Co-Design of Collaboration Monitoring Apps for Teachers to support Children with Autism in Religious Education

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ABSTRACT

Purpose: *This study proposes a collaborative model involving teachers and children, to enhance the religious learning progress of students with Autism Spectrum Disorder (ASD) in educational settings. The primary objective is to design a mobile-based assistive technology application, MyQuranic, tailored to monitor and support the learning journey of these children.*

Method: *Qualitative methods were employed to identify the needs and requirements in developing the MyQuranic application. Interviews and focus group discussions were conducted with UI designers, subject matter experts, and mobile app specialists. Thematic analysis was applied to interpret the data, resulting in the emergence of findings based on key themes. To ensure the active involvement of end-users, including individuals with autism, co-design principles were incorporated in the design process. This collaborative approach aimed to create a user-friendly, contextually relevant, and effective technology solution, emphasising the unique perspectives and needs of individuals with ASD.*

Results: *The findings are expected to contribute valuable insights to the broader community, particularly researchers focused on autism-related studies. The design principles have potential for teachers to monitor the learning engagement and interest of children with autism in religious studies using the MyQuranic application*

Conclusion: *This study underscores the significant role of assistive technology in the education of children with autism, specifically within the religious education context. By employing co-design principles, the MyQuranic application strives to enhance social interaction skills, address individual needs, and contribute to the overall advancement of educational support for individuals with ASD.*

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Key words: *mobile application, religious teachings, Autism Spectrum Disorder (ASD), co-design, assistive technology*

INTRODUCTION

In the realm of Islamic religious education, catering to the needs of children with autism spectrum disorder (ASD) poses unique challenges. These children, who are characterised by diverse developmental patterns, require tailored approaches to ensure a meaningful understanding of Islamic teachings. There is a lack of public awareness about the importance of imparting Ibadah and Quranic education to children with autism, even though Muslim students, including those with special needs, are obligated to receive Islamic education (Ahmad et al, 2019). The misconception that these children are exempt from religious obligations persists, and teachers often struggle to find suitable methods for teaching the Qur'an to them.

Recognising the difficulties in delivering Islamic education to children with autism, particularly due to their challenges with abstract thinking, this study addresses the gap by proposing a collaborative monitoring tool. This tool aims to bridge the communication and learning gap between teachers and children with autism in the context of religious education by leveraging assistive technology, such as mobile applications, which have been proven effective for children with autism (Jamal et al, 2017). As such, the provision and procurement of assistive technologies must be prioritised in order to continuously promote social inclusion and inclusive education in higher education institutions (Duma & Lydia, 2023). By developing a mobile application designed to monitor the religious learning progress of these children at school, the study seeks to enhance the effectiveness of interventions and ensure positive outcomes in educational settings. The collaborative model, which emphasises a co-design approach, integrates assistive technology to facilitate a more inclusive and tailored learning experience for children with autism in Islamic religious education.

Related Work

Social interaction is a significant challenge for children with ASD, as they often face difficulties engaging with their peers (Rogers at al, 2021). Advances in technology, particularly in the realm of co-design, offer innovative solutions to address these challenges. Co-design involves the active participation of end-users, including individuals with autism, in the design process, ensuring that the

technology is tailored to their specific needs. In addition, Abdullah et al (2018) stated that it is important that technology supported approaches are developed in a collaborative process involving participation of children with ASD, along with the parents and teachers who teach and support them, because they are experts in their own lives and in the education domain respectively.

In the context of ASD, co-design technology aims to enhance social interaction skills by incorporating the unique perspectives and needs of individuals with autism. Co-design relies on partnership, with participants bringing essential knowledge of their own context and culture and designers bringing technical and design facilitation skills (Brereton et al, 2015). Several studies have demonstrated the positive impact of co-design technology on children with ASD. For example, higher engagement levels among children with ASD are a result of co-designed interventions that employ the personalised and interactive nature of this technology (Smith et al, 2018). Technology designed in collaboration with individuals with autism has been shown to improve social communication skills, fostering better interactions with peers and caregivers (Jones et al, 2020). In a similar vein, co-design allows for the customisation of interventions based on the specific needs and preferences of each child, increasing the effectiveness of the technology (Williams & Johnson, 2019).

Rosenbloom et al (2019) developed an application to monitor the learning progress of children with autism called I-Connect. It is a self-monitoring application that enables customisable prompts, recording, and data monitoring. The results indicate that each introduction of I-Connect caused an immediate increase in on-task behaviour as well as a decrease in disruptive behaviours. The implications for practice and future research were also discussed in the study. In addition, Abdullah et al (2015) developed MyCalendar, a visual calendar app intended to aid children with autism in communicating about their activities and interests at home and school. MyCalendar supported children with autism and limited verbal skills to communicate their daily activities through photos and videos, and it enabled teachers to model positive behaviours and create more relevant learning opportunities based on the children's lives. Additionally, the app led to novel scaffolding of learning opportunities and modelling of communication in the classroom, surpassing the initial expectation of improving communication between teachers and parents.

In a similar vein, Schuck et al (2022) developed an application to support classroom behaviour management. The application is called iSelfControl, which functions

to prompt students every 30 minutes to self-evaluate using a universal token-economy classroom management system focused on compliance, productivity, and positive relationships. Simultaneously, the teacher evaluates each student separately on the iPad. The researcher concludes that iSelfControl provides a platform for self and teacher evaluation, which is an important adjunct to conventional classroom management strategies. The application captures teacher/student discrepancies and significant variations throughout the day.

