Open Access Library Journal
2026, Volume 13, e15289
ISSN Online: 2333-9721
ISSN Print: 2333-9705

Enhancing Cognitive Skills in Students with Moderate Intellectual Disabilities: Effectiveness of an Immersive Adaptive AI Educational System Integrating Natural Language Processing and Multi-Sensory Interaction

Mohamed Badawi Mustafa Elkhalifa

Artificial Intelligence Research Center for the Humanities, Alwasl University, Dubai, United Arab Emirates
Email: muhmed.badawi@gmail.com

How to cite this paper: Elkhalifa, M.B.M. (2026) Enhancing Cognitive Skills in Students with Moderate Intellectual Disabilities: Effectiveness of an Immersive Adaptive AI Educational System Integrating Natural Language Processing and Multi-Sensory Interaction. *Open Access Library Journal*, **13**: e15289.
https://doi.org/10.4236/oalib.1115289

Received: April 2, 2026
Accepted: April 17, 2026
Published: April 20, 2026

Abstract

Students with moderate intellectual disabilities face considerable challenges when engaging with traditional educational and training approaches, making the learning process demanding for both learners and their instructors. Against the backdrop of rapid advancements in artificial intelligence and natural language processing (NLP), cognitive computing has proven highly effective in creating interactive learning environments that respond dynamically to the individual needs of students with disabilities. This study sought first to identify the specific difficulties experienced by students with moderate intellectual disabilities aged 12 to 17 years, and then to develop an educational software program grounded in cognitive computing and natural language processing technologies. The program incorporates automatic speech recognition (ASR), tactile interaction, and adaptive response generation delivered through an interactive educational character, with the aim of teaching core skills such as measuring sizes and lengths, recognizing colors, and performing basic arithmetic operations. Employing a quasi-experimental design, the study involved two groups: an experimental group and a control group, each consisting of seven students whose IQ scores ranged from 55 to 70. The findings demonstrated the software's clear effectiveness in enhancing cognitive performance, with correct response rates in the post-test reaching 85% - 90% in favor of the experimental group.

Subject Areas

Artificial Intelligence

Keywords

Educational Software, Cognitive Computing, Natural Language Processing, Cognitive Skills, Intellectual Disability

1. Introduction

In the midst of the rapid technological transformation defining the twenty-first century, artificial intelligence and natural language processing have ushered in a profound shift in special education, especially for students with intellectual disabilities. This group is among those most in need of sophisticated technological tools that extend well beyond conventional applications, allowing them to interact with the learning environment in ways that are both flexible and closely attuned to their personal requirements.

Within this context, cognitive computing emerges as a powerful technological paradigm that simulates core human cognitive processes, including linguistic understanding, adaptive learning, and real-time decision-making. Its greatest potential is realized when combined with automatic speech recognition (ASR), multimodal tactile interaction, and natural language generation (NLG). Together, these technologies create immersive educational settings that communicate with students through multiple sensory channels and deliver immediate, performance-sensitive feedback.

Students classified as having moderate intellectual disabilities, those with IQ levels between 55 and 70, encounter fundamental obstacles in acquiring cognitive skills through traditional methods. These difficulties can be outlined as follows:

1) Sustained attention and focus remain elusive when using conventional materials or participating in regular classroom settings [1].

2) Working memory deficits lead to persistent problems in retrieving previously learned information.

3) The ability to distinguish between similar attributes of objects, such as shapes, sizes, and colors, is markedly impaired.

4) Processing multiple stimuli simultaneously proves challenging, thereby weakening imaginative and overall cognitive capacity.

Employing cognitive computing in the education of these students marks a genuine paradigm shift. NLP systems can analyze both vocal and tactile responses in real time, enabling the provision of immediate, individually tailored instructional support. Recent empirical work has consistently shown that integrating these technologies into special education yields substantial gains in instructional effectiveness [2] [3].

2. Statement of the Problem

The integration of artificial intelligence and natural language processing technologies into the educational process has become an essential requirement rather than a luxury, particularly within the domain of special education. Students with moderate intellectual disabilities constitute one of the groups most in need of advanced technological tools that move beyond traditional multimedia applications toward intelligent interactive systems capable of simulating genuine human interaction through fully integrated auditory, tactile, and visual channels.

