Jurnal Ilmiah Teknik Elektro Komputer dan Informatika (JITEKI)
Vol. 10, No. 4, December 2024, pp. 914-929
ISSN: 2338-3070, DOI: 10.26555/jiteki.v10i4.28560

Designing UI/UX on Adaptive Skills Learning Application for Autistic Children Using Design Thinking Method and Applied Behavior Analysis Theory

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ARTICLE INFO

Article history:

Received October 14, 2024
Revised January 08, 2025
Published January 19, 2025

Keywords:

Website;
Adaptive Skills Learning;
Design Thinking;
Applied Behavior Analysis;
Learning Approach

ABSTRACT

This paper introduces he design of SemaiSelaras, an adaptive learning application tailored for children with Autism Spectrum Disorder (ASD), utilizing the Applied Behavior Analysis (ABA) theory and developed through the Design Thinking (DT) methodology. The application aims to address challenges faced by children with ASD in acquiring essential adaptive living skills. While prior studies have explored applications employing the DT methodology, this research uniquely focuses on integrating ABA theory to better meet the specific needs of users. The user-centered and iterative nature of DT ensured the application was designed to effectively address these requirements. The ABA approach, which breaks learning materials into manageable steps, supports children with ASD in gradually mastering life skills. SemaiSelaras integrates advanced technologies such as Optical Character Recognition (OCR), digital storyboard, audio discrimination learning, and video-based learning. The research contribution emphasizes the role of ICT in supporting accessibility and inclusion, helping children with ASD develop essential life skills. Usability testing was conducted using the System Usability Scale (SUS) and the SemaiSelaras prototype achieved an average score of 86.5, reflecting an excellent rating and demonstrating a high level of acceptance and usability for the application.

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1. INTRODUCTION

Children with Autism Spectrum Disorder (ASD) continue to face significant challenges in inclusive education [1]. ASD encompasses a range of neurodevelopmental conditions, including Asperger's Syndrome, Pervasive Developmental Disorders, and autism [2]. Over the past two decades, the prevalence of ASD has risen, with global estimates indicating that 0.62% to 0.70% of children and adolescents under 18 are affected, and rates reaching up to 1% to 2% in some regions [3], [4]. Boys are approximately 4.3 times more likely to be diagnosed with ASD than girls [5]. According to the World Health Organization (2020), ASD typically emerges during early developmental stages and is characterized by difficulties in social interaction, communication, and the presence of restricted and repetitive behaviors, activities, and interests [3], [6], [7], [8], [9]. These traits create unique challenges for children with ASD in developing independence in daily life. As a result, adaptive skills become a critical focus in their education, as individuals with ASD often experience greater difficulties in adaptive functioning compared to their typically developing peers [10], [11]. Individuals with ASD often require intensive support to develop skills that promote independence.

Despite advancements in educational support for individuals with ASD, many continue to experience suboptimal functional outcomes [12], particularly in adaptive and social skills [13], [14]. A persistent gap is often observed between adaptive functioning and intellectual abilities, even among individuals with ASD who do not

exhibit cognitive or language delays. This gap frequently widens as individuals transition from childhood to adulthood [13]. Additionally, children from families facing economic challenges or with lower levels of educational attainment are more likely to exhibit reduced adaptive skills [12].

An initial validation survey, conducted through interviews with autism class educators and administrators from the Rinjani Foundation, followed by a questionnaire, revealed several challenges in the learning process for children with ASD. Four primary issues affecting children with ASD, from school age to adolescence, were identified: social skills, communication abilities, behavioral challenges, and adaptive living skills. Educators also highlighted resource-related obstacles in providing effective instruction for children with ASD. These challenges include meeting competency standards, simplifying instructional materials, ensuring the effectiveness of teaching methods, integrating technology into the learning process, and addressing the limited availability of teaching resources.

The *SemaiSelaras* application was developed as an assistive technology to support children with ASD. This initiative was motivated by the limited availability of learning platforms specifically targeting adaptive skills, a critical development area for children with ASD. The design of the *SemaiSelaras* prototype integrates the Design Thinking (DT) methodology with the Applied Behavior Analysis (ABA) approach. This combination allows learning materials to be presented as small, manageable steps, taught incrementally over time until mastery is achieved. The ABA method is particularly effective for children with ASD, as it breaks down complex skills into smaller, more accessible components. The instructional process is structured, consistent, and patterned, with a clear schedule that facilitates practice and repetition, enabling effective skill acquisition [15], [16].

With rapid technological advancements, DT has emerged as a widely adopted methodology and a foundational principle in the innovation process [17]. DT is an experience-based, human-centered approach that emphasizes collaboration among team members, end users, and other stakeholders to develop innovative solutions [18]. As a problem-solving framework, DT has gained significant attention for its impact on innovation quality, technology development, and problem-solving strategies [19], [20], [21]. By prioritizing empathy, creativity, and an iterative design process, DT effectively identifies user needs and addresses complex problems. It plays a critical role in Requirement Engineering within Agile software development [22], ensuring solutions are user-centric and adaptive. DT fosters competitive advantages by improving user experience and creating products that respond effectively to user needs [17]. One of DT's strengths lies in its ability to explore both the problem and solution spaces. The problem space involves understanding user challenges and their contextual factors, while the solution space focuses on generating, developing, and refining innovative solutions [19]. Through its need elicitation process, DT enables the identification of socio-technical problems, encompassing the problem itself, its contextual framework, the stakeholders involved, and the interconnections among these elements [22].