The principles of user-centred design (UCD) are critical in developing mobile applications that resonate with religious users. Research by Johnson et al (2021) emphasises the importance of involving the religious community in the design process. This collaborative approach ensures that the application meets the unique needs, preferences, and cultural nuances of the target religious audience. A successful mobile application design requires an understanding of the diversity within religious communities (Rahman et al, 2020). Al-Mouhamed and Al-Muhtadi (2016) stated the significance of content personalisation to accommodate various religious practices, rituals, and interpretations. Tailoring content to users with diverse religious backgrounds ensures inclusivity and fosters a sense of belonging (Johnson et al, 2017).

Technological considerations in the design of religious mobile applications include the integration of features that enhance the spiritual experience. Research by Gupta et al (2019) suggests incorporating features such as prayer time reminders, scripture readings, and virtual community engagement. Khan (2018) reported that it is crucial to ensure accessibility and inclusivity in religious mobile applications in order to reach a broad user base. Haque et al (2021) highlight the importance of designing applications that are accessible to users with varying levels of technological literacy and physical abilities. User satisfaction and engagement ultimately determine the success of a religious mobile application. Evaluation studies, such as that of Jamal et al (2021), emphasise the value of continuous assessment through user feedback, surveys, and analytics. Iterative improvements based on user input contribute to a more meaningful and effective application. Additionally, a holistic approach that integrates user-centred design, cultural sensitivity, technological innovation, accessibility, and privacy considerations is necessary in designing mobile applications for religious contexts.

Prototyping, which plays a pivotal role in the iterative design process, aids designers in visualising and refining their concepts. Two common categories of

prototypes are low-fidelity and high-fidelity, each serving distinct purposes in the design workflow. Low-fidelity prototypes are characterised by simplicity, minimal detail, and a focus on basic functionality (Snyder, 2003). Paper sketches, wireframes, or digital tools that prioritise speed and ease of modification are often used to create these prototypes. A key advantage is rapid iteration, which facilitates quick adjustments and efficient exploration of various ideas (Rubin & Chisnell, 2008). Conversely, high-fidelity prototypes are more detailed and closely resemble the final product in terms of visual design and functionality (Snyder, 2003). They often involve interactive elements and realistic content and may be developed using specialised prototyping tools. A more accurate evaluation of user interactions is made possible by high-fidelity prototypes, which provide a more realistic representation of the final product (Rubin & Chisnell, 2008). They are valuable for conducting usability tests that closely simulate the actual user experience and are effective in conveying the final vision of the product to stakeholders (Ahmed et al, 2018). Both low-fidelity and high-fidelity prototypes have different roles in the user-centred design process.

MyQuranic Application

This study is positioned within the broader landscape of inclusive education for children with Autism Spectrum Disorder (ASD), focusing on the development of MyQuranic — a mobile application designed to support the religious learning progress of these unique learners based on the Religious Mobile Apps Guidelines by Zamry et al (2022). Acknowledging the distinctive needs and challenges faced by children with ASD in the context of Islamic religious education, this study underscores the imperative to adopt a User-Centred Design (UCD) approach in crafting an application that is not only technologically effective but also aligned with the nuanced requirements of its end-users.

This study identifies guidelines crucial for the development of MyQuranic, as informed by a comprehensive literature review. Leveraging the principles of User-Centred Design, a low-fidelity prototype is meticulously crafted based on the identified guidelines. However, the success of any educational tool hinges not only on technological soundness but also on its resonance with the intended users, in this case, teachers and children in specialised educational settings.

Moreover, this study actively involves teachers and children with autism in the design process by engaging in interviews and focus group discussions at Pondoku

and Malaysia High Functioning Autism Association (MAHFAA) to ensure a holistic understanding of the needs and requirements for MyQuranic. Co-design principles come to the forefront as the research emphasises the importance of understanding the technological guidelines as well as appreciating the lived experiences, challenges, and preferences of those who will interact with the application on a daily basis. The combination of UCD and co-design enables this study to achieve its aim of bridging the gap between technological functionality and user expectations, fostering a collaborative and inclusive approach to the development of MyQuranic.

Eliciting requirement phase for MyQuranic

A comprehensive review of previous literature on mobile application guidelines for autism and religious mobile application guidelines was conducted. The comprehensive literature review method was used in this study to identify, evaluate, and summarise the related guidelines from previous literature. The seven steps suggested by Onwuegbuzie and Frels (2016) for a comprehensive literature review are followed in this study. These steps include exploring beliefs and topics, initiating the search, storing and organising information, selecting and deselecting information, expanding the search, and analysing and synthesising information and communication. A meta-analysis was conducted to take the findings from several studies on the same subject and analyse them using standardised statistical procedures. Patterns and relationships are detected, and conclusions are drawn using meta-analysis, which is associated with the deductive research approach.