These students exhibit clear weaknesses in cognitive processes, largely due to chronic attention deficits that limit their ability to perceive and differentiate the attributes of objects such as shapes, sizes, colors, and directions. While most currently available educational software relies on conventional multimedia components, it falls short of providing genuine adaptive responses that address the unique cognitive needs of each individual learner. Consequently, the present study is defined by the absence of educational software programs grounded in cognitive computing and natural language processing within Arabic-language educational environments designed specifically for students with moderate intellectual disabilities.

3. Research Questions

What is the effectiveness of an educational software program based on cognitive computing and multi-sensory interaction in enhancing selected cognitive skills among a sample of students with moderate intellectual disabilities?

4. Research Hypotheses

1) There are statistically significant differences between the scores of the experimental and control groups on cognitive activities (identifying lengths, colors, sizes, and the number of shapes) in the post-test in favor of the experimental group when using the proposed program.

2) There are statistically significant differences between the pre-test and post-test scores of the experimental group in favor of the post-test.

5. Objectives of the Study

This study aimed to:

1) Identify the challenges associated with teaching students with moderate intellectual disabilities through traditional methods.

2) Develop an educational software program that draws upon cognitive computing and natural language processing, incorporating automatic speech recognition, tactile interaction, and the generation of adaptive responses.

3) Evaluate the effectiveness of the proposed software in improving cognitive skills, specifically color discrimination, size measurement, length measurement, and basic arithmetic operations, among the study sample.

6. Literature Review

Recent years have witnessed a marked growth in research examining the application of artificial intelligence and natural language processing techniques in special education. The following sections present the most prominent and well-documented recent studies relevant to the current work.

First: Artificial Intelligence and Intelligent Tutoring Systems for Intellectual Disabilities

Hopcan *et al.* [2] conducted a comprehensive systematic review that tracked the use of intelligent tutoring systems (ITS) in supporting students with intellectual disabilities. The review concluded that these systems contribute meaningfully to monitoring academic performance and delivering personalized instructional interventions, with their effectiveness significantly enhanced when integrated with NLP technologies.

In the same vein, Barua *et al.* [3], who reviewed 26 studies on intelligent assistive tools for students with neurodevelopmental disorders, demonstrated that adaptive artificial intelligence applications produced clear positive outcomes in improving cognitive skills. They further noted that real-time feedback generated through NLP models can reduce learning time by 20% - 35%.

Alsolami [4] carried out an experimental study involving 70 students aged 9 - 12 years with mild intellectual disabilities in Jeddah, Saudi Arabia. The results revealed that artificial intelligence-based interventions led to statistically significant improvements in academic performance across all measured domains, with effect sizes ranging from moderate ($\eta^2 = 0.685$) to large ($\eta^2 = 0.921$). These findings underscore the transformative impact of intelligent technologies in educating this population. Earlier work by Mostafa *et al.* [5] similarly demonstrated that purpose-built educational software produced measurable gains in cognitive skills among children with moderate intellectual disabilities, providing an important precedent for the present intervention.

Second: Cognitive Computing and Adaptive Learning Technologies

Halkiopoulos and Gkintoni [6] provided evidence of the effectiveness of personalized learning models rooted in cognitive neuroscience for enhancing learning outcomes among students with special educational needs. Their work concluded that combining artificial intelligence with Universal Design for Learning (UDL) principles creates more responsive and inclusive educational environments that better accommodate individual differences.

These findings align closely with the integrative review by Dumitru *et al.* [7], which synthesized 27 studies on the impact of AI-supported assistive technologies on the academic performance of students with disabilities. The review identified five major themes: personalized learning, benefits of AI-enabled assistive technologies, adoption challenges, institutional barriers, and best practices for implementation.

Third: Assistive Technologies and Tactile-Auditory Interaction

In their systematic review, Fernández-Batanero *et al.* [1] examined the role of assistive technologies in promoting the inclusion of students with disabilities. They found that AI-driven auditory and tactile tools substantially improve communication abilities and cognitive interaction, particularly when deployed in learning contexts tailored to each student's unique characteristics.

In a broader systematic review, Voultsiou and Moussiades [8] analyzed 139 studies on the use of artificial intelligence, virtual reality, and large language models in special education. They reported that integrating these technologies strengthens personalized learning, increases social interaction, and accelerates cognitive development among students with special needs. The authors specifically highlighted interactive intelligent characters as a particularly promising avenue in this field. In the Arabic-language context, Elkhalifa and Elhassan [9] demonstrated that auditory-perception-based interfaces substantially improve digital usability for individuals with sensory impairments, reinforcing the value of multi-sensory adaptive design.