DT consists of five sequential problem-solving stages: observing and listening to users, translating their expressions and behaviors into problem statements that address their needs, exploring alternative solutions, developing cost-effective and rapid prototypes, and ultimately implementing the most effective solution [23]. As shown in Fig. 1, these five key steps are empathize, define, ideate, prototype, and test [24]. DT is closely aligned with human-computer interaction and plays a vital role in software development [22]. Furthermore, DT is a robust, effective, and widely accessible methodology that can be applied across various sectors and products, generating concepts that are both ready for implementation and impactful. In the context of challenges faced by educators in special education, DT presents a promising approach for developing innovative learning platforms tailored for children with ASD. By using DT in the design process, applications can be developed to enhance user interaction with educational materials.

Fig. 1. The Design Thinking Process

Several studies have explored the application of DT in software development within the educational field. Nasution *et al.* (2021) developed a learning website application called *IdeIn* using the DT methodology. Through usability testing with the System Usability Scale (SUS), the *IdeIn* prototype achieved a score of 90, indicating high efficiency, effectiveness, and user satisfaction [25]. Similarly, Saputra *et al.* (2022) reported that CV Unindo Hestama Kreatif developed a mobile learning application, *UNI Course*, using DT. The design aimed to enhance the usability of existing e-learning systems by offering more service variations and reaching a broader audience. Testing with the Single Ease Question (SEQ) method showed scores ranging from 5.5 to 6.5 among five respondents, indicating a high level of user-friendliness [26]. Additionally, research by Alao *et al.* (2022) found that applying DT in designing the User Interface (UI) and User Experience (UX) for a web-based University

Management Information System resulted in an excellent SUS score of 87 [27].

Syahuda *et al.* (2023) applied DT and the Felder-Silverman learning preference model to design the UI and UX for a student discussion application. The prototype was evaluated using the SUS, achieving an excellent score of 85.56 [28]. Juansyah *et al.* (2023) redesigned a mobile-based Academic Information System (SIMAK) application using DT. Usability assessment through the User Experience Questionnaire (UEQ) yielded favorable results, with scores of 1.6 across five evaluation categories and a score of 1.3 in one category [29]. Amalia *et al.* (2023) developed the *Digilearn* application using DT to assist students with teaching and learning activities. The SUS evaluation showed an average score of 91, indicating that the *Digilearn* application offers a high or excellent level of usability [30]. Ma'roef *et al.* (2024) designed a mobile learning UI/UX for programming language content using DT. The SUS evaluation resulted in an average score of 65, categorizing it as sufficient, suggesting that the design is functional [31]. Ramadansyah *et al.* (2024) demonstrated the use of DT in redesigning an online learning platform. UEQ testing showed an improvement of over 0.8 points from the previous design, reflecting very good performance [32]. Table 1 summarizes several previous studies that were used by the researchers as references and sources.

Table 1. List of Previous Research Journals Related to The Past Three Years

No.	Journal Title	Equality
1.	UI/UX Design Web-Based Learning Application Using Design Thinking Method [25]	The researchers employed identical development and testing methodologies to those utilized in this study
2.	Designing User Interface of a Mobile Learning Application by Using a Design Thinking Approach: A Case Study on UNI Course [26]	The researchers utilized the same development methodology as implemented in this study
3.	User Centered/User Experience Uc/Ux Design Thinking Approach for Designing a University Information Management System [27]	The researchers employed identical development and testing methodologies to those utilized in this study
4.	UI/UX Design for Student Discussion Applications Based Felder Silverman Learning Style with the Design Thinking Method [28]	The researchers employed identical development and testing methodologies to those utilized in this study
5.	Application of Design Thinking Method in Redesigning the UI/UX of SIMAK (Academic Information System) of Sriwijaya University Based on a Mobile Platform [29]	The researchers utilized the same development methodology as implemented in this study
6.	UI/UX Design on Digilearn Application with the Iterative Design Thinking Methodology [30]	The researchers employed identical development and testing methodologies to those utilized in this study
7.	Designing UI/UX for Mobile Learning on Programming Language Material Using the Design Thinking [31]	The researchers employed identical development and testing methodologies to those utilized in this study
8.	Design Thinking Approach for User Interface and User Experience on Campus Online Learning Platform [32]	The researchers utilized the same development methodology as implemented in this study

The research contribution is the development of *SemaiSelaras*, a web-based e-learning platform aimed at enhancing adaptive skills in children with ASD. By utilizing the DT and ABA methods, *SemaiSelaras* integrates advanced technologies such as Optical Character Recognition (OCR), digital storyboard, audio discrimination learning, and video-based learning. The platform offers a comprehensive range of modules that cover essential life skills, including numbers, letters, emotions, social rules, communication, social skills, and more, organized into basic, intermediate, and advanced levels. This research is significant because adaptability in education is crucial to support accessibility, especially for individuals with special needs. Information and Communication Technology (ICT), particularly the internet, facilitates access to knowledge and inclusion, aiding individuals with disabilities in academic achievement, social skills, and employment opportunities. For individuals with ASD, human-computer interaction can create a safe, focused environment for more targeted development. Technologies such as specialized input devices, AI-based systems, arcade games, extended reality, and robotics have shown positive results in supporting individuals with ASD. Similarly, e-learning system design must understand the interaction between individuals with disabilities in learning environments to identify areas for improvement.