The study aimed to gather information on mobile application guidelines for children with autism through specific search techniques. Two main categories were considered: guidelines for mobile applications for children with autism and guidelines for religious mobile applications. The search for the first category yielded 12,900 publications using keywords such as "mobile apps," "guidelines," and "autism spectrum disorder." The number decreased to 8,600 after filtering was done for articles published in the last five years, with only 35 that were relevant based on the guideline criteria. Relevance was determined by the connection to mobile application guidelines for children with autism. Following that, 20% of the relevant papers were further analysed, leading to the proposal of a guideline for developing mobile applications for children with autism.

The second category of the search focused on religious mobile applications,

incorporating terms like "religious" and "Islamic" in addition to "mobile apps" and "guidelines." A total of 32,200 publications were initially identified, and the number decreased to 16,800 due to the filtering results for publications in the last five years. Among these, 26 publications were analysed in the first cycle based on their relevance to religious mobile application guidelines for children with autism. Following a detailed analysis of guideline criteria, only 19% of the publications were further examined within the study domain. The study revealed two key findings: 1) multimedia elements encompassing text, images, and sounds; and 2) application features including interface, navigation, customisation, and interaction, as highlighted by Zamry et al (2022). The next section will elaborate on these findings, focusing on guidelines for mobile applications in religious contexts. The findings obtained from the comprehensive literature review are shown in Table 1.

Table 1: Religious Mobile Application guidelines for Children with Autism

Multimedia Elements	Guidelines	Features of application	Guidelines
Text	1. The text used must be clear, simple, and short. 2. Use only a maximum of two typefaces. 3. The use of text coincides with the original source.	Interface	1. The design and structure must be simple, clear, and predictable. 2. Avoid cluttered interfaces. 3. The application should be based on the elements that best symbolise Islam, which are widely recognised by the Islamic community. 4. The application should use features that present the Islamic identity.
Images	4. Provide suitable images. 5. Use images that are identical to real life. 6. Use well-mannered clothes for any character, figure, or real person. 7. The image used in the application should be relevant to the content; do not display images that are not related to Islamic elements.	Navigation	5. Applications should have simple navigation and be easy to use. 6. Navigation in the application should be consistent. 7. Use standard navigation icons that are familiar to ASD.

Sounds	8. Use clear, comprehensible, short audio expressions. 9. Avoid using disturbing and explosive sounds. 10. Use familiar sounds and voices. 11. Use audio commonly used in Islam.	Customisation	8. Allow customisation. 9. The application should have relevant customisation according to the user's preferences for the Islamic features of the application.
		Interaction	10. Avoid simultaneous tasks at one time. 11. Avoid distractions and interruptions in the application. 12. The speed of the application interaction must be consistent without any delay.

MyQuranic design interface

Based on the guidelines proposed by Zamry et al (2022), this application was designed and developed for teachers as a proxy to record the daily activities of children with autism in religious lessons. Teachers will use the mobile application to record the routines and activities of the children in school. However, there are some students who have the ability to use this application. According to the founder of this centre, students who are able to use this application will record their own daily activities or those of their friends. Students will also tend to follow and repeat the activities they have done based on the videos they watch on their smartphones. There are four main sections for this application: the homepage, the student's profile, the student's visual calendar, and the student's learning progress. An explanation of the details for each section follows.

Homepage

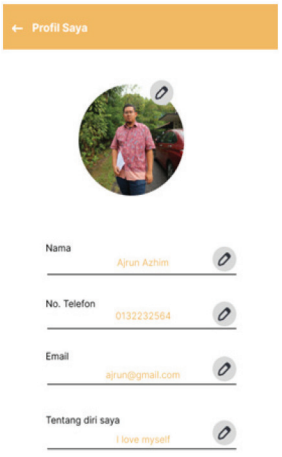
The homepage of the application features a simple and user-friendly design that adheres to the guidelines established in the literature review. The main theme is pastel colours, and students have the option to customise colours according to their preferences. In addition, customisation options for audio volume and font size are provided to accommodate children with autism. Standard navigation buttons are employed to prevent confusion and maintain focus. Recognising the importance of customisation for children with autism, the application allows individual adjustments to cater to each user's specific needs and preferences, promoting a comfortable and personalised user experience, as advocated by Lyu et al (2021) and Dattolo et al (2017). Figure 1 shows the homepage design.

Figure 1: MyQuranic Homepage

Student's Profile

In this section, students, assisted by teachers, are required to input their personal information for effective tracking of progress. The comprehensive details, which include name, identification, age, and gender, enable teachers to identify and understand each child's unique capabilities. An appropriate and personalised learning style that aligns with the individual needs of the students can be created based on this information, facilitating a more effective and supportive educational experience, as shown in Figure 2.

