A Serious Game Integrating Facial Emotion Recognition to Support Emotional Learning in Children with Autism

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ABSTRACT

Autism is a neurodevelopmental condition that affects children's ability to recognise and express emotions, influencing social interaction and emotional growth. Current interventions, such as serious games, rarely incorporate facial emotion recognition (FER) to observe how children respond during play. This study presents the development and exploratory evaluation of a serious game designed to support emotional recognition in children with autism, with FER technology used as an observation tool. Design requirements were derived from the literature and discussed with special-needs teachers before iterative refinement. A qualitative methodology was employed, incorporating teacher input, iterative design, and structured testing to explore usability and educational and developmental potential. The study was conducted with the National Autism Society of Malaysia (NASOM) Melaka, involving a pre-screening of 33 children and a comparative evaluation with 8 selected participants, supported by 4 teachers through gameplay facilitation and interviews. The game includes three progressive levels targeting tasks such as mimicking, identifying, and recalling emotions, while MorphCast FER software recorded children's facial expressions during play. Findings suggest that FER readings were more informative for expressive children, whereas readings for less expressive children were often dominated by sad, surprise or undetected frames. Auditory feedback and repeated play appeared to support engagement and independence and to reduce the need for teacher prompting. These preliminary findings indicate that serious games combined with FER-based observation may be a promising approach to emotional skill development in autism, although the small sample, short two-week duration and lack of ground-truth validation limit generalisation. Future work should examine larger samples, alternative FER tools and long-term outcomes.

Keywords: Autism, Serious Games, Facial Emotion Recognition, Emotional Learning, Disability Education

INTRODUCTION

Autism is a lifelong neurodevelopmental condition that typically emerges in the first three years of life and affects communication, social interaction and behaviour (Lord et al., 2020). A core difficulty is recognising and interpreting emotions from facial expressions, which can limit social relationships and emotional development (Carlier et al., 2020). The National Autism Society of Malaysia (NASOM) provides early intervention, vocational training and therapy services.

Serious games (digital games for educational or therapeutic purposes) can sustain the attention of children with autism and let them practise social-emotional skills in a safe and repeatable setting (Carneiro et al., 2024; Hassan et al., 2021). Facial emotion recognition (FER) can analyse a child's expressions in real time (Dalwadi et al., 2023; Huang et al., 2023).

However, many serious games for children with autism still lack integrated, real-time FER (Carlier et al., 2020), and few studies examine FER inside game environments designed specifically for this group (Francillette et al., 2021). Open challenges include FER accuracy for atypical expressions and privacy (Abd El-Sattar et al., 2024; Marín-Vega et al., 2024).

This paper reports the development and exploratory qualitative evaluation of a serious game that uses FER as an observation tool to support emotional learning in children with autism. It is guided by three research questions: (RQ1) What are the requirements for developing a serious game for children with autism? (RQ2) How can FER be effectively used alongside such a game? (RQ3) How can FER be used to observe and evaluate emotional responses in these children? It contributes design requirements, a three-level game with MorphCast FER as an observation tool, and preliminary qualitative evidence on where FER works and where it does not.

LITERATURE REVIEW

Serious Games for Emotional Learning

Systematic reviews show that serious games with structured environments, clear visual cues and immediate feedback are effective for teaching social and emotional skills to children with autism, particularly when difficulty adapts to the player's progress (Carneiro et al., 2024). High-contrast visuals and expressive animated characters help children interpret emotional expressions, and a game offers a safe place to practise (de Carvalho et al., 2022).

Facial Emotion Recognition in Autism Interventions

FER can follow a child's expressions in real time and give immediate, consistent feedback that supports recognition of non-verbal cues (Elhaddadi et al., 2021; Huang et al., 2023), and embedding it in game-based platforms may widen access to therapy (Abd El-Sattar et al., 2024). Yet FER tools are less reliable for children with reduced expressivity (Elhaddadi et al., 2021) and tend to be biased toward typical emotional intensity (Dalwadi et al., 2023). Marín-Vega et al. (2024) also showed that a FER-based game detected only four emotions and ran only on desktop computers.

Design Elements and Research Gap

Prior work on visuals, sound, rewards, mobile platforms and touch interaction is fragmented. Simple, image-based interfaces raise interaction and reduce frustration (Francillette et al., 2021; Hassan et al., 2021), and emotion classifiers often generalise poorly to children with autism (Kalantarian et al., 2020). Spoken examples and audio cues reinforce imitation (Rouhi et al., 2019; Zhao et al., 2017), and rewards motivate play but are hard to sustain (Graham et al., 2022; Strickroth et al., 2020). Mobile games improve accessibility, although gains may not persist (Penev et al., 2021). Adaptive monitoring and larger samples remain gaps, motivating FER in a game co-designed with teachers.