2. METHODS

Selecting the right materials is a crucial step in the product design and development process. Materials affect the entire product lifecycle, from manufacturing and usability to user satisfaction and technical feasibility (including cost, time, and resource efficiency for the organization). Product design must address all functional requirements based on user needs while utilizing the most appropriate material properties and manufacturing

processes [33]. The *SemaiSelaras* application was designed using the DT methodology and incorporates an ABA theory-based learning approach. DT is a problem-solving method that uses abductive reasoning and a human-centered approach. It consists of five iterative stages: empathize, define, ideate, prototype, and test. These stages are interconnected, influencing one another, and reflect the dynamic nature of DT [19].

2.1. DT

DT is a user-centered, iterative methodology that emphasizes empathy, creativity, and collaboration in problem-solving. It involves understanding the requirements and experiences of users to develop innovative solutions tailored to their specific challenges. When designing applications for children with ASD, DT allows researchers and developers to engage deeply with the target audience, ensuring the final product meets their unique needs. By following a structured process of defining problems, generating solutions, prototyping, and testing, DT helps create adaptable and effective learning tools that resonate with users.

2.1.1. Empathize

The empathize phase focuses on gaining a deep and comprehensive understanding of the challenges, values, and issues faced by users [18]. This foundational step is essential for guiding subsequent design decisions and ensuring user-centered solutions. The goal is to understand users' needs, motivations, and daily routines. Psychological insights are particularly valuable during this stage and can be obtained through interviews [25] or observation [34]. The approach used in the empathy phase is qualitative, involving interviews and observations to collect sufficient data and begin empathizing with users from their own perspective.

2.1.2. Define

The define stage involves synthesizing the insights gathered and outlining the problem space [18]. The goal of this stage is to identify the core problems that need to be addressed [25]. During this phase, the pain points related to the emerging issues are categorized [26]. The methodology used in this stage is "How Might We" (HMW). HMW is a DT technique that allows designers to reframe and expand their problem statements, fostering more efficient, focused, and innovative brainstorming sessions to tackle design challenges. HMW acts as a bridge between the define and ideate stages in the DT process. Crafting effective HMW statements requires a balance between detail and flexibility, guiding innovation while meeting user needs and desires. This technique frames ideas through concise questions that begin with HMW, serving as cognitive prompts that stimulate the flow of better ideas, all while maintaining a pre-defined point of view [35].

2.1.3. Ideate

The ideate stage focuses on generating a wide range of innovative ideas [18]. These ideas will eventually evolve into high-fidelity mockups and prototypes [26]. This stage involves more intensive brainstorming, addressing the issues identified in the previous phase by developing ideas or solutions [26]. During ideation, all ideas generated are recorded for further exploration. These ideas will serve as the foundation for system development. Methods used in the ideate stage include use case diagrams, flowcharts, and business requirement documents [36].

2.1.4. Prototype

The prototype phase focuses on developing prototypes to refine and enhance the concepts and ideas generated in the previous stages [18]. Once ideas or solutions are established during ideation, they are transformed into product prototypes [25], [26]. In this phase, ideas are realized as wireframes or low-fidelity designs and high-fidelity prototypes. Low-fidelity designs are initial sketches of the application's feature architecture, while high-fidelity designs represent the final design [26]. For prototype creation, this study uses Figma software.

2.1.5. Test

The test stage focuses on evaluating the prototype to assess its usability through direct interaction with end users [18]. The high-fidelity prototype will be tested with users to ensure the design meets their needs [26]. This stage provides feedback on whether the design needs improvement, particularly if users encounter difficulties or discomfort. The methodology used for testing is usability testing, a process where representative users assess how easy the design is to use [37]. Acceptance and usability are measured quantitatively using the SUS score [38].

SUS is the most widely used tool for usability testing [39]. Its advantages include being easily understood by respondents, accommodating small sample sizes while yielding effective results, and clearly differentiating between usable and unusable applications [28]. SUS consists of 10 questions using a five- point Likert scale [40],

designed to evaluate the usability of digital systems by assessing user satisfaction and system efficiency. In SUS usability testing, the questions posed to users are aligned with usability characteristics based on software usability assessment standards, particularly ISO 9241 [41], [42]. SUS evaluations are categorized into three levels: unacceptable (scores from 0 to 50.9), marginal (scores from 51 to 70.9), and acceptable (scores between 71 and 100) [43]. The standard mean score for SUS acceptance is 68, as illustrated in the SUS score visualization in Fig. 2 [41].

