# *Exploring Potential Application Areas of Artificial Intelligence-Infused System for Engagement Recognition: Insights from Special Education Experts*

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Won Kim
Gwangju Institute of Science and Technology
Gwangju, South Korea
kimwon30@gm.gist.ac.kr

Minwoo Seong
Gwangju Institute of Science and Technology
Gwangju, South Korea
seongminwoo@gm.gist.ac.kr

Joseph DelPreto
Massachusetts Institute of Technology
Cambridge, United States
delpreto@csail.mit.edu

Wojciech Matusik
Massachusetts Institute of Technology
Cambridge, United States
wojciech@csail.mit.edu

Daniela Rus
Massachusetts Institute of Technology
Cambridge, United States
rus@csail.mit.edu

SeungJun Kim*
Gwangju Institute of Science and Technology
Gwangju, South Korea
seungjun@gist.ac.kr

## Abstract

Active engagement where children with autism spectrum disorder (ASD) are involved (e.g., educational and social activities) plays a crucial role in enhancing their cognitive, motor, and social development. This offers opportunities to enhance overall development, including learning abilities, physical coordination, and social interactions. Indirect methods, leveraging sensors and artificial intelligence (AI), have exhibited potential for enhancing engagement predictions but have been primarily focused within specific fields, resulting in a gap that leads to limited generalizability of ASD studies. This gap, due to small ASD sample sizes, presents a significant challenge as the annual ASD population increases, highlighting the need for practical and applicable research solutions, especially for general learning. In this work, we conducted expert interviews to explore the potential application areas of AI-infused systems that provide three levels of engagement status for children with ASD, ranging from "not engaged and out of control" to "highly engaged." Interviews with special educators revealed five key application areas for AI-driven engagement recognition: social skills training, stereotyped behavior modification, support for leisure activities, effective tutoring, and independent daily living skills. These findings highlight the potential of adaptive AI interventions in improving educational and daily outcomes, advocating for expanded applications for children with ASD.

## CCS Concepts

• **Human-centered computing → Accessibility theory, concepts and paradigms**.



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## Keywords

Application; Artificial intelligence-infused system; Autism spectrum disorder; Engagement recognition; Expert interview

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## 1 Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by delays and deficits in cognitive, motor, and social development [8, 27], which may compromise engagement in daily activities [28, 39]. Active engagement has been conceptualized as a dynamic construct crucial for learning in the early stages of children with ASD [37], implying that recognizing engagement is crucial. However, understanding the direct engagement status of children with ASD is complex and challenging, considering that individuals may exhibit different patterns or behaviors based on their engagement level [35]. Therefore, indirect methods such as the use of sensors have become prevalent [5]. Moreover, the adoption of artificial intelligence (AI) has resulted in advancements in the accuracy of engagement prediction [33]; however, most studies have not focused on its practical application and further development toward potential application areas for children with ASD [22].

An Engagnition dataset was proposed for "engagement recognition" and facilitating interventions of children with ASD, aiming at AI application purposes in the context of a serious game (SG) with off-the-shelf wearable devices (Empatica E4 [18]), all of which have demonstrated potential for practical implementation in real world settings [22]. This dataset publicly provides multi-dimensional data while children are involved in SG, defined as "a game designed not just for enjoyment but also for skill development." SG offers benefits such as ease of use, potential for practical replication, and structured, repetitive learning [4, 36]. It is widely utilized in research


**Figure 1: Expert interview illustration depicting the process of exploring potential application areas for an AI-infused system of engagement recognition.**

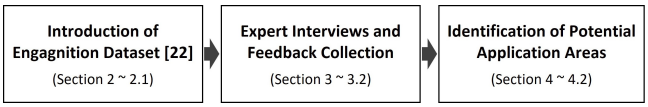


**Figure 2: Flowchart outlining the procedures of the study.**

involving children with ASD (e.g., FroggyBobby [7], ECHOES [2]) and is integrated into special education programs and on-site classroom settings [44]. By incorporating interactive and immersive elements from gamification, SG helps maintain engagement and enhance learning outcomes of a given task or goal, which in turn emphasizes the importance of SG and makes it promising due to its potential applications in the acquisition of skills across daily life and various domains and educational purposes.