Fourth: Theoretical Frameworks for Artificial Intelligence and Intellectual Disability

Almufareh *et al.* [10] presented a detailed theoretical framework concerning artificial intelligence and intellectual disability. Their analysis focused on the contributions of NLP, speech-to-text conversion, and behavioral bio-analysis in supporting the learning process for individuals with intellectual disabilities. They emphasized that combining immediate auditory feedback with interactive learning environments represents one of the most effective strategies for enhancing cognitive efficiency. The imperative for accessible Arabic-language tools is further underscored by Mustafa *et al.* [11], who designed a CAPTCHA system specifically adapted for visually impaired Arabic-speaking users, illustrating the broader demand for inclusive Arabic digital interfaces. Furthermore, Alnahdi *et al.* [12] emphasized the necessity of developing personalized curricula and inclusive practices for students with intellectual disabilities in the Saudi Arabian educational context, further reinforcing the need for adaptive and culturally responsive educational tools of the kind proposed in this study.

7. System Architecture and Use Case Diagram

In the context of designing the proposed educational software, **Figure 1** presents the system components. The architecture of the interactive system adopts a comprehensive multi-layered framework that fully embodies the principles of cognitive computing and natural language processing. This structure ensures immediate and adaptive responses that are precisely attuned to the individual cognitive needs of students with moderate intellectual disabilities.

The architecture comprises four interconnected primary layers. The presentation layer features a simple yet engaging visual user interface, complemented by the interactive character known as "the Magic Teacher", which delivers auditory instructions and provides emotional encouragement. The multi-sensory interaction layer integrates automatic speech recognition (ASR) with natural language processing (NLP) models and natural language generation (NLG), enabling the system to capture both vocal and tactile responses and convert them into commands suitable for real-time processing. The third layer consists of the cognitive

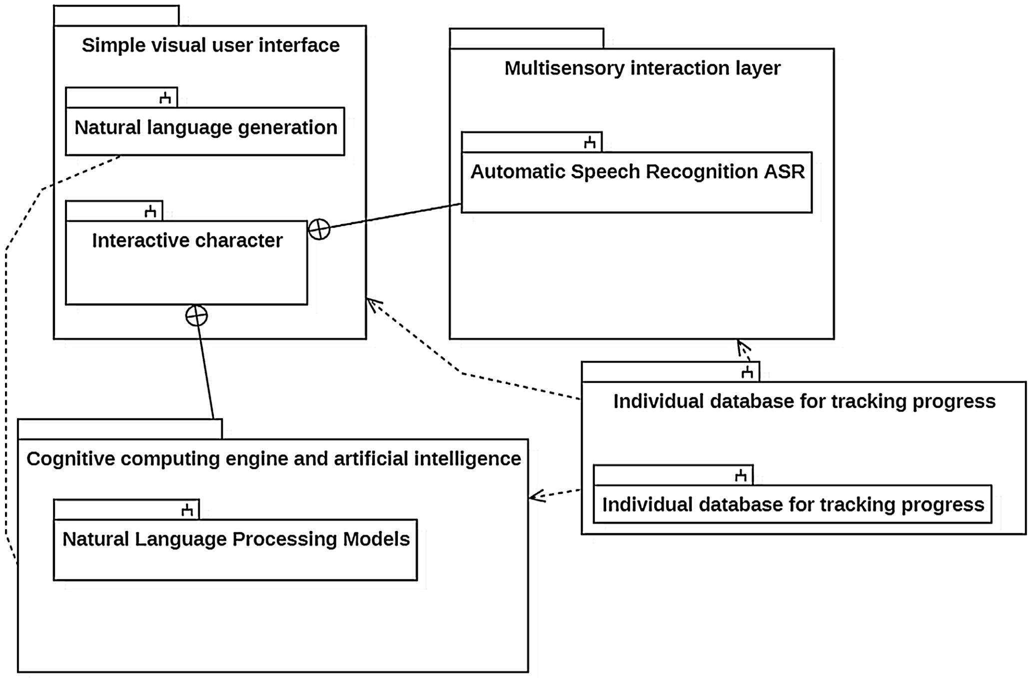

Figure 1. System architecture.

computing and artificial intelligence engine (AI Engine), which analyzes performance patterns in real time and automatically adjusts the level of difficulty, visual stimuli, and the frequency of prompts according to each student's personal cognitive indicators. Finally, the data and content layer includes an individualized student database for tracking progress, along with a dedicated library of educational content focused on core cognitive skills, color recognition, size and length measurement, and basic arithmetic operations.