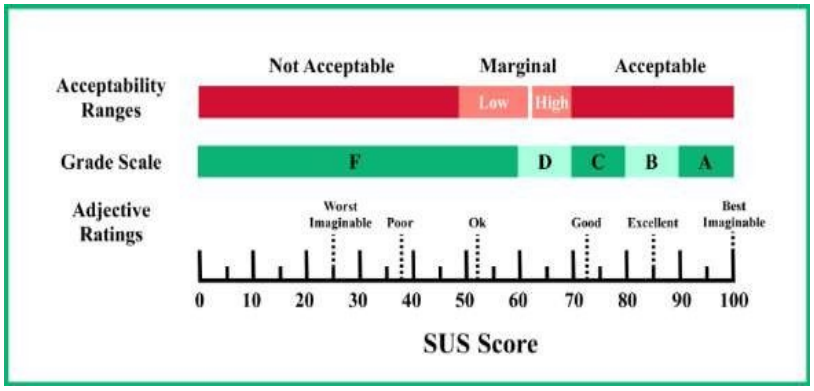

Fig. 2. SUS Score

2.2. ABA Theory

The *SemaiSelaras* application design incorporates the ABA theory as its learning approach. ABA is an instructional methodology that applies psychological principles derived from learning theory to modify behaviors commonly observed in individuals diagnosed with ASD [3]. ABA was originally founded by Ole Ivar Lovaas in 1974 to tackle deficiencies in children and adolescents with ASD across all functioning levels. This approach encompasses various domains, including cognition, social skills, language, adaptive skills, and behavior, such as personal care tasks like tooth brushing and dressing, along with other general applications of ABA [3], [16]. ABA is defined by three core characteristics: applied, behavioral, and analytical. Additionally, ABA must be technologically advanced, effective, conceptually systematic, and capable of demonstrating generalization [15]. The ABA approach is strongly supported by empirical evidence showing its effectiveness in enhancing the development of children with ASD [5]. For the *SemaiSelaras* application design, one ABA-based method used is Discrete Trial Training (DTT). The primary goal of DTT is to teach new behaviors and skills to children, including behaviors they have not previously performed, either consciously or unconsciously [3].

3. RESULTS AND DISCUSSION

The development of the *SemaiSelaras* application follows the DT method, which consists of several stages: empathize, define, ideate, prototype, and test [44]. The following presents the results from each stage of the DT process.

3.1. Empathize

The empathize phase in the DT process is crucial for gaining a deep understanding of users' experiences and needs. During this stage, user interviews are essential, providing direct insights into the challenges faced by children with ASD and their caregivers. These interviews allow for the collection of qualitative data that sheds light on users' perspectives, preferences, and motivations. Furthermore, creating user personas based on this information helps to synthesize and visualize the diverse characteristics of the target audience. These personas act as valuable reference points throughout the design process, ensuring that the solutions developed are closely aligned with users' unique needs and contexts.

3.1.1. User Interview

The researchers conducted interviews with two key informants to gain a comprehensive understanding of the perceived problems and needs. The results of these interviews are summarized in Table 2**.** The Board of Rinjani Foundation shown in Fig, 3 and Autism Class Teacher of Rinjani Foundation shown in Fig. 4.

3.1.2. User Persona

After conducting the interviews, the researchers developed user persona summaries to provide a deeper understanding of the product's end users. Two user personas were created: learners and educators, as shown in Table 3.

Table 2. The Results of The Interviews

Interviewe	Perceived Issues	Identified Needs
 **Fig. 3.** The Board of Rinjani Foundation	Limitations of media that can support adaptive skills training for individuals with ASD.	Practical e-learning platform.
	Existing educational media do not support individualized and contextual learning and are also less engaging	E-learning platforms with features for visual, auditory, reading/writing, and kinesthetic (VARK) modalities.
 **Fig. 4.** Autism Class Teacher of Rinjani Foundation	There is a lack of specialized instructional design, including the selection of methods, materials, and media.	The use of assistive technology applications with adaptive skills content
	Conventional teaching methods (lectures, demonstrations, and assignments) are less effective.	E-learning platforms featuring video-based learning, digital storyboards, audio discrimination learning, and hand drawing.

Table 3. User Persona

No.	User Persona	Objectives	Frustrations
1.	Azmi (Special Education School, Rinjani Foundation)	1.Access engaging learning materials anytime and anywhere 2.Enhance enthusiasm and motivation for learning 3.Facilitate learning through interactive play	1. Difficulty understanding instructions 2. Access engaging learning materials anytime and anywhere 3. Enhance enthusiasm and motivation for learning 4. Facilitate learning through interactive play
2.	Mrs. Irint (The Board of Rinjani Foundation)	1. Develop engaging and interactive learning materials 2. Adapt teaching methods to individual learning styles 3. Support effective communication for students 4. Maintain consistent routines and manage transitions	1. Difficulty keeping students engaged with repetitive materials. 2. Challenges in addressing diverse needs. 3. Managing sensory overload in the classroom. 4. Issues with student adaptation to routine changes.

3.2. Define

The define phase in the DT process is a critical step for clearly articulating user challenges in a focused and concise manner. During this phase, insights gathered from the empathize stage are synthesized to develop a problem statement that accurately represents the specific needs and challenges faced by children with ASD. The HMW method is then utilized to create guiding questions that inspire solution ideation. These HMW questions not only enhance understanding of the problem but also foster creative exploration, enabling the team to identify and develop innovative, user-centered solutions that are both relevant and impactful.

3.2.1. Problem Statement

Based on the empathy results for the target user groups, the researchers defined problem statements to prioritize the needs and challenges of the users. The three problem statements identified for the target users are:

1. Inadequate support for developing adaptive skills in autism.
2. Lack of integrated strategies for effective learning and competency achievement.
3. Limited accessibility and flexibility in current educational materials.

