceived benefits for users in their daily work and for students with ID. The benefits focus on the users themselves, investigating whether the system encouraged more frequent use of DEG in the teaching process, provided new information, facilitated the search for new DEG, and made it easier to integrate games into teaching. The benefits also address students with ID, examining whether the games were useful and whether they enabled learning and skill acquisition in a more entertaining way. The list of all items is provided in Table 6.

Table 6. Items of the construct Net benefit

ID	Item	Source
NB1	The system encouraged me to use or additionally use DEG in the educational and rehabilitation process.	New
NB2	The system has made it easier for me to find DEG for my students.	New
NB3	The system provided me with new information (games I have not been familiar with before).	New
NB4	Students found the proposed games useful in learning and acquiring skills.	New
NB5	The system enables my students to learn and acquire skills in a more entertaining way.	New
NB6	The system enables me to successfully integrate DEG into my students' learning process.	New

Source: Authors

A measurement instrument was created using all the listed items, with adaptations made to suit the sample by replacing certain words to improve respondents' understanding of the statements. For example, the word "system" was replaced with "web application". All items use a version of the Likert-type scale with five ratings, where 1 is "strongly disagree" and 5 is "strongly agree".

4. RESULTS AND DISCUSSION

This chapter presents the data collected and analyses the results of this research. First, it presents the validation of the designed rules and associated algorithms for recommending DEG, testing the H1 hypothesis. Then, it examines the frequency and satisfaction of using the designed prototype system, testing the H2 hypothesis.

4. 1 Validation of proposed rules

As mentioned above, six experts from different institutions that train special education teachers or work with people with intellectual disabilities participated in the process of validating the algorithms. The rules and algorithms were tested with hypothesis H1 using the Jaccard index, which measures the similarity between two sets (Costa, 2021). The value of the index ranges from 0 to 1, where 0 indicates no similarity between sets and 1 indicates that the sets are identical (Falk, 2019). To verify that the DEG recommended by the system align with the unique learning needs of students with intellectual disabilities, experts were consulted to identify which games are appropriate for each student. As outlined in the research methodology, experts selected suitable games for each student based on initial assessments and the available set of DEG. At the same time, the developed algorithms were run with the same set of DEG for the same students to compare the results. If the experts' recommendations match the system's recommendations, then hypothesis H1 can be accepted. If we consider the DEG suggested by the system (the algorithms) and the recommendations of experts in the

context of set theory, with each game ID representing one element of the set, we can calculate the Jaccard index. A higher value of the Jaccard index indicates greater similarity between the two sets (Verma & Aggarwal, 2020). The result also depends on the context and the number of respondents. In a study by Abd-Ellah *et al.* (2023), a satisfactory level of agreement according to the Jaccard index was determined to be 70% through comparative analysis of different algorithms. Given the specialised research domain and the smaller number of respondents in the expert group, agreement $p \geq 70\%$ is considered satisfactory in this study to confirm hypothesis H1. To obtain the total agreement P, that is, the mean value of the Jaccard index per student expressed as a percentage, it is necessary to sum all the Jaccard indices for one student, divide by the number of experts in the group, and multiply by 100 to obtain the percentage of agreement (Lee, 2017). Accordingly, the percentage of agreement for students is shown in Table 7.

Table 7. Agreement for students

Student	Agreement P
Student 1	72%
Student 2	71%
Student 3	70%

Source: Authors

The information above shows that agreement for all three students is 70% or higher. This supports hypothesis H1, indicating that the system-recommended digital educational games are effective in addressing the personalised learning needs of students with intellectual disabilities.