Figure 2: Student's Profile in MyQuranic



Student's Visual Calendar

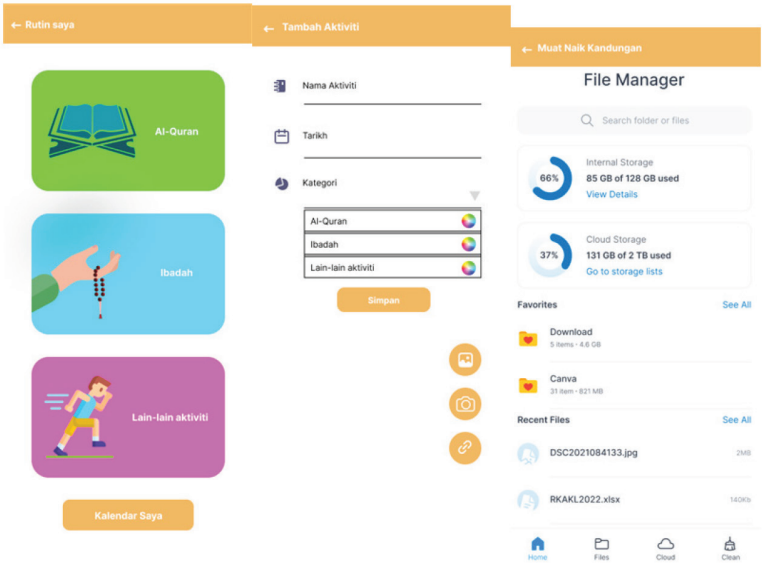
The calendar feature displays the daily activities of students, organised by each day of the month. It serves as a convenient tool for teachers to use in documenting their students' religious activities at school. Teachers can record the students' learning progress through videos or photos, and easily monitor their daily activities by playing uploaded videos directly from the calendar. This streamlined process enhances the efficiency of teachers in monitoring and assessing students' learning progress more conveniently and quickly. Figure 3 shows the design of the visual calendar.

Figure 3: Student's Visual Calendar in MyQuranic

Activity Update

In this section, both teachers and children can upload their daily progress. It enables video recording and picture-taking directly within the application, as well as the uploading of pre-recorded videos. The purpose is to facilitate the organised storage of images and videos of the students' activities based on the designated days and times set in the calendar. This feature simplifies the process for teachers and students to seamlessly document and archive their daily progress, as shown in Figure 4.

Figure 4: Student's Progress Update Features



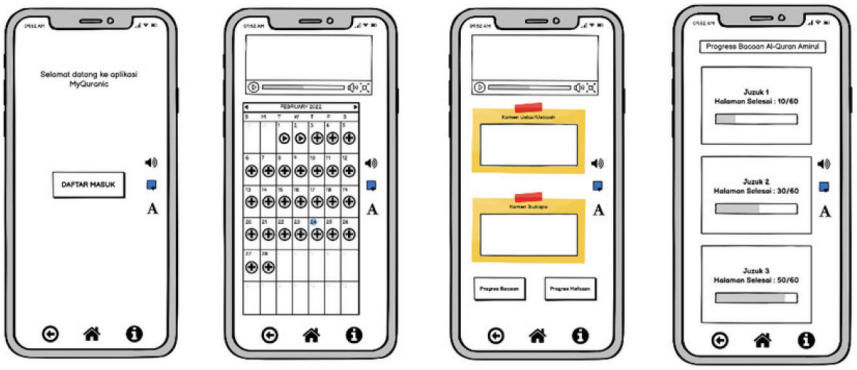
METHOD

Co-design is an ethical and pragmatic approach that involves designers engaging with those who will use or be affected by their designs from the outset in order to prioritise their agency and quality of experience (Brereton et al, 2015). Designers bring their creative and technical skills to the table, while experts contribute valuable domain-specific knowledge about the unique needs and preferences of individuals with autism. This study creates collaboration between designers and experts, resulting in several prototypes to be tested and validated before the actual application is developed. The guidelines obtained in the eliciting requirements phase led to the creation of a low-fidelity prototype. The validation process of the low-fidelity prototype came next, which was done with four user interface designers. The second version of the low-fidelity prototype was created after receiving feedback from UI designers and validated by a subject matter expert in a two-hour interview session. Then, a high-fidelity prototype was designed from the data obtained in the previous phase and validated by five subject matter experts from Pondoku and eight mobile experts. A subject matter expert from Pondoku and three special education experts from MAHFAA validated the final version of the high-fidelity prototype, which was designed from the data obtained in the previous phase. The details of each section are elaborated on in the section below.

Low-fidelity Prototype

A low-fidelity prototype was created as a result of a thorough literature review and interview sessions. The research indicates that children with autism express a preference for a straightforward and user-friendly design. Lyu et al (2021) emphasise the importance of simplicity, clarity, and predictability in design, a sentiment echoed by Dattolo et al (2017), who advocate for applications with minimal on-screen elements. Aligning with these principles, a preliminary design interface for the application was developed to present only the essential features and content required for the current user task, ensuring a simple and focused user experience. Figure 5 shows the design of the low-fidelity prototype.

Figure 5: Low-fidelity Prototype of MyQuranic



Low-fidelity Prototype Validation

The researcher conducted and moderated a one-hour focus group discussion with four experienced designers from the research team who specialise in the field of special needs. The primary focus of the discussion was on improving the prototype. The aim of this collaborative session was to ensure adherence to established guidelines and the fulfilment of user needs. The UI designer team provided valuable feedback and comments, addressing elements like multimedia usage and application features. The recorded and transcribed feedback was analysed as part of the data collection process, which helped refine the prototype to better align with user requirements. The analysed data is presented in Table 2.