3.2.2. HMW Method

The HMW method serves as a pivotal tool within the DT framework, driving innovation through open-ended questions that encourage exploration and ideation. This technique enables teams to reframe challenges as opportunities, fostering a collaborative environment conducive to creative problem-solving. By transforming specific issues into broader inquiries, the HMW method supports the generation of diverse perspectives and ideas, ultimately resulting in more effective solutions. This section examines the application and impact of the HMW method within DT processes, emphasizing its role in enhancing user-centered design and achieving

successful outcomes. Table 4 presents the HMW statements derived from the identified problem statements alongside the solutions proposed by the researchers.

Table 4. HMW Method

No.	HMW	Pain Reliever	Gain Creator	Features
1.	HMW facilitates structured adaptive skills learning	Utilize the ABA method with step-by-step material delivery	Clear and easily followed learning structure	Multi-level classes (basic, intermediate, advanced) with structured modules
2.	HMW reduces the gap between intellectual and adaptive functioning	Provide content tailored to the capabilities of children with ASD	Learning tailored to the developmental level of the child	Basic communication skills, social skills, and fundamental social rules classes
3.	HMW supports educators in teaching adaptive skills	Integrated guides and ready-to-use resources	Easy access to teaching materials and supportive guidelines	Digital storyboard, emotion board checklist, animated videos
4.	HMW addresses technological and resource limitations	Lightweight web-based platform accessible across various devices	Compatibility with multiple devices and flexible access	Optimized website for various device
5.	HMW ensures consistent practice of adaptive skills	Automated scheduling and reminders for repeated practice	Regular and consistent practice to reinforce skills	Reminder and progress tracking features
6.	HMW makes adaptive skills learning engaging	Incorporate gamification and interactive activities	Engaging and motivating learning experiences with a reward system	Counting quizzes, picture crossword puzzles, animated videos
7.	HMW create an e-learning platform for children with ASD	Content that is easily comprehensible with an emphasis on adaptive skills	Learning tailored to the specific needs of children with ASD, with customizable access	Modules on emotion recognition, healthy living skills, and recreational activities
8.	HMW designs a simple and ASD-friendly UI and UX	Minimalist design with colors specifically chosen for children with ASD	Intuitive, focused navigation with design elements suitable for children with ASD	ASD-friendly interface design with calming, special color schemes

3.3. Ideate

The ideate phase in the DT process encourages creativity by enabling the team to generate diverse ideas and potential solutions. This stage prioritizes brainstorming and open dialogue, with a particular focus on formulating a clear value proposition for the application. The value proposition outlines the unique benefits offered to children with ASD and their caregivers, such as improving adaptive skills and delivering personalized learning experiences. By defining this specific value, the process ensures that the proposed solutions effectively address user needs and resonate with the target audience, serving as a foundation for the development of impactful interventions.

3.3.1. Value Proposition

SemaiSelaras is an innovative web-based learning platform designed to enhance the adaptive skills of children with ASD. Unlike existing applications, *SemaiSelaras* integrates OCR, digital storyboard, audio discrimination learning, and video-based learning with key components such as educators' needs, the surrounding environment (family, school, and community), curriculum, strategies, methods, and evaluation processes. This comprehensive framework ensures practical applicability in real-world educational settings. The platform provides a structured, multi-level learning experience based on ABA methodologies, delivering clear, step-by-step instruction across essential life skills, ranging from basic communication and social interaction to advanced vocational training. Its user interface is thoughtfully designed to accommodate the sensory needs of children with ASD, featuring a minimalist layout and ASD-friendly color schemes. Moreover, *SemaiSelaras* equips educators with ready-to-use materials and resources, ensuring consistency and efficacy in teaching practices. By addressing the disparity between intellectual abilities and adaptive functioning, *SemaiSelaras* empowers children with autism to achieve greater independence in daily life and reach their full potential,

3.3.2. ABA Implementation

The ABA method implemented in *SemaiSelaras* utilizes the DTT technique, which focuses on mastering behaviors or subject matter through small, incremental steps taught systematically within a defined timeframe

until proficiency is achieved. This technique involves repetitive practice and reinforces accomplishments, grounded in Lovaas's theory and behavioral learning principles. The DTT approach in *SemaiSelaras* features a structured trial cycle, beginning with clear instructions or guidance and concluding with rewards or appreciation, seamlessly integrated into its features. The ABA-based instructional methodology also adheres to fundamental principles, including warmth through genuine affection and consistent eye contact, firmness with clear and non-negotiable guidance, non-violence by avoiding anger and frustration, and assertive yet gentle assistance. The learning materials in *SemaiSelaras* are structured into three levels: basic, intermediate, and advanced. The basic level targets foundational skills such as compliance, eye contact, receptive and expressive communication, imitation, early academic abilities, and self-care. The intermediate level builds upon these skills, increasing complexity while maintaining the same core targets. The advanced level focuses on more sophisticated abilities, including complex instruction adherence, abstract language comprehension, academic proficiency, socialization, and advanced self-care skills. This tiered structure ensures a comprehensive and scalable learning experience, addressing the developmental needs of children with ASD.