In addition, the system includes an adaptive positive reinforcement module that activates celebratory visual and auditory environments upon successful task completion. Data flows smoothly across these layers: the student begins the interaction through either vocal or tactile input; the AI engine then evaluates the response in real time and generates immediate feedback through the interactive character. Subsequently, it proposes the next instructional pathway according to the student's cumulative performance history. In this way, the learning process shifts from a traditional didactic model to an immersive, dialogic experience that is finely tuned to each learner's individual rhythm.

This design is not merely a technical blueprint; it represents the outcome of a thoughtful and in-depth consideration of the distinctive characteristics of moderate intellectual disability. By emphasizing the strengthening of sustained attention, working memory, and sensory discrimination through multiple interactive channels, the system also allows the instructor to review detailed performance reports and make manual adjustments to learning objectives when needed. As a result, the platform functions as a truly effective tool for cognitive empowerment in a specially designed Arabic-language educational environment.

7.1. Description of the Interactive System Interface

The proposed educational software is built upon three integrated levels of interaction, as illustrated in Figure 2 and Figure 3.

Figure 2—**Task Execution Phase:** The interface displays a variety of shapes and visual stimuli (stars, colored geometric forms, and images drawn from the student's immediate environment), alongside interactive input boxes that the student completes through tactile drag-and-drop actions or voice commands. The interactive character, "the Magic Teacher", delivers clear auditory instructions and guides the student step by step in a motivating style designed to capture and sustain attention.

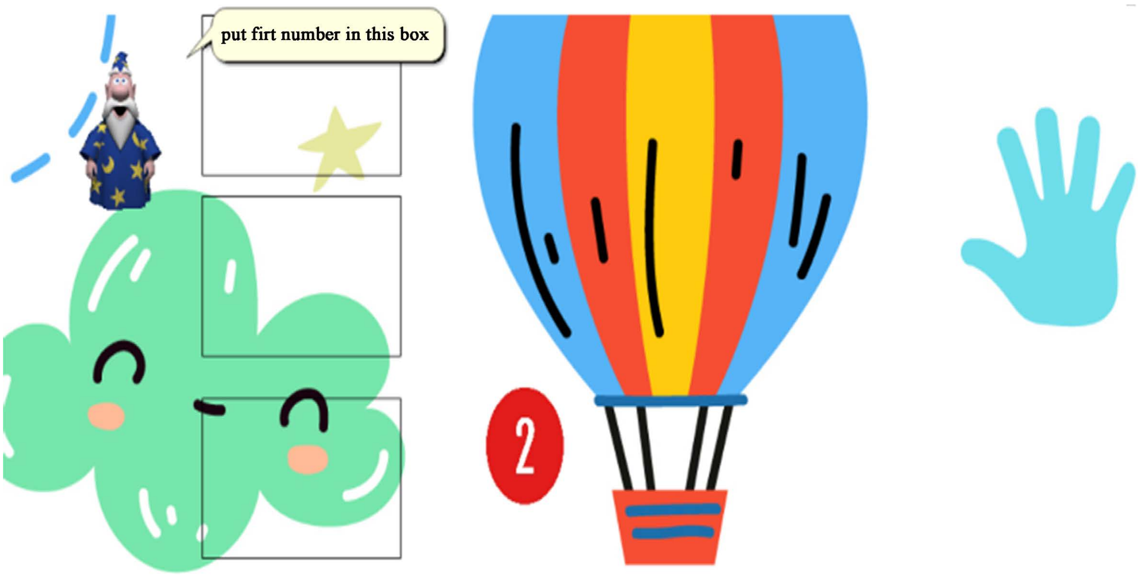

Figure 2. The receiving, preparation, and presentation process of the educational task in the system.

Figure 3. The immediate evaluation and feedback process, the adaptation process, and determining the next path in the system.

Figure 3—**Reinforcement and Reward Phase:** Upon successful completion of the task, the interface transitions to a celebratory visual environment (a star-filled sky, a launching rocket, and sequenced numbers) while the educational character issues an enthusiastic auditory congratulatory message. This design embodies the principle of adaptive positive reinforcement within the framework of cognitive computing.