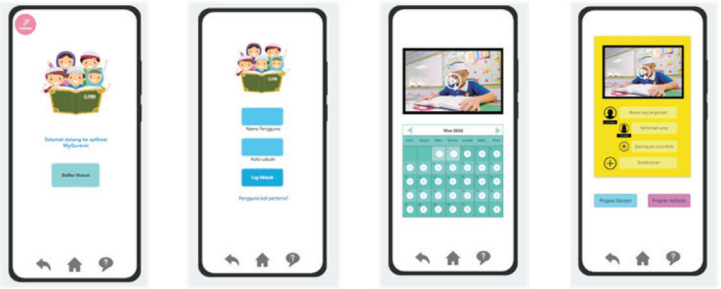
Table 2: Feedback from UI Designers on Low-fidelity Prototype

UI Designer 1	UI Designer 2	UI Designer 3	UI Designer 4
1. Avoid using capital letters in apps. 2. Need to create a section to measure the IEP goals. 3. Need to link the IEP goals section to daily activities videos. 4. Don't make it colour blind. Use colour for prototype for user to experience the colour suitability used for this application. 5. Need to add one function to identify whether the students like or dislike the apps. 6. Need to add additional parts (rating for children's learning progress).	1. Make sure the icon is visible instead of making it a hideout icon. 2. Please label each video to make it easier to trace students' progress. 3. Need to enable multiple videos upload per day. 4. No need to separate the calendar by section. One calendar can record all sections.	1. Reduce in-app usage steps. Create a button for students' direct access to the visual calendar. No need to select by year and month.	1. Use date picker for calendar instead of drop-down menu. 2. Add a rating section in apps. 3. Reduce redundant pages to make apps simpler and easier to use.

Second version of Low-fidelity Prototype

A second version of the low-fidelity prototype was developed following feedback validation from the UI designers on the initial prototype. This enhanced prototype focuses on improvements, particularly in the utilisation of multimedia elements and application features. Figure 6 depicts the design of the second prototype.

Figure 6: Second Version of the Low-fidelity Prototype of MyQuranic



Second version of Low-fidelity Prototype Validation

The validation process for the prototype involved a religious expert who is the founder of Pondoku and has extensive expertise in Islamic studies for children with autism. The application's adherence to guidelines was the main focus of the validation, and it featured a prototype for the expert to assess its suitability for fulfilling the needs of children with autism. During the session, the expert used the prototype and provided feedback, which was recorded. The received feedback will be utilised to enhance the actual application development. Table 3 depicts the expert's comments that align with the guidelines and contribute valuable insights for improvement.

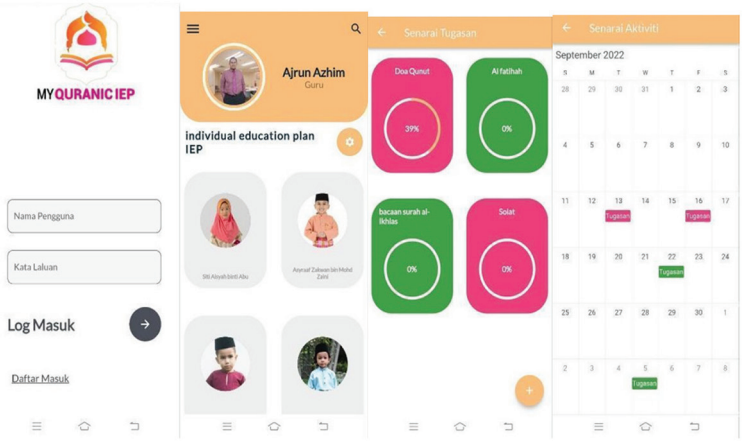
Table 3: Feedback from Religious Expert

Proposed Guidelines	Religious Expert's Feedback
Design and structure should be simple, clear, and predictable.	Just a one-time log in. No need to login and logout many times.
Avoid interaction timeouts.	One user (parents/teachers) can register many kids.
Use familiar sounds and voices.	Use a familiar voice to be heard (voice of ustaz/ustazah or voice from YouTube).
Use audio commonly used in Islam.	Need to provide options for ASD to change the theme colour.
Allow customisation.	Make memorisation not focused on the Quran only; can add prayer recitation, Zikr recitation, etc.
The application should be based on the elements that best symbolise Islam, which are widely recognised by the Islamic community.	Al-Quran student progress if done by pages is too high and difficult. Try to make it customised (e.g., by line or by verse).
The application should use features that present the Islamic identity.	
The application should allow relevant customisation according to the user's preferences for the Islamic features of the application.	

High-fidelity Prototype

A high-fidelity prototype was developed after two low-fidelity prototype versions were created. This iteration features increased interactivity compared to its predecessors, incorporating navigation buttons, icons, and text to enhance the user experience with the MyQuranic application. Figure 7 displays elements of the interface from the first version of the high-fidelity prototype.

Figure 7: High-fidelity Prototype of MyQuranic



High-fidelity Prototype Validation

This study conducted a focus group discussion with subject matter experts in Islamic studies, particularly teachers from Pondoku, to gather feedback on the prototype design. The participating experts, who have significant experience in instructing children with autism in religious contexts, provided valuable insights and recommendations during the discussion. The subsequent section outlines the opinions and recommendations expressed by these experts in the focus group session, as shown in Table 4.

Table 4: Feedback from Subject Matter Experts

Experts	Apps Setting	Interface
Religious Expert 1	1. I suggest adding another role which is the management of Pondoku. This makes it easier for management to monitor any issues/complaints from parents or if there are other problems that arise.	1. Tiles for the student list do not need to be too big. Makes it difficult for the user to scroll down to see the full list.