3.4. Prototype

The prototype phase in the DT process focuses on developing tangible representations of proposed solutions, including use case diagrams, wireframes, and high-fidelity prototypes. Use case diagrams define user interactions with the application, providing clarity on essential functionalities. Wireframes offer a foundational layout of the user interface, illustrating the organization and navigation structure. High-fidelity prototypes build on these elements, incorporating detailed visuals and interactivity to enable usability testing and feedback collection. This iterative approach ensures that the application design aligns with user expectations and supports continuous improvement based on real-world interactions.

3.4.1. Use Case Diagram

The use case diagram is illustrated in Fig. 5.

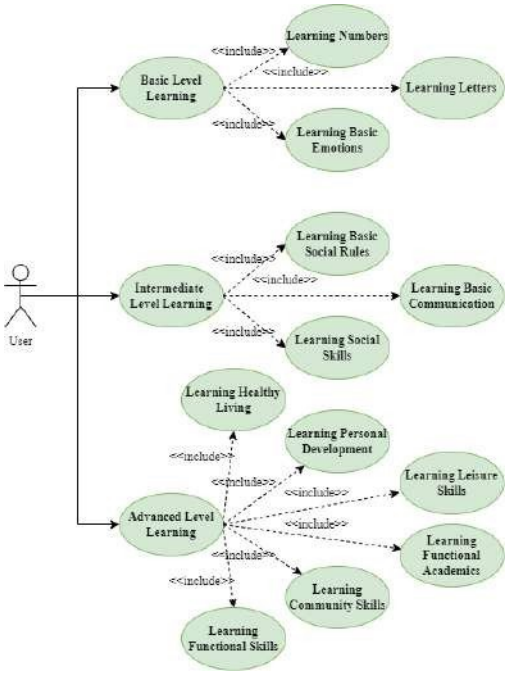

Fig. 5. Use Case Diagram

3.4.2. Wireframe

The wireframe serves as a critical visual representation of the application's layout and user interface, offering a clear framework for navigation and functionality. By emphasizing the arrangement of elements rather than detailed design aspects, wireframes provide a simplified yet comprehensive overview of the user experience, facilitating effective planning and development.

3.4.3. High-fidelity Prototype

The high-fidelity prototype provides a detailed and interactive representation of the application, incorporating design elements such as colors, typography, and visual aesthetics to closely simulate the final

product. This stage enables realistic user interactions and feedback, offering deeper insights into the user experience. Fig. 6 illustrates the high-fidelity prototype.

Fig. 6. High-fidelity Prototype

3.4.4. User Scenario

The following is Table 5, which presents the user scenarios of *SemaiSelaras*. User scenario shown in Fig. 7-Fig. 24.

Table 5. User Scenario

User Scenario	
Scenario 1: User Register	**Scenario 10: Accessing Social Skills Materials**
	
Fig. 7. User Register	**Fig. 8.** Accessing Social Skills Materials
Users must register first by clicking the "Register" button on the landing page. After completing the required information, they will be redirected to the sign- in page to access the website.	Users must register first by clicking the "Register" button on the landing page. After completing the required information, they will be redirected to the sign- in page to access the website.
Scenario 2: User Login	**Scenario 11: Accessing Basic Social Rules Materials**
	
Fig. 9. User Login	**Fig. 10.** Accessing Basic Social Rules Materials
For users who have registered an account, they can directly click the "Sign In" button on the landing page. After entering their registered email and password, users will be able to access the website.	For users who have registered an account, they can directly click the "Sign In" button on the landing page. After entering their registered email and password, users will be able to access the website.
Scenario 3: Accessing Profile	**Scenario 12: Accessing Healthy Living Materials**
	
Fig. 11. Accessing Profile	**Fig. 12.** Accessing Healthy Living Materials
After signing in, users are directed to the home page. To view their profile and learning progress, they can click the "Profile" button in the top right corner.	To access healthy living materials, users click "Select Advanced Level" on the home page, then "Start Learning" in the healthy living class. After selecting the material, click "Start" and "Continue" to complete all three learning stages.

User Scenario	
Scenario 4: Accessing Alphabet Learning Materials	**Scenario 13: Accessing Self-Development Materials**
	
Fig. 13. Accessing Alphabet Learning Materials	**Fig. 14.** Accessing Self-Development Materials
Users can access alphabet learning by clicking "Select Basic Level" on the home page, then "Start Learning" in the alphabet class. They can navigate A-Z materials using "Back" or "Next," and choose to "Learn Again," switch classes, continue, or return to the home page.	Users can access alphabet learning by clicking "Select Basic Level" on the home page, then "Start Learning" in the alphabet class. They can navigate A-Z materials using "Back" or "Next," and choose to "Learn Again," switch classes, continue, or return to the home page.
Scenario 5: Accessing Alphabet Practice Materials	**Scenario 14: Accessing Crossword Puzzles**
	
Fig. 15. Accessing Alphabet Practice Materials	**Fig. 16.** Accessing Crossword Puzzles
To access alphabet practice, users click "Select Basic Level" on the home page, then "Start Learning" in the alphabet class, and click "Start Practice" to begin writing exercises.	To access alphabet practice, users click "Select Basic Level" on the home page, then "Start Learning" in the alphabet class, and click "Start Practice" to begin writing exercises.
Scenario 6: Accessing Number Learning Materials	**Scenario 15: Accessing Math Quizzes**
	