METHODOLOGY

Research Design

A qualitative, user-centred design approach was adopted because the aim was to understand the engagement, usability and emotion-related responses of children with autism, which quantitative measures cannot fully capture. Five interrelated phases were followed: analysis (literature review and interviews with special-needs educators and developers to define requirements), design (mock-ups, storyboards and level concepts), development (game build and FER observation set-up), implementation (tablet deployment with teacher guidelines and consent protocols) and evaluation (teacher validation, observation, FER data and structured interviews).

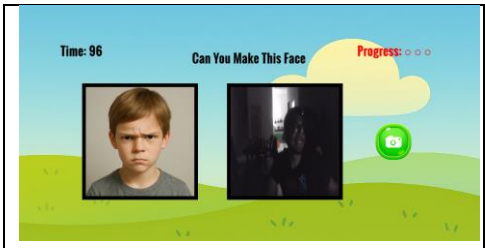
Game Requirements and Design

Requirements were derived from the literature and organised by game element (Table 1, below). The game was developed in Unity, with Figma used for mock-ups and flow design, Adobe Photoshop for graphics, and the MorphCast AI platform for FER-based observation. It combines real photographs and cartoon-like graphics to balance realism and approachability.

Table 1. Design requirements implemented features and supporting references.

Game element	Implemented feature	Supporting references
Game world	Calm colours, minimal interface elements, large icons	Carlier et al. (2020); Francillette et al. (2021); Jaramillo-Alcázar et al. (2022); Daud et al. (2023); Saidin et al. (2024)
Characters	Faces showing happy, sad, angry and surprise expressions	Rouhi et al. (2019); Kalantarian et al. (2020); Dantas & do Nascimento (2022); Löytömäki et al. (2024); Hu et al. (2025)
Challenges	Touch-based tapping; three progressive levels	Carlier et al. (2020); Zhao et al. (2017); Walsh et al. (2025); Liu et al. (2025)
Feedback	Emotion voice prompts, success and failure sounds, animations	Rouhi et al. (2019); Zhao et al. (2017); Jaramillo-Alcázar et al. (2022); Abouelenein et al. (2025)
Progress	Star ratings; Levels 2 and 3 unlocked by progress	Strickroth et al. (2020); Graham et al. (2022); Liu et al. (2025); Abouelenein et al. (2025)
Emotion detection	MorphCast FER as an observation tool (emotion graph and level bars)	Dalwadi et al. (2023); Huang et al. (2023); Al-Saadi & Al-Thani (2023); Talaat (2023); Piazzalunga et al. (2023); Anto-Chavez et al. (2024)

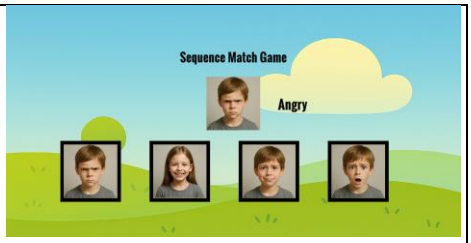
The game has three progressive levels (Figure 1). In Level 1 (mimic), the child copies the emotion shown on screen while the camera feed is displayed and presses a capture button. In Level 2 (identify), the child matches a displayed face to the correct emotion label. In Level 3 (recall), the child memorises a short sequence of expressions and reproduces it in the correct order. Levels 2 and 3 are locked until the previous level is completed, and a result screen gives star-based feedback.



a) Level 1: Mimic



b) Level 2: Identify



c) Level 3: Recall

Figure 1. Game interfaces for (a) Level 1, (b) Level 2 and (c) Level 3.

Participants and Sampling

The study was conducted at NASOM Melaka with 33 children diagnosed with autism and 4 teachers. All 33 children took part in the pre-screening, and eight were then selected through purposive sampling for the comparative evaluation. Selection required that a child could progress to at least Level 2, showed consistent engagement and motivation, and was judged comfortable and ready by teachers, whose evaluations of each child's capability and observations of the child during gameplay also informed the choice. This was deliberate, since FER observation needs engaged children, but it introduces selection bias: the eight came from the 17 children who were engaged, so the 16 who were not are unrepresented and the findings cannot be generalised to them. The eight (recoded Child A to H) came from the Early Intervention Programme

(EIP), Pre-Vocational and Vocational groups and included verbal and limited-verbal children. Teachers had at least one year of experience with children with autism.

Design Validation and Refinement

A design validation session with special-needs teachers was held at NASOM Melaka on 20 June 2025. Teachers reviewed mock-ups, storyboards and an early prototype, which was briefly tried with two children. Four refinements followed. Visual clarity was improved with simpler backgrounds and larger elements. Audio support was added as voice buttons that read emotion labels in English and Malay. Clear sound effects and animated rewards reinforced correct answers, and facial expressions were made more distinctive.