	2. I also suggest that there be a function to add a second teacher for each student. This is important as a backup if the teacher on duty is not available to teach students at that time.	2. It needs to be more dynamic in the category part. Doa dan solat can be placed under one category (Ibadah). Use the "+" button to add tasks instead of "other". 3. Change the word "add" to "update". Users may be confused between the "add tasks" and "add activities" sections. 4. Fix the order of tasks in the calendar. Customise the arrangement of tiles with many tasks. It is recommended to add the button "add" or "more" if the tiles are too full.
Religious Expert 2	1. If you can add a platform for the web, even better. This can address the problem of differences in the use of applications for Android and Apple. 2. Storage is likely to hang/lagging when there are too many videos/ pictures. Make sure these apps are able to accommodate a large database.	1. Avoid using pink. Most male students do not want to touch/interact with items that are pink in colour.
Religious Expert 3	1. Need to add a notification system to notify parents if there is a new assignment from the teacher. 2. Addition of categories for students, such as daily students, one-off students and so on will help management to easily organise the students.	1. Most male students will avoid the colour pink. It is possible that this colour looks quite feminine to them. 2. Students' pictures need to use the same style and background in order to look uniform. 3. Create a reward system after students complete a task. 4. Add a function like rating system to evaluate student activities in the task section.
Religious Expert 4	1. Need to ensure that the app has a user-friendly interface with intuitive navigation. Users should easily find key features such as prayers, religious texts, community forums, and events without confusion.	1. There are some students who have a problem when they see the colour pink, but there are also students who don't have a problem with it. 2. Students like to see their pictures the same as other friends. For example, if someone wears a vest during a picture, other students want to wear it too.

Religious Expert 5	1. Maintain a consistent design and layout throughout the app to create a cohesive user experience. Consistency helps users feel more comfortable and confident as they navigate different sections of the app.	1. If given a choice of colours when they do class activities, pink is the least favourite choice for them. It's good if you use other colours rather than pink. 2. We at Pondoku practice uniformity for autistic children. Students will feel more comfortable when they wear the same clothes among themselves.

Furthermore, a focus group discussion was conducted, involving mobile application experts, who are well-versed in areas such as mobile applications, human-computer interaction, user-interface design, and user experience. These experts, some with research experience in developing applications for children with autism and Islamic studies, provided valuable perspectives on the guidelines utilised in the prototype development. The feedback gathered from this focus group discussion, as summarised in Table 5, offers insights into the expert opinions and recommendations regarding the prototype development guidelines.

Table 5: Feedback from Focus Group Discussion with Mobile Application Experts

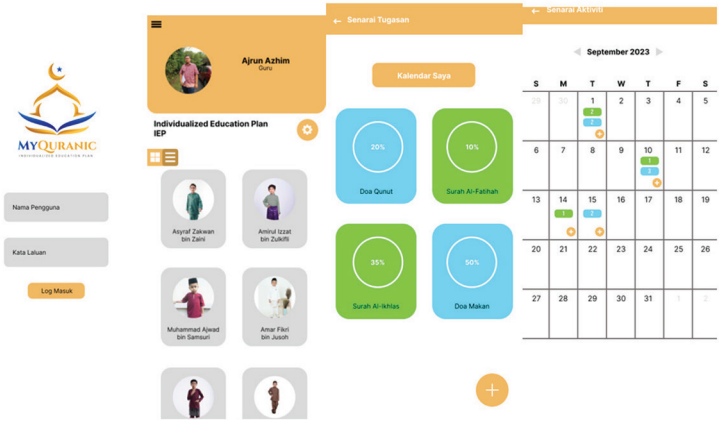
Expert	Quotes
Mobile Apps Expert 1	Children with autism feel comfortable with familiar sounds.
Mobile Apps Expert 1 and Religious Mobile Expert 1	Children with autism are more inclined towards visual communication.
Mobile Apps Expert 1	Children with autism are more likely to use mobile applications due to their comfort with touch screen-based interfaces.
Religious Mobile Expert 1	The activities of children with autism are influenced by the teachers at the centre.
User-interface Expert 1 and Human-computer interaction Expert 1	Technology supports the development of children with autism in the presence of a technology-friendly environment.
All Experts	Parents and teachers play roles in monitoring and supporting the learning progress of children with autism.
Mobile Apps Expert 1, User-interface Expert 1, Human-computer interaction Expert 1 and Human-computer interaction Expert 2	Must treat autism according to the cognitive level based on their respective autism category.
Mobile Apps Expert 2	Communication for children with autism should be personalised.

Religious Mobile Expert 1	Teachers, therapists, and doctors are involved in development/growth at different times and in different capacities.
User-interface Expert 1 and Religious Mobile Expert 2	Technology can support traditional formal communication between parents and teachers.
All Experts	There is a need for a technology-based support system alongside traditional teaching.
Mobile Apps Expert 1, User-interface Expert 1, Human-computer interaction Expert 1 and Human-computer interaction Expert 2	Technology can provide better support for formal communication and learning
User-interface Expert 1, Human-computer interaction Expert 1 and Human-computer interaction Expert 2	Monitoring and guidance are required for the use of technology by children with autism.
Mobile Apps Expert 1, Mobile Apps Expert 2 and User-interface Expert 2	Everyone has a role in ensuring children with autism's learning progress.