Fig. 17. Accessing Number Learning Materials	**Fig. 18.** Accessing Math Quizzes
To access number learning, users click "Select Basic Level" on the home page, then "Start Learning" in the number recognition class, and select "Start Learning" for the 1-10 materials.	To access number learning, users click "Select Basic Level" on the home page, then "Start Learning" in the number recognition class, and select "Start Learning" for the 1-10 materials.
Scenario 7: Accessing Number Practice Materials	**Scenario 16: Accessing Leisure Skills Materials**
	
Fig. 19. Accessing Number Practice Materials	**Fig. 20.** Accessing Leisure Skills Materials
To access number practice materials, users click "Select Basic Level" on the home page, then "Start Learning" in the number recognition class, and click "Start Practice" to begin the writing exercises.	To access number practice materials, users click "Select Basic Level" on the home page, then "Start Learning" in the number recognition class, and click "Start Practice" to begin the writing exercises.
Scenario 8: Accessing Basic Emotion Materials	**Scenario 17: Accessing Community Skills Materials**
	
Fig. 21. Accessing Basic Emotion Materials	**Fig. 22.** Accessing Community Skills Materials
To access basic emotion recognition materials, users click "Select Basic Level" on the home page, then "Start Learning" in the emotion recognition class, and select "Watch Video" for the desired material.	To access basic emotion recognition materials, users click "Select Basic Level" on the home page, then "Start Learning" in the emotion recognition class, and select "Watch Video" for the desired material.

User Scenario	
Scenario 9: Accessing Basic Communication Materials	**Scenario 9: Accessing Basic Communication Materials**
	
Fig. 23. Accessing Basic Communication Materials To access basic communication materials, users click "Select Intermediate Level" on the home page, then "Start Learning" in the basic communication class, select the material, and click "Start" and "Continue" to complete the lesson stages.	**Fig. 24.** Accessing Vocational Skills Materials To access basic communication materials, users click "Select Intermediate Level" on the home page, then "Start Learning" in the basic communication class, select the material, and click "Start" and "Continue" to complete the lesson stages.

3.5. Test

The test phase in the DT process is crucial for assessing the effectiveness of the prototypes and ensuring they meet user needs. This stage involves conducting usability testing, where real users interact with the application to identify usability issues and collect feedback on their experience. A key tool used in this phase is the SUS score, a widely recognized survey instrument that evaluates the perceived usability of the application. By analyzing the results from usability testing and SUS, valuable insights can be gained regarding the application's functionality, necessary improvements, and alignment with user expectations, ultimately guiding further refinements to enhance the user experience.

3.5.1. Usability Testing

At this stage, the researchers conducted usability testing with five target users, accompanied by a classroom teacher, who directly interacted with the *SemaiSelaras* application. The target users were children with ASD, aged 7 to 16 years.

3.5.2. SUS

Usability testing was assessed using the SUS score, where evaluators were asked to rate each SUS item on a scale from 1 (strongly disagree) to 5 (strongly agree). Table 6 presents the SUS questions.

Table 6. SUS Questions

No	Question
1.	I think I will reuse this system in the future.
2.	I perceive this system as complex and challenging to navigate.
3.	I consider **this** system to be user-friendly.
4.	I require assistance from others or technicians to effectively utilize this system.
5.	I observe that the functionalities of this system operate as anticipated.
6.	I perceive that there are numerous inconsistencies within this system.
7.	I believe others will readily grasp how to utilize this system.
8.	I find this system to be unclear.
9.	I feel there are no obstacles in using this system.
10.	I need to familiarize myself with this system before using it.

After collecting data from the respondents, the next step is to calculate the results. When using SUS, there are specific rules for computing the SUS score. The following guidelines must be followed when determining the scores on the questionnaire:

1. For every question with an odd number, deduct 1 from the user's score.
2. For every even-numbered question, deduct the user's score from a total of 5.
3. The SUS score is derived by aggregating the scores for each question and subsequently multiplying the total by 2.5.

The average SUS score is calculated by adding all scores and dividing by the total number of respondents. The formula for calculating the SUS score is presented in (1).

$$\bar{x} = \frac{\sum x}{n} \tag{1}$$

$\bar{x}$ is average score $\sum x$ is total SUS score, n is number of respondents

The original scores from each respondent are presented in Table 7, whereas the results of the SUS calculation are presented in Table 8.

Table 7. Original Scores of Respondents

No	Respondent	Age	Gender	Original Score									
				Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
1	User 1	35	Male	**5**	**1**	**4**	**2**	**5**	**1**	**5**	**2**	**5**	**2**
2	User 2	15	Male	**5**	**1**	**5**	**1**	**4**	**1**	**3**	**1**	**4**	**1**
3	User 3	13	Male	**4**	**1**	**5**	**1**	**5**	**2**	**4**	**3**	**3**	**1**
4	User 4	46	Female	**5**	**2**	**4**	**2**	**5**	**1**	**4**	**1**	**5**	**3**
5	User 5	15	Female	**3**	**1**	**5**	**1**	**4**	**2**	**5**	**2**	**5**	**2**

Table 8. Score of Sus Calculation Results

Calculated Scores										Total	Value
Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10		(Total x 2.5)
4	4	3	3	4	4	4	3	4	3	36	90
4	4	4	4	3	4	2	4	3	4	36	90
3	4	4	4	4	3	3	2	2	4	33	82.5
4	3	3	3	4	4	3	4	4	2	34	85
2	4	4	4	3	3	4	3	4	3	34	85
Average Score (Final Result)											**86.5**

The mean SUS score across all respondents is illustrated in Fig. 25. The SUS evaluation generated an average score of 86.5, indicating that the *SemaiSelaras* application has a high or excellent level of usability.