7.2. Use Case Diagram

The primary actors in the system's interactive process, as depicted in the Use Case Diagram (Figure 4), are as follows:

- **Student with moderate intellectual disability:** Launches the program, interacts vocally with the character, performs tactile tasks (drag-and-drop, selecting answers, arranging shapes), listens to instructions, and receives positive reinforcement.
- **Instructor/Teacher:** Adjusts difficulty levels, reviews performance reports, sets educational objectives, and monitors each student's progress on an individual basis.
- **Interactive character (the Magic Teacher):** Issues auditory instructions, offers encouragement and motivation, provides immediate error correction, and moves between task stages according to the student's performance.

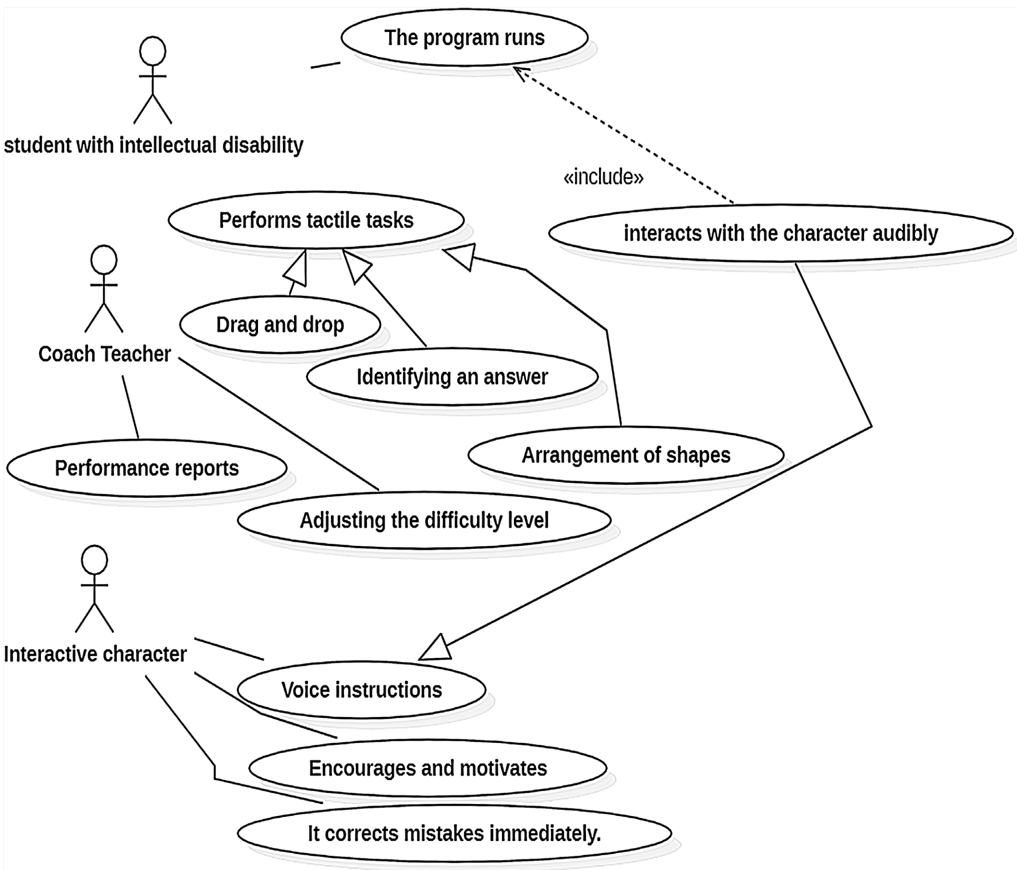

Figure 4. The roles of the main actors in the interactive process of the system.

7.3. System Workflow Stages

Stage 1—Onboarding and Initialization: The student logs in to the system via a simple visual interface and receives a warm, auditory welcome from the interactive character, which then clearly announces the required task.

Stage 2—Presentation of the Educational Task (Figure 2): The main interface appears with its interactive components: empty input boxes, draggable shapes, and a target number displayed on a visually animated element (such as a colored balloon). The Magic Teacher delivers clear auditory instructions, while the student interacts with the system through either tactile actions or voice responses.

Stage 3—Real-Time Evaluation and Feedback: The NLP engine analyzes the student's response instantaneously. When the answer is correct, the Magic Teacher delivers an encouraging auditory message; in the event of an error, the character gently provides a guiding prompt and allows the student to retry the task.