Second version of High-fidelity Prototype

Some improvements were made to the first version of this prototype as a result of the feedback obtained from subject matter experts and mobile application experts. Figure 8 shows the latest design for the second version of the high-fidelity prototype.

Figure 8: Second version of High-fidelity Prototype of MyQuranic



Second version of High-fidelity Prototype Validation

Interview sessions were conducted with subject matter experts from two different autism centres; these involved three experts from MAHFAA and an expert from Pondoku. Table 6 shows the feedback received from the sessions.

Table 6: Feedback from Subject Matter Experts

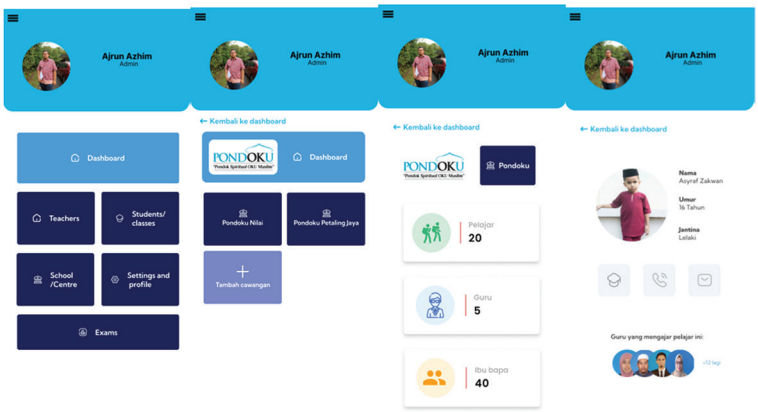
Experts	Apps Setting
Special education Expert 1	1. Can combine buttons to upload images and videos. No need for many buttons. 2. Students have no problem if there is no uniformity between them. It is not something that is mandatory to make them uniform. 3. Add special pages/dashboard for admin.
Special education Expert 2	1. There really needs to be customisation for each child because they have different preferences. 2. Students need special attention from teachers to make them more focused in learning.
Special education Expert 3	1. Add a smiley Likert scale. 2. The colours used for this application are very suitable for students.
Religious Expert 4	1. I suggest it would be good if these apps can also create a reward system to make these children have fun while using this app. 2. Customise colour on student assignments according to their preferences. 3. Each centre can set its own routine for autistic children 4. Separate the admin dashboard by centre. 5. Suggested to create a student routine list (on/off button) instead of ustaz/ustazah having to fill in the routine themselves every day. 6. For Al-Quran assignments made by individuals. 7. For worship assignments made by groups.

Final version of High-fidelity Prototype

The final version of the MyQuranic prototype was produced after it went through several validation processes from designers, subject matter experts, and mobile experts. Figures 9 and 10 show the final design for this prototype.

Figure 9: Final version of High-fidelity Prototype of MyQuranic (Teacher's dashboard)

Figure 10: Final version of High-fidelity Prototype of MyQuranic (Admin's dashboard)



Data Collection and Analysis

Stakeholders need to be involved in the design process during co-design. In this study, interviews and focus group discussions were conducted with the stakeholders to validate the guidelines that were proposed to be used in the application. The stakeholders involved subject matter experts and mobile application experts. The subject matter experts were from two autism centres, namely Pondoku and MAHFAA. Five teachers from Pondoku and three teachers from MAHFAA were appointed as the subject matter experts for the study. A few series of interviews and focus group discussions were conducted at each

centre, with every session lasting approximately two hours. In addition, eight mobile application experts were appointed for this study. All of the experts have extensive experience in the fields of mobile applications, human-computer interaction, user interface design, and Islamic studies. One out of three focus group discussion sessions was conducted for two hours. The data collected from the focus group discussion sessions and interviews was further analysed using thematic analysis.

Thematic analysis was chosen to identify patterns that exist in quotes collected from experts, designers, and teachers. Several themes emerged from the patterns that were successfully identified, providing initial themes that will be used to develop this study application. Thematic analysis unfolds in a structured cycle that commences with data immersion, where a thorough understanding of the content is established through repeated readings. Subsequently, initial codes are generated systematically, encapsulating pivotal concepts within the data. These codes then undergo a process of thematic grouping to form potential themes. Following that, rigorous review and refinement are carried out to ensure the internal coherence and distinctiveness of each theme. A coherent narrative is constructed when the refined themes are in place, interweaving them with supporting evidence from the data. The robustness of themes is consistently checked against the entire dataset to safeguard against undue influences. The process culminates in the production of a well-structured research report, delineating the analytical journey, defined themes, and supporting examples.

Ethics Approval

The Human Research Ethics Committee of Universiti Teknikal Malaysia Melaka approved the study protocol with serial number UTeM.11.02/500-25/1/4 Volume (44). Prior to the trial, written consent to involve each participant was obtained from the coordinator of MAHFAA and Pondoku.

RESULTS and DISCUSSION

The interviews with subject matter experts revealed that it is necessary to involve three key themes in designing applications for children with autism. The findings were also supported by the mobile application experts from the focus group discussion. All experts agreed that these themes needed to be emphasised in the design process for this study. The following are discussions on these themes.