However, the expandability of these areas requires further exploration, as the majority of studies have been biased toward developing highly predictable models for engagement in the context of assistive robots, aiming to enhance prediction accuracy [33, 34]. In addition, studies involving children with ASD are challenging due to participant specificity and small sample sizes, resulting in insufficient empirical evidence from recent studies [35] within specific domains [33, 34], rather than for general purposes that are practically applicable and feasible in classroom settings. This in turn has resulted in a gap that leads to a lack of empirical studies necessary for broader application and expansion into various areas [22]. There have been no comprehensive investigations exploring potential application areas of engagement recognition for children with ASD. To bridge this gap, additional study is required, focusing on exploration and proposals for applicable areas that are crucial for expanding into diverse domains. With the growing ASD population [9], broadening assistive technology into areas such as general learning and cultural leisure activities is becoming important [21].

The goal of this work is to investigate the potential application areas of an AI-infused system that provides engagement status of children with ASD by classifying their engagement within three levels (i.e., 0: not engaged and out of control, 1: moderately engaged, 2: highly engaged). To achieve this, we conducted expert interviews involving nine teachers in the special education field to answer the following research question: "*What are the potential application areas of an AI-infused system for engagement recognition in children with ASD?*" as illustrated in Figure 1. This approach enables the identification of applicable areas in recognizing engagement status and its AI applications, revealing gaps and on-site challenges that need improvement in special education and assistive technology, thereby inspiring further research in ASD.

The following section introduces the Engagnition dataset, providing detailed context and data description, as illustrated in Figure 2. Section 3 outlines the entire process of conducting expert interviews and administering detailed questionnaires for feedback collection. And section 4 reports the results on potential application areas for engagement recognition in children with ASD. The final section discusses the conclusions and outlines future directions.

## 2 Engagnition Dataset

### 2.1 Dataset Description

This dataset is dedicated to provide multi-dimensional data (i.e., physiological and behavioral responses, expert annotations, and post-hoc questionnaires) of children with ASD in the context of playing an SG, with the purpose of incorporating AI and advancing engagement recognition [22]. This dataset involves engagement [16, 25], gaze fixation [32, 41], intervention [38], responses on galvanic skin response [3, 6] and skin temperature [15], performance [1], elapsed time [17], accelerometer [26, 31], NASA task load index [47], and system usability scale [12] as summarized in Table 1. It provides data in the context of limited access and a few publicly available datasets of children with ASD, focusing on practical implementations (e.g., SG and off-the-shelf devices) in a real world setting in terms of cost-effectiveness and lower barriers. This dataset was established with the background of an SG, known as "Defeat the Monster," which aims to promote cognitive and motor development by incorporating visual perception, motor planning, and execution of movements by recognizing and classifying toy blocks [11, 29]. When children with ASD recognize the color of the tasks from the screen that presents the target color and classify them into boxes with matching colors, an attack on the monster occurs. By repeating this attack process, the monster is finally defeated when the anger gauge reaches its maximum.

**Table 1: Dataset description for engagement recognition**

| Data/signal | Sampling rate | Range/Unit |
|---|---|---|
| Engagement | 60 Hz | Code (0/1/2) |
| Gaze fixation | 60 Hz | Code (0/1) |
| Intervention | *On each occasion* | Time stamp |
| Galvanic skin response | 4 Hz | $\mu$S (Siemens) |
| Skin temperature | 4 Hz | ℃ |
| Performance | *Every session* | Score (0/1) |
| Elapsed time | *Every session* | s (second) |
| Accelerometer | 32 Hz | g $\approx 9.81 m/s^2$ |
| System usability scale | *Post-experiment* | Score (0-100) |
| NASA task load index | *Post-experiment* | Score (0-100) |

# 3 Expert Interview

We designed and conducted expert interviews to investigate the potential application areas of an AI-infused system for engagement recognition from expert perspectives, as incorporating on-site feedback for practical application is considered crucial [46].