Testing Procedure and Data Collection

Testing took place over two weeks in a quiet room, with the researcher and at least one autism-specialised teacher present. In Week 1 (11–13 August 2025), all 33 children played Levels 1–3. Navigation, engagement and motivation were observed; children reaching at least Level 2 were considered for Week 2. In Week 2 (19 and 21 August 2025), the eight selected children played again while MorphCast recorded their expressions. A teacher pre-interview (Day 1) covered digital familiarity and emotional readiness, and a post-interview (Day 2) covered gameplay experience, emotion imitation and the usefulness of FER. FER was used purely as an observation tool: it recorded children's expressions during play and did not drive game feedback. Analysis was descriptive and qualitative. For each child, the MorphCast graphs and level bars were read alongside observation notes and interview responses, and expressivity was rated low, moderate or high from the FER graphs and teacher observation. Observed behaviour, FER output and interpretation are reported separately in Section 4. No formal coding scheme, inter-rater procedure or ground-truth labelling of expressions was used, which limits reliability.

Ethical Considerations and Data Handling

The research followed institutional ethical guidelines that emphasise confidentiality and informed consent. Consent forms were collected in advance for all 33 children and from the teachers; the teacher form states that activities are for research only, no identifying information is published, and images, audio and video are kept secure and anonymised. Children are identified only by codes (Child A–H), and no images of children appear in this paper. Facial recordings and FER outputs are private and confidential. No separate ethics committee approval number is reported here.

RESULTS AND DISCUSSION

Pre-Screening

All 33 children completed the pre-screening. In this sample, children with good tablet navigation were also engaged and motivated, and those with poor navigation were not (17 of 33 children were engaged; 16 were not). The Pre-Vocational group was the most consistent, with 8 of 10 children navigating well and engaging. In the Vocational group, 5 of 10 did so, and the game was often treated as a secondary task alongside independence training. Poor navigation was most common in the EIP group (9 of 13), so motor demands were a barrier for some younger children. Eight children who reached at least Level 2 and stayed engaged were shortlisted.

Device Set-Up and FER Output

Two FER set-ups were tried in pre-screening. A visible front-facing camera increased the children's self-awareness and reduced natural expressivity, so the final set-up used a mobile phone with its rear camera, which was less distracting and easier to position. MorphCast presents its output as a real-time graph of colour-coded emotion intensities and a bar for each emotion that shows the current level (Figure 2a).

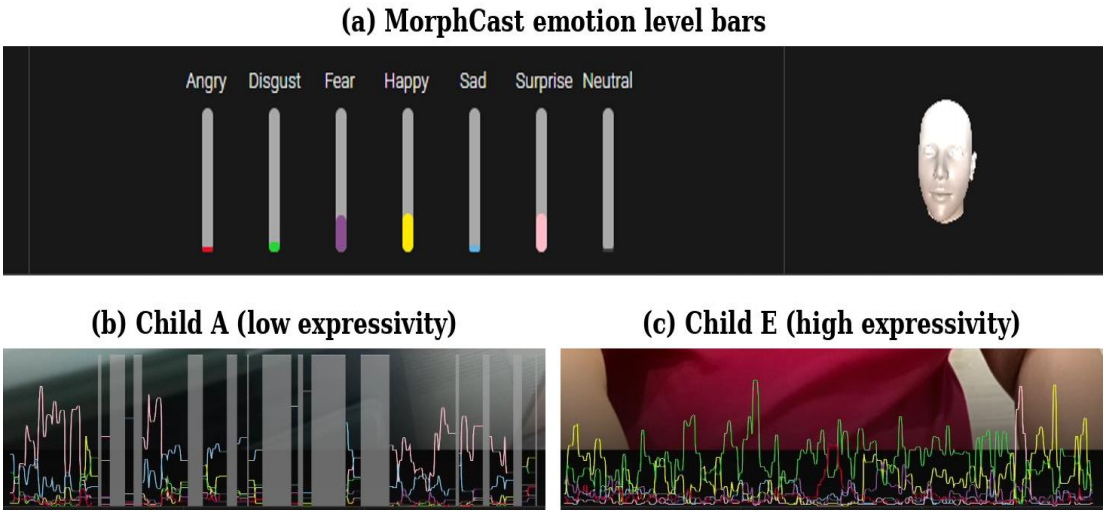


Figure 2. MorphCast output: (a) emotion level bars; emotion graphs (time on the horizontal axis, intensity on the vertical axis, grey bands marking no detection) for (b) Child A and (c) Child E.