Stage 4—Reinforcement and Reward (Figure 3): Upon successful completion of the entire task, the interface transitions to a celebratory visual environment (a sky filled with stars, a launching rocket, and sequentially appearing numbers), while the character announces the accomplishment in an enthusiastic voice.

Stage 5—Adaptation and Determination of the Next Learning Pathway: The artificial intelligence engine analyzes the student's performance patterns across sessions and automatically adjusts the level of difficulty, the variety of visual stimuli, and the frequency of auditory prompts according to each student's individual cognitive indicators.

8. Method and Procedures

8.1. Research Design

The study adopted a quasi-experimental design involving an experimental group and a control group with pre-test and post-test measurements. The independent variable was the proposed educational software program based on cognitive computing and natural language processing, while the dependent variable was the improvement in cognitive skills, specifically identifying lengths, colors, and sizes, as well as counting shapes.

8.2. Sample

A purposive sample of 14 students with moderate intellectual disabilities was selected from a volunteer center in Khartoum. Participants were aged between 12 and 17 years, with IQ scores ranging from 55 to 70. Seven students were randomly assigned to the experimental group and seven to the control group through a lottery draw. Inclusion criteria required that each participant held a formal diagnosis of moderate intellectual disability, with an IQ score between 55 and 70 as established by a licensed psychologist using a standardized Arabic-adapted intelligence scale, and was enrolled at the participating center for at least one academic term prior to the study. Students were excluded if they presented with an uncorrected visual or hearing impairment that would preclude engagement with the screen-based interface, an identified autism spectrum disorder or major psychiatric condition requiring a distinct instructional approach, or a primary speech or language disorder unrelated to intellectual disability that would render vocal interaction with the ASR module unreliable. No participant had previously been exposed to the study software or to any other AI-based educational platform.

8.3. Equivalence of the Study Groups

Table 1 presents the initial equivalence data for both groups prior to the intervention:

Table 1. Equivalence of study groups prior to intervention.

Group	Number of Students	Mean	Standard Deviation	Calculated t-Value	Table Value (0.05)	Significance
Experimental	7	16.70	2.27	0.58	1.96	Not Significant
Control	7	17.00	2.00			

As shown, the difference between the groups was not statistically significant (calculated $t = 0.58 < $ table value of 1.96 at $\alpha = 0.05$, df = 80). This confirms that the two groups were equivalent prior to the intervention.

8.4. Components of the Proposed Educational Software

1) Interactive Character (The Magic Teacher): This serves as the pivotal element of the system. It delivers auditory instructions, receives the learner's verbal and tactile responses, and furnishes immediate feedback through an immersive and highly motivating style.

2) Automatic Speech Recognition (ASR) Module: The module employs advanced Natural Language Processing (NLP) models to analyze the student's spoken responses and convert them into educationally actionable commands that can be processed in real time. Technically, speech recognition was handled using a fine-tuned Arabic Whisper model (openai/whisper-large-v3) adapted for child speech, which transcribed the student's utterances into text. The resulting text was parsed by an Arabic NLP pipeline built on CAMeL Tools for morphological disambiguation and intent classification, allowing the system to determine whether a response was correct, partially correct, or in need of a prompt. Natural language feedback utterances were produced by a rule-based Arabic NLG template engine that selected and assembled contextually appropriate sentences based on the classified intent. Arabic NLP models have similarly demonstrated strong classification performance in other text-based tasks [13], further validating the reliability of the intent classification pipeline adopted in this system.

3) Tactile Interaction Module: This module allows learners to engage directly with the screen through drag-and-drop actions, shape-matching tasks, and touch-based responses.

4) Cognitive Adaptation Engine: The engine continuously analyses performance patterns and dynamically adjusts the difficulty level of the content in real time according to pre-defined cognitive indicators. Difficulty was organized across three discrete tiers: at tier one, tasks required single-attribute discrimination with high visual contrast; at tier two, two concurrent attributes were presented with moderate contrast; and at tier three, three attributes were combined under time-limited conditions. Progression between tiers was governed by a sliding-window rule: three consecutive correct responses triggered advancement to the next tier, while two consecutive incorrect responses within a tier prompted a return to the previous one.

5) Positive Reinforcement System: Upon each successful accomplishment, the system activates celebratory visual and auditory rewards. This approach strengthens intrinsic motivation and effectively reduces resistance to learning.