## 3.1 Expert Composition

To explore and broaden the practical application areas of expertise, we recruited teachers in special schools. The recruitment criteria were (i) more than 5 years of experience in the field, and (ii) being an on-site special educator currently working with our focus group. We interviewed nine teachers (age: $M$ = 35, $SD$ = 6) who were currently working in special schools and classes for children with ASD and intellectual disabilities, as summarized in Table 2. These teachers had an average of over 16 years of experience, spanning from education (i.e., special education) to work experience as teachers. All experts have research experience in studies involving children with ASD, with experts B and E holding doctoral degrees in special education. Experts A and G specialize in AI fusion in special education, and experts A, B, C, D, E, F, and G are part of a program planning group run by the city's education office for software education and AI applications. Considering the diversity of specialization in the field of special education and the decades of on-site experience of the experts we have recruited, we believe that our expert group is ideally aligned with our goals. Furthermore, their extensive knowledge of the characteristics, challenges, and needs of school-aged children with ASD makes them particularly well-suited for our investigation.

**Table 2: Interview group of experts *(Note: Gen = Gender, YEW = Years of Education and Work Experience, M = Male, F = Female)***

| Expert | Gen | Age/YEW | Specialization |
|---|---|---|---|
| A | M | 35/14 | Science and AI fusion education |
| B | M | 36/18 | Learning disability |
| C | M | 29/12 | Secondary special education |
| D | M | 33/15 | Information and computer |
| E | M | 49/23 | Multiple physical disabilities |
| F | F | 36/19 | Secondary special education |
| G | M | 41/21 | AI fusion education |
| H | M | 32/14 | Secondary special education |
| I | F | 29/10 | Secondary special education |

## 3.2 Interview Process and Questionnaire

The interview was designed to be concurrently conducted with the administration of the questionnaire, taking approximately 1 h per expert. The questionnaire was delivered using a survey tool (i.e., SurveyMonkey) and provided via laptop PC. Experts were required to type their responses directly into the survey platform during the interview. All expert responses were digitized and output in CSV format for each question.

The questionnaire comprised three sections, starting with demographic information (e.g., name, age, gender, affiliation, major, specialization, years of work experience, types of disabilities that the special education teacher has previously worked with, and research experience). The second section provided an introduction to engagement recognition in the context of SG, including its background and operation method, the purpose and detailed description of the dataset, and a brief video illustrating the AI-infused system that classifies engagement status into three levels. In the last section, experts were asked to answer questions on potential application areas where AI-infused systems of engagement recognition could provide substantial benefits, particularly in assisting children with ASD and supporting educators. For instance, three questions were asked for each scenario: Q1. "*In which areas (e.g., education, culture, and daily living) and which activities within those areas (e.g., vocational training) can this AI-infused system of engagement recognition for intervention be utilized for children with ASD?*", Q2. "*Why is engagement recognition and intervention necessary for children with ASD in the activities proposed in Q1?*", and Q3. "*What expected benefits are anticipated through the engagement recognition of children with ASD?*" After the interviews, experts received $90 as compensation.

# 4 Interview Result

We reviewed the results from individual interviews. All questionnaire answers were compiled and similar responses were merged, ultimately resulting in the identification of five distinct application areas for AI-infused systems for engagement recognition, as illustrated in Figure 3. The following section 4.1 presents five potential application areas derived from the expert interviews, along with the distribution of individual responses to identify the prioritized and biased outcomes, as detailed in section 4.2.

## 4.1 Potential Application Areas

*4.1.1 Social skills training and social adaptation.* Improving communication skills, basic functional abilities for the independent use of public facilities, vocational skills for economic activities, and interpersonal relationships for social activities is important [27]. According to expert G, "*Social adaptation impacts various areas, including personal life, vocation, leisure, and independent living. Therefore, special education programs aim to teach and train in areas such as interpersonal, communication, and basic learning skills in actual classes. For children with ASD, social skills training and social adaptation are considered to be the starting point in all life areas, playing a crucial role in their development.*" Hence, applying an AI-infused system to understand their engagement levels could serve as a significant milestone for improving social abilities, considering the need for varied experiences and training in social skills and adaptation. Understanding the precise moment when an individual's engagement declines can help identify areas of competence deficiency in social interactions of children with ASD. This allows for the development of personalized teaching methods and adaptive interventions to improve social abilities, according to expert I [23].