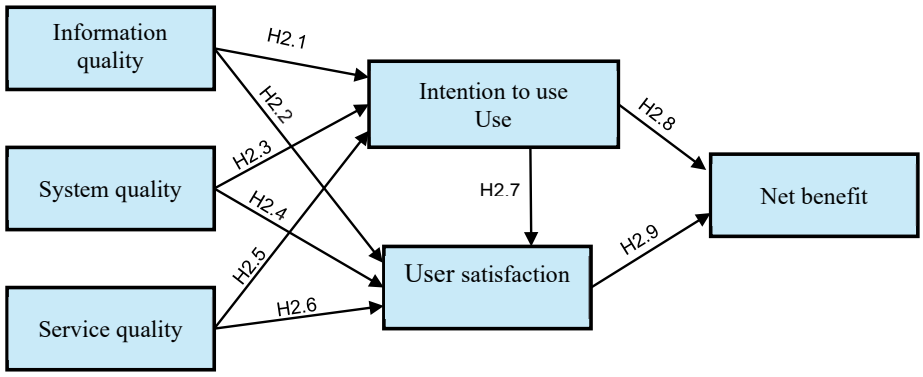
4. 2 Exploratory system assessment

Given the small sample size (N = 29), an exploratory approach was taken using multiple linear regression rather than structural equation modelling or confirmatory factor analysis (Hammachukiattikul & Supithak, 2024). Composite variables were created by averaging items for each construct, reducing model complexity and increasing statistical stability. Findings are interpreted with caution, emphasising effect sizes, explained variance (R^2), and directionality rather than significance alone (Cohen, 1988; Hair *et al.*, 2019). Effects with p-values between 0.05 and 0.10 are reported as "marginally significant" or "trends" (Pritschet *et al.*, 2016), and are interpreted as potentially meaningful relationships that require confirmation in larger samples.

To assess whether special education experts can effectively integrate DEG into learning for students with ID (hypothesis H2), the system's effectiveness was evaluated using the DeLone and McLean Information System Success Model (2003). The model includes six constructs, each analysed individually, with nine sub-hypotheses formulated to examine system success (Figure 4):

- H2.1: The quality of the information has a positive impact on the use (or intention to use) of the system.
- H2.2: The quality of information has a positive impact on user satisfaction.
- H2.3: The quality of the system has a positive impact on the use of (or intention to use) the system.
- H2.4: The quality of the system has a positive impact on user satisfaction.
- H2.5: The quality of the service has a positive impact on the use of (or intention to use) the system.
- H2.6: The quality of the service has a positive impact on user satisfaction.
- H2.7: The use (or intention to use) of the system has a positive impact on user satisfaction.
- H2.8: The use (or intention to use) of the system has a positive impact on the net benefit of the system.
- H2.9: User satisfaction has a positive impact on the net benefit of the system.

Figure 4. Proposed research model



Source: Authors

Twenty-nine participants who tested the system completed the questionnaire. Respondents had an average of 21 years of work experience (range: 4–30+ years) and taught an average of six students per class. Items for each construct were adapted from validated scales and reviewed by experts for content validity. Internal consistency was assessed using Cronbach's alpha, and descriptive statistics and normality tests confirmed the data were appropriate for regression analysis.

Post hoc power analysis evaluated sample size adequacy. For Use as the outcome (k=3, R^2=0.31, f^2=0.45) and User Satisfaction (k=4, R^2=0.34, f^2=0.52), achieved power was 0.81, exceeding the 0.80 threshold. For Net Benefits (k=2, R^2=0.15, f^2=0.18), achieved power was 0.47, indicating insufficient power to detect a medium-sized effect. The first two models were adequately powered, lending confidence to significant findings. However, the non-significant Net Benefits result may reflect insufficient power rather than the absence of relationships

(Button *et al.*, 2013). These findings emphasise effect sizes and directional consistency, with replication in larger samples needed for stronger conclusions.

Cronbach's alpha coefficients indicated satisfactory reliability: Information Quality (α=0.88), Service Quality (α=0.75), Use (α=0.70), User Satisfaction (α=0.77), and Net Benefits (α=0.71). System Quality (α=0.65) was slightly below the 0.70 threshold but is acceptable in exploratory research with small samples, where values above 0.60 are considered adequate (Hair *et al.*, 2019). Overall, internal consistency was satisfactory for further analysis.