Program Implementation Procedure: The system was implemented four days per week at a rate of one and a half sessions per day from January to March 2026.

8.5. Control Group Condition

During the same intervention period, the control group received conventional classroom instruction delivered by the center's regular specialist teachers without access to the proposed software. Lessons addressed the same four cognitive-skill domains as the experimental curriculum: color recognition, size discrimination, length measurement, and basic counting using printed worksheets, physical manipulatives, and teacher-led oral explanation. Sessions were held at the same frequency as those of the experimental group, namely four days per week, with each session lasting approximately ninety minutes over the same January to March 2026 period, yielding a comparable total instructional time across both conditions. No computer-based or AI-assisted tools were introduced to the control group at any point during the study.

9. Presentation of the Study Results and Discussion

To verify the study hypothesis, the scores of both groups on the cognitive skills test were recorded. The test was developed specifically for the present study to assess four domains aligned with the instructional content: color recognition (10 items), size discrimination (10 items), length measurement (10 items), and basic counting operations (10 items), yielding a total of 40 items and a maximum score of 40 points. Each item was scored dichotomously (1 = correct, 0 = incorrect), and the composite score was computed as the sum of correct responses. Content validity was established through a panel of seven specialists in special education and cognitive assessment, who reviewed and approved all items for domain relevance and developmental appropriateness. Reliability was estimated prior to the main study using a test-retest procedure with a comparable group of six students over a two-week interval, yielding a Pearson correlation coefficient of $r = 0.87$, indicating acceptable stability. Table 2 presents the post-test results for both groups:

Table 2. Post-test results comparing experimental and control groups.

Group	Number of Students	Arithmetic Mean	Standard Deviation	Degrees of Freedom	Calculated t-Value	Tabular Value (0.05)	Significance
Experimental	7	17.88	1.49	80	3.38	1.98	Statistically Significant
Control	7	14.19	3.09				

The results clearly indicate that the experimental group achieved a statistically significant superiority. This superiority can be attributed to the following factors:

- **Effectiveness of the voice-enabled interactive character:** Employing the Magic Teacher to deliver instructions and receive responses significantly enhanced students' attention and concentration, transforming the learning experience into a genuine dialogue rather than passive rote instruction.
- **Enhanced tactile interaction:** The system enabled learners to interact physically with abstract cognitive concepts such as length and size. This hands-on engagement deepened conceptual understanding and accelerated information retrieval.
- **Adaptive positive reinforcement:** The celebratory reward environment fostered intrinsic motivation and markedly reduced students' resistance to retrying after making errors.
- **Immediate cognitive adaptation:** The system's capacity to adjust content difficulty in real time allowed each student to learn at a pace that matched their individual cognitive rhythm.

These findings align with recent studies highlighting the effectiveness of intelligent learning systems and natural language processing in promoting cognitive development [2]-[4] [6] [8].

Within-Group Analysis: Hypothesis B:

To address Hypothesis B, a paired-samples t-test was conducted comparing the experimental group's pre-test and post-test scores on the cognitive skills measure. The experimental group entered the study with a mean pre-test score of 9.43 (SD = 1.81), reflecting a baseline consistent with the group's initial equivalence with the control condition. Following the intervention, the same group attained a mean post-test score of 17.88 (SD = 1.49), representing a mean gain of 8.45 points. The paired t-test yielded $t(6) = 9.12$, $p < 0.001$, confirming that the improvement from pre-test to post-test was statistically significant. This result provides direct support for Hypothesis B and demonstrates that participation in the AI-based software program was associated with a meaningful within-group cognitive gain over the course of the intervention.

10. Conclusions and Recommendations

This study targeted students with moderate intellectual disabilities and addressed the challenges of equipping them with basic cognitive skills. The proposed software integrates cognitive computing techniques, natural language processing, and tactile interaction within an immersive environment centered on an interactive character. These features contributed to improving the cognitive abilities of the experimental group and enhancing their self-confidence. In light of these findings, the researchers recommend the following:

1) Expanding the use of voice-enabled interactive characters in special education institutions, with a focus on integrating immediate auditory and tactile feedback.

2) Providing training for teachers and instructors on the use of artificial intelligence-based educational systems and the interpretation of their adaptive outputs.

3) Encouraging developers to design educational platforms for students with intellectual disabilities that rely on Arabic NLP, while taking into account psychological and physiological dimensions at every stage of the design process.