FER Results and Expressivity Patterns

Results are separated into observed behaviour, FER output and interpretation (Table 2). **Observed:** The Vocational children (A–D) recognised and repeated emotion names, and voice prompts kept them attentive, but this did not strengthen facial imitation; Children E–H recognised emotions more readily and needed less help. **FER output:** Vocational output was dominated by sad, surprise and no-detection intervals (Figure 2b), whereas Children E and H showed a wide range of emotions (Figure 2c).

Child F's excitement and the visible camera produced undetected frames, and Child G's subdued expressions were read as happy or disgust. **Interpretation:** FER output seemed to follow how visibly children expressed emotion, not what they felt; Child D's repeated surprise may reflect a default expression. Programme, age and teacher change are confounded with expressivity.

Table 2. Observed behaviour and FER output for the eight children; expressivity was rated by the researcher from FER graphs and teacher observation

Child (group)	Expressivity	Observed behaviour	FER output
A (Vocational)	Low	Limited facial movement	Mostly sad, surprise
B (Vocational)	Moderate	Knew names; weak imitation	Not individually reported
C (Vocational)	Low	Minimal improvement	Not individually reported
D (Vocational)	Low	Focus dropped on Day 2	Surprise repeatedly
E (Pre-Vocational)	High	Independent; clear imitation	Wide range: anger, happy, sad
F (EIP)	High	Enthusiastic; camera distracting	Often happy; undetected frames
G (EIP)	Moderate	Subdued; needed prompting	Mostly happy, disgust
H (Pre-Vocational)	High	Expressive, independent	Varied emotions across levels

FINDINGS AND DISCUSSION

Finding 1: FER readings were more informative for expressive children. Observed: Children E and H produced clear expressions, whereas the Vocational children's were subtle. A teacher explained, "The younger ones were more willing to exaggerate their expressions, which helped the system detect them". FER output: readings for E and H were varied, but the Vocational group's often defaulted to sad, surprise or no detection.

Interpretation: This agrees with reports that FER is less reliable for reduced expressivity (Elhaddadi et al., 2021) and biased toward typical emotional intensity (Dalwadi et al., 2023); Löytömäki et al. (2024) report that younger children adapt more easily. It partly answers RQ3, but without ground-truth labels we can speak of detectability, not accuracy.

Finding 2: Sound feedback appeared to support motivation and independence. Observed: Winning sounds and voice buttons for emotion labels maintained attention and reduced teacher prompting, especially for the EIP and Pre-Vocational children. A teacher said, "The voice button helped a lot, when they heard the word, they repeated it without waiting for me to guide them".

Interpretation: This is consistent with evidence that audio-visual cues improve engagement and accessibility (Francillette et al., 2021; Hassan et al., 2021) and lower cognitive load (de Carvalho et al., 2022), addressing RQ1. It indicates motivation, not measured learning.

Finding 3: Repetition appeared to increase interaction and expression. Observed: Children E and H completed all levels independently on Day 2, and Child F became less distracted by the camera and more expressive. A teacher noted, "On the second day, they already knew what to do, especially Child E, F and H, who needed less help from me". Interpretation: Repeated game-based practice is known to strengthen emotional learning and retention (Carneiro et al., 2024; de Carvalho et al., 2022), so a game paired with FER observation may complement classroom emotion training (RQ2). These two-day observations are not evidence of measurable learning improvement.

CONCLUSION

This study developed and evaluated a three-level serious game, with MorphCast FER as an observation tool, for children with autism at NASOM Melaka. FER was feasible and informative, but it was more effective with younger, expressive children than with children showing minimal or atypical facial movement. Voice prompts and sound effects supported motivation and reduced teacher prompting, and repeated play increased independence.

Combining FER data with teacher observations gave a more balanced evaluation than FER alone. For children with limited facial expressivity, FER should not be the only evidence: teacher observation and voice prompts should complement it, and body gestures or voice tone may help in future. Children with poor tablet navigation (16 of 33) may need simpler touch interaction first. Teachers can treat FER graphs as a discussion prompt, not a score. The study has limitations.

The sample was small and purposively chosen from children who engaged, and the two-day comparison had no baseline or learning-outcome measure, so effects on emotional learning are unknown. Group differences are confounded with programme, age, verbal ability and teacher change. FER output was not validated against labelled expressions, and the visible camera affected some children. Future work should measure emotion recognition before and after play, validate FER against labelled expressions, use larger and more diverse samples, compare FER systems and run longitudinal studies.

Conflict of Interest

The authors declare no conflict of interest.

Data Availability

The data and recordings from this study, including observations and facial recordings of children with autism, are private and confidential and are therefore not publicly available.

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