All constructs showed high mean values (range: 4.25-4.75 on a 5-point scale): Use (*M*=4.75, SD=0.32), Service Quality (*M*=4.68, SD=0.73), System Quality (*M*=4.61, SD=0.43), User Satisfaction (*M*=4.53, SD=0.46), Information Quality (*M*=4.33, SD=0.59), and Net Benefits (*M*=4.25, SD=0.51). Small standard deviations indicated limited response dispersion and consistent perceptions. Responses were concentrated towards the upper end (MIN: 2.33–3.80; MAX: 5.00), suggesting a possible ceiling effect. Overall, respondents evaluated the information system very positively across all measured dimensions.

Shapiro-Wilk tests showed that most constructs deviated from normality: Information Quality (W=0.89, p=0.01), System Quality (W=0.84, p<0.001), Service Quality (W=0.51, p<0.001), Use (W=0.77, p<0.001), and User Satisfaction (W=0.84, p<0.001). Only Net Benefits (W=0.93, p=0.06) approached normality. These deviations, consistent with the ceiling effect, do not preclude regression analysis, which is robust to predictor non-normality when examining relationships between composite constructs (Hair *et al.*, 2019).

Multiple linear regression examined the effects of Information Quality (H2.1), System Quality (H2.3), and Service Quality (H2.5) on Use. The model was significant, F(3,25)=3.73, p=0.024, explaining 31% of the variance (R^2=0.31, Adj. R^2=0.23). System Quality had the largest effect (β=0.42, p=0.065), followed by Service Quality (β=0.24, p=0.184) and Information Quality (β=0.16, p=0.466). All predictors were positively related to Use, as hypothesised. Multicollinearity diagnostics were acceptable (tolerance: 0.59–0.93; VIF: 1.08–1.68). H2.3 (System Quality → Use) showed a marginal trend (p=0.065), while H2.1 and H2.5 were positive but non-significant, likely due to sample size and limited variability. System Quality appears most important for explaining usage intention, though larger samples are needed for confirmation (Hair *et al.*, 2019; Cohen, 1988).

Multiple linear regression examined the effects of Information Quality (H2.2), System Quality (H2.4), Service Quality (H2.6), and Use (H2.7) on User Satisfaction. The model was significant, F(4,24)=3.16, p=0.032, explaining 34% of the variance (R^2=0.34, Adj. R^2=0.24). Only Information Quality significantly predicted satisfaction (β=0.65, p=0.006). System Quality (β=–0.27, p=0.260), Service Quality (β=–0.18, p=0.332), and Use (β=0.16, p=0.435) were not significant. Multicollinearity diagnostics were acceptable (tolerance: 0.52–0.86; VIF: 1.16–1.94). These findings provide partial support for the hypotheses: H2.2 (Information Quality → User Satisfaction) is strongly supported, while H2.4, H2.6, and H2.7 were not supported in this small exploratory sample. The results suggest that, within this specialised group of special education teachers, perceived information quality is the primary driver of user satisfaction,

while system quality, service quality, and usage intention contribute less strongly or may require larger samples to detect significant effects.

Multiple linear regression examined the effects of Use (H2.8) and User Satisfaction (H2.9) on Net Benefits. The model was not significant, $F(2,26)=2.32$, $p=0.118$, explaining 15% of the variance ($R^2=0.15$, Adj. $R^2=0.09$). User Satisfaction showed a marginal trend ($\beta=0.34$, $p=0.085$), while Use was not significant ($\beta=0.12$, $p=0.523$). Multicollinearity diagnostics were acceptable (tolerance: 0.92; VIF: 1.08). These findings provide partial support for H2.9 as a trend, whereas H2.8 was not supported in this exploratory small-sample study. The results suggest that user satisfaction appears more relevant than system use for explaining perceived net benefits.