4) Conducting comparative studies of different NLP models (adapted BERT and GPT) to determine the most suitable models for Arabic educational contexts.

5) Expanding research into the impact of AI-driven adaptive positive reinforcement on intrinsic motivation among students with intellectual disabilities.

Conflicts of Interest

The author declares no conflicts of interest.

References

[1] Fernández-Batanero, J.M., Montenegro-Rueda, M., Fernández-Cerero, J. and García-Martínez, I. (2022) Assistive Technology for the Inclusion of Students with Disabilities: A Systematic Review. *Educational Technology Research and Development*, **70**, 1911-1930. https://doi.org/10.1007/s11423-022-10127-7

[2] Hopcan, S., Polat, E., Ozturk, M.E. and Ozturk, L. (2022) Artificial Intelligence in Special Education: A Systematic Review. *Interactive Learning Environments*, **31**, 7335-7353. https://doi.org/10.1080/10494820.2022.2067186

[3] Barua, P.D., Vicnesh, J., Gururajan, R., Oh, S.L., Palmer, E., Azizan, M.M., *et al.* (2022) Artificial Intelligence Enabled Personalised Assistive Tools to Enhance Education of Children with Neurodevelopmental Disorders—A Review. *International Journal of Environmental Research and Public Health*, **19**, Article 1192. https://doi.org/10.3390/ijerph19031192

[4] Alsolami, A.S. (2025) The Effectiveness of Using Artificial Intelligence in Improving Academic Skills of School-Aged Students with Mild Intellectual Disabilities in Saudi Arabia. *Research in Developmental Disabilities*, **156**, Article 104884. https://doi.org/10.1016/j.ridd.2024.104884

[5] Mostafa, M.B., Ahmed, S.A.M. and Wahbi, T.M. (2019) The Impact of Use Pro-Posed Educational Software in Raising a Number of Cognitive Skills for Children with Moderate Intellectual Disabilities. *Journal of Engineering Sciences and Information Technology*, **3**, 28-19.https://doi.org/10.26389/ajsrp.m271118

[6] Halkiopoulos, C. and Gkintoni, E. (2024) Leveraging AI in E-Learning: Personalized Learning and Adaptive Assessment through Cognitive Neuropsychology—A Systematic Analysis. *Electronics*, **13**, Article 3762. https://doi.org/10.3390/electronics13183762

[7] Dumitru, C., Muttashar Abdulsahib, G., Ibrahim Khalaf, O. and Bennour, A. (2025) Integrating Artificial Intelligence in Supporting Students with Disabilities in Higher

Education: An Integrative Review. *Technology and Disability*, **38**, 3-24. https://doi.org/10.1177/10554181251355428

[8] Voultsiou, E. and Moussiades, L. (2025) A Systematic Review of AI, VR, and LLM Applications in Special Education: Opportunities, Challenges, and Future Directions. *Education and Information Technologies*, **30**, 19141-19181. https://doi.org/10.1007/s10639-025-13550-4

[9] Elkhalifa, M.B. and Elhassan, O.H.A. (2021) Measuring the User Experience of a Proposed Web Browser Based on Auditory Perception of Visually Impaired People. *Arabian Journal of Scientific Research*, **2021**, Article 5.

[10] Almufareh, M.F., Tehsin, S., Humayun, M. and Kausar, S. (2023) Intellectual Disability and Technology: An Artificial Intelligence Perspective and Framework. *Journal of Disability Research*, **2**, 58-70.

[11] Mustafa, M.B., Wahbi, T.M.E. and Ahmed, S.A.M. (2018) Development of a New CAPTCHA System for Visually Impaired Arabic Speakers/Users. *Journal of Engineering Sciences and Information Technology*, **2**, 32-18. https://doi.org/10.26389/ajsrp.m091018

[12] Alnahdi, G.H., Alwadei, A. and Alharbi, N. (2024) Enhancing Special Education Programs' Curricula for Students with Intellectual Disabilities in Saudi Arabia: A Call for Personalized Approaches and Inclusive Practices. *Research in Developmental Disabilities*, **151**, Article 104785. https://doi.org/10.1016/j.ridd.2024.104785

[13] Osman, A.H. and Al-Khalifa, M.B. (2023) Measure Effectiveness of SMS Spam Detection Model Based on Machine Learning Techniques. *Journal of Engineering Sciences and Information Technology*, **7**, 58-68.