*4.1.2 Stereotyped behavior modification.* Stereotyped behavior in children with ASD exacerbates difficulties for those around them (e.g., family members, caregivers, and teachers), posing dysfunctional challenges to their coexistence in society [31]. This may include high-risk behaviors such as biting, hitting, head-banging, scratching, and self-harm. Disruptive behaviors such as crying, screaming, refusal to speak, and leaving seats can also occur, along

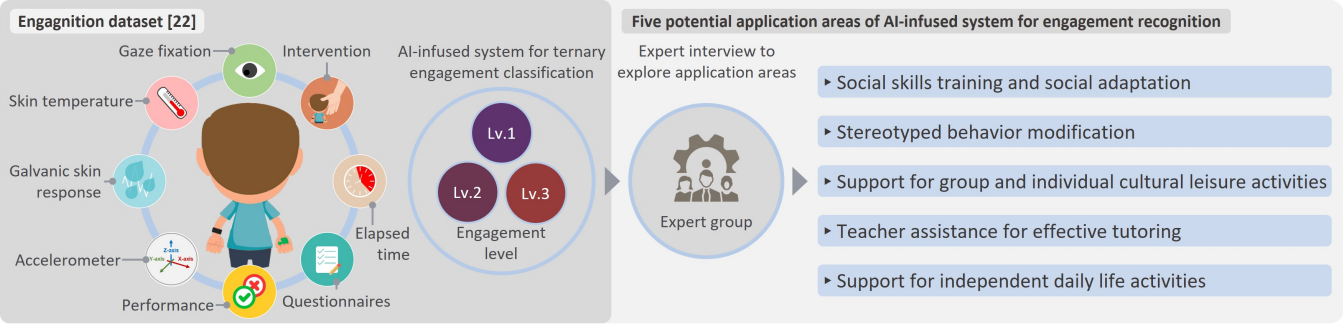


**Figure 3: Diagram illustrating five potential application areas of the engagement recognition based on expert interviews.**

with echolalia, clapping, tics, and body shaking in public places. These stereotyped behaviors not only cause physical, psychological, and economic pain for those around them but also deprive children with ASD of educational opportunities. Identifying problem behaviors in advance and applying an AI-infused system to monitor engagement levels is meaningful for correcting these behaviors [24]. In addition, experts D and G noted that, "*Attacks or self-harming behaviors are often influenced by preceding events, though not all cases can be definitively linked. Nevertheless, if low levels of engagement or disengagement associated with stereotyped behavior are identified in advance, they can be addressed through proactive interventions.*"

*4.1.3 Support for individual and group leisure and cultural activities.* Playful and physical activities are commonly used by children with ASD and are enjoyable and easily adaptable to their developmental levels, according to expert F [22]. These activities allow children to express their emotions and relieve their stress. They also aid in forming relationships with peers [43]. In addition, these activities can promote basic daily living skills and sociability. These skills can be enhanced by following simple rules to address problems individually or collaboratively within an activity [30]. According to experts C and G, "*Behavioral patterns represented in one-on-one activities may differ from those in group activities. In this context, an AI-infused system for monitoring individual's engagement level can be helpful for programming teaching methods and personalizing them by observing their interactions* [33]."

*4.1.4 Teacher assistance for effective tutoring.* Integrating feedback from monitoring both the engagement and physiological and behavioral responses of children with ASD can be used for intensive instruction [48]. For instance, it can be helpful in guiding students to use step-by-step techniques in task analysis. Expert D emphasized, "*By foreseeing and preventing impulsive behaviors at the stage where children with ASD are experiencing limitations or difficulties (i.e., when their engagement level is low as detected by AI), appropriate instruction can be provided, such as resting or additional intervention.*" Additionally, it can be effectively applied to physical education activities [39], according to expert B. In response to obesity and underdeveloped basic motor skills, the inclusion of physical activity in curricula is being actively promoted [28]. In physical activity, it is important to perform core and basic physical exercises, understand the concentration required to maintain posture, the limits of an individual, and health status, and provide guidance accordingly. Intensive instruction is expected to be possible not only through engagement but by also monitoring other measuring indices (e.g., heart rate and endurance), according to expert D.

*4.1.5 Support for independent daily living activities.* For children with ASD, whose daily living skills have not yet been developed, providing adaptive feedback based on the performance of an individual plays an important role in enhancing daily living skills [45] (e.g., going to the theater (experts I and H), boarding a bus (expert D), using a kiosk (expert E), and hand washing (expert C)). For instance, teaching children hand washing as part of their daily living skills involves multiple steps. However, for children with ASD, instructions are further divided into smaller tasks, starting from approaching the sink and finally drying their hands using a towel. If a child struggles or fails to complete a stage, providing follow-up intervention (e.g., guidance or clues) based on engagement levels can be beneficial for developing daily living skills. In particular, expert C noted that, "*The feedback is expected to be helpful when combined with backward or forward chaining methods* [13]."