These findings indicate that the core constructs of the model are meaningful and interrelated as theorised, with Information Quality and System Quality playing central roles in shaping user perceptions and behaviour. Although not all hypotheses were statistically confirmed, likely due to the limited sample size (N = 29) and reduced variance, the direction of the effects aligns with the theoretical model, supporting its exploratory validity in this context. Therefore, the model can be considered a useful framework for understanding information system success in small, specialised educational settings, with the caveat that larger samples would be needed for full statistical confirmation of all hypothesised relationships. The findings of this study provide exploratory support for key relationships within the DeLone and McLean Information System Success Model, demonstrating its continued relevance in evaluating information system success, even in small samples and specialised professional contexts. Consistent with recent empirical evidence from various domains, Information Quality emerged as a significant predictor of User Satisfaction, reinforcing its role as a central determinant of perceived system success (Al-Kofahi *et al.*, 2025). This is in line with broader literature indicating that high-quality information enhances user perceptions and satisfaction across complex digital environments (Salisu *et al.*, 2025). Likewise, System Quality showed a positive association with Use/Intention to Use, echoing findings from recent studies that emphasise the importance of usability, reliability, and technical performance for user adoption and engagement with information systems (Al-Naqbi, 2024). While Service Quality did not reach significance in this study, research in specific application contexts suggests that its effects may be context dependent, with some systems showing strong links between service support and satisfaction when users rely heavily on ongoing assistance (Salisu *et al.*, 2025). The association between User Satisfaction and Net Benefits observed in this study is also reflected in recent literature, where user satisfaction often emerges as a proximal determinant of perceived benefits or value outcomes (Rahmatullah *et al.*, 2025). In practical terms, this suggests that satisfaction captures essential aspects of user experience and perceived value that extend beyond mere usage, a pattern also reported in evaluations of digital government systems and learning platforms.

Information quality and user satisfaction consistently rank among the strongest predictors of IS success across sectors (Al-Kofahi *et al.*, 2025), reflecting both objective system quality and subjective user experience. The model demonstrates adaptability to modern technologies, including social media and generative AI (Jiang *et al.*, 2025; Salisu *et al.*, 2025). These

results affirm that DeLone and McLean's constructs remain valid across technological and organisational contexts. Patterns in this exploratory sample align with broader evidence that quality dimensions and satisfaction are key drivers of system value and success.

Recent reviews further highlight that information quality and user satisfaction consistently rank among the strongest predictors of IS success across sectors and technologies (Al-Kofahi *et al.*, 2025). These dimensions remain central in contemporary research as they reflect both the objective quality of system outputs and the subjective experience of users, two facets that jointly influence perceptions of success. Additionally, emerging studies show the model's adaptability to modern technologies, including social media and generative AI tools, where quality constructs continue to predict user satisfaction and usage behaviours (Jiang *et al.*, 2025; Salisu *et al.*, 2025). Taken together, these results affirm that the core constructs proposed by DeLone and McLean maintain conceptual validity in explaining information system success, even in different technological and organisational contexts. The patterns of relationships observed in this small exploratory sample align with broader empirical evidence, indicating that quality dimensions and satisfaction are key levers for perceived system value and success in contemporary information environments.

To gain insight into the system's impact on DEG integration and student learning, the Net Benefits construct is elaborated. Table 8 shows mean values around 4.0. The lowest score (3.97) was for providing previously unfamiliar games, which respondents explained by noting prior familiarity with some games. The highest score (4.59) was for enabling more enjoyable student learning and skill acquisition. A mean of 4.0 for successful DEG integration into learning processes supports the analysis results. These findings indicate that the system effectively facilitates DEG selection for special education teachers and encourages innovative teaching methods.

Table 8. Mean values for the net benefit construct

Item	Mean values	Standard deviation
The system encouraged me to use or additionally use DEG in the educational and rehabilitation process.	4.17	0.85
The system has made it easier for me to find DEG for my students.	4.31	0.81
The system provided me with new information (games I have not been familiar with before).	3.97	0.98
Students found the proposed games useful in learning and acquiring skills.	4.21	0.90
The system enables my students to learn and acquire skills in a more entertaining way.	4.59	0.57
The system enables me to successfully integrate DEG into my students' learning process.	4.00	0.76
Total mean:	4.21	