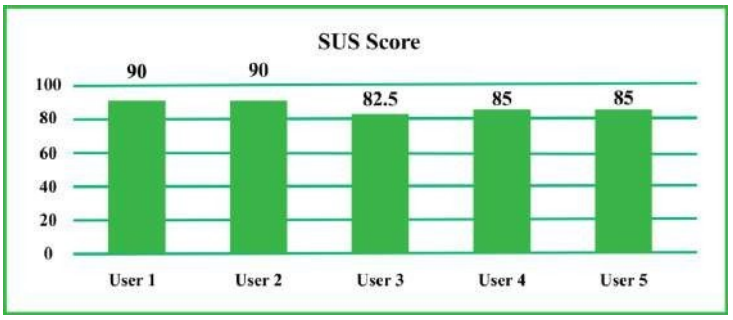

Fig. 25. SUS Score Result

3.6. Benchmarking

A comparison of the *SemaiSelaras* application with other ASD support applications, based on the technology implemented and main contribution, is presented in Table 9.

Table 9. Benchmarking

No.	Author	Year	Title	Technology Implemented	Main Contribution
	Putri *et al.* (Proposed)	2024	Designing UI/UX on Adaptive Skills Learning Application for Autistic Children Using Design Thinking Method and Applied Behavior Analysis	E-learning platform design	The author developed SemaiSelaras, a web-based e-learning platform for enhancing adaptive skills in children with ASD, using DT and ABA methods. It for Autistic Children Using Design Thinking Method and Applied Behavior Analysis incorporates OCR, digital storyboards, audio discrimination, and video-based learning across modules such as numbers, letters, emotions, communication, social skills, and more. The prototype received a high SUS score of 86.5, indicating very high usefulness.
	Al-Meyah*et al.* [45]	2024	Web-site Design (Behavioral + Educational) to Help Autism Children Disorder	E-learning platform design	This article introduces an interactive digital program to teach children with autism the Arabic alphabet, numbers, and basic arithmetic through a six-page educational website with dynamic visuals, developed in HTML, aimed at maintaining attention and enhancing focus.

No.	Author	Year	Title	Technology Implemented	Main Contribution
	Wulandari *et al.* [46]	2024	Feasibility Test of Web-Based Video Modelling Media for Learning Social Skills for Autistic Students at Inclusive Elementary Schools in Surakarta	E-learning platform design	This study evaluates a web-based video modeling tool for teaching social skills to autistic students in an inclusive elementary school in Surakarta, receiving high ratings from experts and users, confirming its suitability.
	Chung *et al.* [47]	2022	Towards Developing Digital Interventions Supporting Empathic Ability for Children with Autism Spectrum Disorder	Mobile application design	The authors developed a mobile app using DT to foster empathy in children with Asperger's syndrome. Experts familiar with ASD evaluated its usability and suitability, ensuring it meets the specific needs of the target users.
	Polychronis *et al.* [48]	2022	Use of an App with Embedded Video Modeling to Increase Eye Contact	Mobile application design	This paper presents *We Are Friends*, a mobile app designed to improve eye contact in children with ASD by using video modeling and gradually replacing familiar faces with unfamiliar ones in daily routines and social skill modules.
	Purnama *et al.* [49]	2021	Educational Software as Assistive Technologies for Children with Autism Spectrum Disorder	Mobile applications using assistive technology	The study presents Squizzy, a mobile app developed using Scrum to help autistic children aged 5 to 15 improve their social interaction skills.
	Ahmad *et al.* [50]	2020	Development of a Mobile Application Using Augmentative and Alternative Communication and Video Modelling for Autistic Children	Mobile application design	This paper presents AutiAct, a mobile app designed to help children with ASD learn daily routines through training videos at three difficulty levels: easy, medium, and hard, using augmentative communication and video modeling techniques.

4. CONCLUSION

The *SemaiSelaras* application, developed using DT methods and based on the ABA approach, effectively addresses the unique challenges adopted by children with ASD in learning adaptive skills. The user-centered and iterative nature of DT ensures that the application is tailored to the specific needs of its users, while the ABA approach provides a structured framework for breaking down complex tasks into manageable steps. Based on design results from DT methods and usability testing using SUS, the *SemaiSelaras* application prototype achieved an average score of 86.5. According to the SUS justification table presented in **Fig. 2**, the *SemaiSelaras* application falls into Quadrant B, indicating an acceptable level of user acceptance with an excellent rating.

Acknowledgments

The author expresses their deepest gratitude to the Bachelor of Telecommunications Engineering study program and the School of Electrical Engineering, Telkom University for their invaluable support throughout the research. Special thanks are also extended to the Rinjani Foundation for their significant contribution to this study.

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