## 4.2 Distributions of Individual Responses

A total of 26 feedback reports from experts were categorized within five potential application areas because one feedback was not completed and was thus excluded. As shown in Figure 4, the distribution result was visualized based on 26 feedback reports. Social skills training and social adaptation was mentioned the most. This aligns with the trend that primarily focuses on social engagement and interaction involving children with ASD [10, 19]. Supporting individual and group leisure and culture followed next. Forming a healthy mindset can lead to increased participation in all areas for an individual with ASD, and can prevent stereotyped and disruptive behavior [24]. The effects can be further maximized in interactive and playful activities [40], and in interaction between peers and groups [43]; thus, this might have been considered important. Independent support for daily living activities follows, focusing on increasing the independent daily living skills of children with ASD from school age and beyond [13]. To support an independent life, acquiring and enhancing skills in various daily living skills (e.g., brushing teeth (expert A) [42], cleaning (expert E) [14], and washing hands (expert C) [20] is the focus in the field of special education. The highly mentioned and ranked categories align well with the trend of previous studies traditionally targeting children with ASD,

and have been identified as promising areas for the incorporation of AI-infused systems.

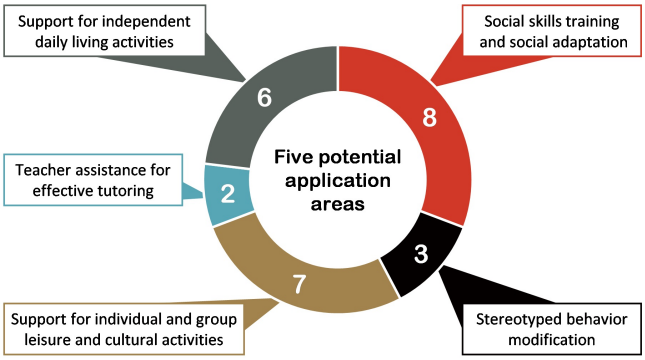


**Figure 4: Visual representation of individual interview results distributed across five potential application areas.**

## 5 Conclusion and Future Works

This work highlighted the potential of AI-infused systems that provide engagement status with three levels and integrate follow-up interventions. Through expert interviews, we identified five key application areas where AI-infused systems can benefit: (1) social skills training and social adaptation (e.g., an AI that monitors engagement levels to improve social skills and adaptation in children with ASD by identifying moments of disengagement and areas of social competence deficiency, such as communication, cooperation, and emotional regulation), (2) stereotyped behavior modification (e.g., an AI that can predict in advance the moment when engagement decreases, leading to proactive intervention by a teacher or assistive system), (3) support for group and individual leisure and cultural activities (e.g., an AI that can monitor engagement levels in one-on-one and group activities to optimize leisure and cultural programs), (4) teacher assistance for effective tutoring (e.g., an AI that monitors engagement levels during lessons to detect moments of limitations or difficulties, providing appropriate instruction to optimize tutoring), and (5) support for independent daily living activities (e.g., an AI that monitors engagement levels during daily living activities to help children with ASD develop independent living skills through tailored guidance and support). In addition, we recognized the significant role and need for early prediction of declining engagement, personalized learning, and linking follow-up interventions based on engagement levels of children with ASD. This work contributes to expanding the application areas of AI from the perspectives of special educators, researchers, and parents, and aims to inspire further research on AI-driven assistive technologies for children with ASD.

Implementing an AI-infused system for engagement recognition involves several practical considerations. Tasks involving children with ASD can vary widely, leading to diverse cognitive and motor demands, which may require tailored modeling of engagement recognition for specific contexts. Extensive data collection and learning from various contexts are necessary to optimize engagement recognition across activities. The AI-infused system in this study uses physiological and behavioral data to determine the child's level of engagement while ensuring data anonymization for privacy. However, using facial or emotional data for advanced engagement modeling raises security concerns, necessitating informed consent and robust data protection measures.

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