Source: Authors

5. LIMITATIONS

Despite efforts to minimise methodological constraints, several limitations should be noted. First, the sample size in the prototype validation phase was small (N = 29), reflecting the specialised population of Croatian special education teachers working with students with intellectual disabilities. While this represents a substantial proportion of the accessible population, future studies with larger samples and more institutions could improve generalisability. Second, the algorithm validation phase involved six experts and three initial student assessments. A larger number of experts and student profiles would provide more robust validation and enhance recommendation precision. Third, the prototype database included 40 digital educational games; expanding this repository could improve recommendation accuracy, personalisation, and user satisfaction. Although respondents shared a similar professional background, the students they support vary in intellectual functioning and individual needs, which may have influenced evaluations of system usefulness and benefits. Future studies could focus on more homogeneous student subgroups to better assess system impact. Finally, the study relied on self-reported measures, which may be subject to bias. Incorporating objective indicators, such as usage logs or measurable learning outcomes, would strengthen the assessment of system effectiveness. Taken together, these limitations indicate that findings should be interpreted as exploratory. Nonetheless, the study provides an important initial validation of the system in a highly specialised educational context and lays the groundwork for future large-scale investigations.

6. CONCLUSION

This study introduced an innovative system for recommending DEG tailored to students with intellectual disabilities, supporting special education teachers in integrating technology effectively. The system was evaluated in two phases, confirming the validity of its algorithms (H1) and demonstrating positive effects on use, satisfaction, and perceived benefits (H2) through multiple regression analyses. Despite the small, specialised sample, results suggest that the system enhances personalised learning, increases teacher confidence, and addresses a gap in tools designed for this population. Overall, the research highlights the potential of targeted technological support to improve engagement and learning outcomes in special education.

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SUSTAV TEMELJEN NA PRAVILIMA ZA PREDLAGANJE DIGITALNIH OBRAZOVNIH IGARA ZA UČENIKE S INTELEKTUALNIM TEŠKOĆAMA

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SAŽETAK

Motivacija za ovo istraživanje proizlazi iz transformativnog potencijala digitalnih edukativnih igara u pomoći učenicima s intelektualnim teškoćama u razvijanju konceptualnih, socijalnih i praktičnih vještina. Integracija koncepta učenja temeljenog na igrama u svakodnevni odgoj i obrazovanje može značajno unaprijediti iskustvo učenja, međutim, pronalaženje igara posebno dizajniranih za učenike s intelektualnim teškoćama još uvijek predstavlja izazov. Ovo istraživanje ima za cilj premostiti taj jaz razvojem sustava koji predlaže digitalne obrazovne igre na temelju ontologije prilagođene jedinstvenim potrebama učenika s intelektualnim teškoćama. Učinkovitost sustava testirana je u dva koraka. Prvi korak uključivao je validaciju osmišljenih pravila predlaganja i algoritama za predlaganje igara pomoću kreiranog instrumenta kojeg je ispunila ekspertna skupina. Drugi korak procjenjivao je učestalost i zadovoljstvo korištenja sustava, koristeći model uspješnosti informacijskog sustava prema DeLone i McLean. Rezultati pokazuju da sustav učinkovito predlaže digitalne obrazovne igre koje su u skladu s individualnim obrazovnim potrebama učenika. Nadalje, istraživanje potvrđuje da edukacijski rehabilitatori mogu uspješno integrirati predložene igre u svoj nastavni proces, čineći obrazovni proces zanimljivijim, uključivijim i učinkovitijim. Analizom prethodnih istraživanja otkriveno je da u postojećim sustavima koji predlažu digitalne obrazovne igre nedostaje naglasak na učenike s intelektualnim teškoćama. To čini razvijeni prototip pionirskim rješenjem u ovom području jer personalizacija osigurava da učenici dobivaju obrazovni sadržaj prilagođen njihovim jedinstvenim sposobnostima, omogućujući nastavniku da digitalne alate integrira s većim povjerenjem i jednostavnošću.

Ključne riječi: *digitalne obrazovne igre, D&M model, intelektualne teškoće, ontologija, sustav temeljen na pravilima*