Theme 1: Usability of Multimedia Elements in Religious Skills

The emphasis on usability and accessibility in a co-design approach involves actively engaging end-users, including individuals with ASD, in the design process. Co-design also encourages designers to collaborate with users to understand their preferences, challenges, and needs. The co-design principle of simplicity aligns with recommendations such as reducing redundant pages and avoiding capital letters, ensuring that the application is intuitive and easy to use for individuals with diverse abilities.

> *"…reduce redundant pages to make apps simpler and easier to use"* (Designer's comment).

Feedback from the designer supports the guidelines mentioned by Zamry et al (2022).

> *"…Design and structure should be simple, clear and predictable"* (Zamry et al, 2022).

The resonance between these recommendations and the guidelines outlined by Zamry et al (2022), which emphasise simplicity, clarity, and predictability in design and structure, further underscores the importance of these principles. The study by Hening et al (2023) is an example of research that highlights the significance of simplicity and visibility in interface design to promote usability and accessibility, particularly for diverse user groups. This convergence of co-design insights and established guidelines, alongside the recent findings by Dawson et al (2023), serves as a robust foundation for the creation of effective, accessible, and user-centric mobile applications tailored for children with autism.

Theme 2: Personalised Religious Skills Progress Monitoring

Co-design promotes the active participation of end-users in shaping the content and features of educational tools. The co-design principle of involving users in decision-making processes is shown in the emphasis on IEP goals, student feedback, customisation, and progress tracking. Developers can create a more personalised and engaging learning experience by incorporating feedback in order to cater to the unique requirements of learners with ASD. One of the religious experts mentioned in the interview:

> *"…Al-Quran student progress if done by pages is too high and difficult. Try to make it personalised"* (Religious Expert 1).

Furthermore, Zamry et al (2022) advocated that the call for customised progress monitoring aligns with the principles of personalised learning, allowing learners to progress at their own pace and in ways that align with their individual strengths and preferences. They reported that:

> *"…the application should provide for relevant personalisation based on the user's preferences"* (Zamry et al, 2022).

This resonates with the principles of personalised learning, as presented by Zamry et al (2022), which highlight the importance of allowing learners, particularly those with Autism Spectrum Disorder (ASD), to progress at their own pace and in ways that align with their unique strengths and preferences. The researchers' report further reinforces the call for relevant personalisation based on user preferences. Additionally, the call for customised progress tracking aligns with the principles of personalised learning, which are promoted by educational theorists like Solomon (2012), allowing learners to progress at their own pace and in ways that align with their individual strengths and preferences. Similarly, Abdullah et al (2023) confirmed that technological intervention that is personalised to the needs and abilities of individuals with ASD is required for the intervention to be successful. These insights collectively emphasise the potential of personalised progress monitoring in creating a more engaging and effective educational tool, catering specifically to the diverse and individualised needs of learners within the autism spectrum.

Theme 3: Customisation Accessibility for ASD Monitoring Skills at School

This theme highlights the necessity of tailoring the application to meet the specific needs of individuals with Autism Spectrum Disorder (ASD). A fundamental aspect of co-design is tailoring the application to meet the specific needs of individuals with ASD. The incorporation of customisation options, such as theme colour adjustments and recognition of sensory preferences, aligns with the co-design principle of inclusivity. An application that is more accommodating and user-centric is produced when designers involve individuals with ASD in the design process to better understand and address their sensory sensitivities and preferences.

> *"…need to provide options for ASD to change theme colour"* (comment by Special Education Expert 2).

According to Zamry et al (2022), it is crucial to consider sensory sensitivities and individual preferences in creating environments that support the engagement and comfort of individuals with ASD. Their study also highlighted:

> *"…need to allow customisation for font type, font size, themes and colours"* (Zamry et al, 2022).

Furthermore, other researchers, such as Grandin and Duffy (2013), emphasise the importance of taking sensory sensitivities and individual preferences into account when designing environments that facilitate the comfort and participation of individuals with ASD. Similarly, Maidon et al (2023) highlighted that customised teaching can be effectively conducted by implementing an application that helps provide a variety of pedagogical approaches to teachers. This theme reaffirms that involving children with autism in the design process not only allows for a better understanding of their unique sensitivities and preferences but also leads to the creation of a more user-centric and accommodating application. It also provides guidelines for the development of educational tools that prioritise inclusivity and customisation.

In summary, these themes align with the principles of co-design by emphasising the importance of collaboration and user involvement in the design and development of educational applications. By integrating these themes into the co-design process, developers can create more effective, accessible, and user-friendly tools that cater to the diverse needs of learners, including those with ASD.

CONCLUSION

The MyQuranic application holds significant promise as an organisational and communicative tool for teachers and children with autism in religious skills development, aligning with co-design principles that emphasise user-centred solutions. The application aims to monitor religious learning skills at school and is positioned to support communication between educators and students, particularly in religious learning, by reflecting inclusivity in accommodating diverse learning environments. The call for effectiveness testing with real participants underscores a commitment to empirical validation, a key facet of co-design processes that value real-world feedback for iterative refinement. The study's intention is to provide empirical evidence that supports the application's efficacy in aiding children with autism in religious learning. This demonstrates a

co-design approach focused on outcome validation and continuous improvement. The subsequent call for an evaluation process, encompassing feedback from various stakeholders, reflects co-design principles of inclusivity and iterative refinement, ensuring that the MyQuranic application is not only promising but also responsive to the dynamic needs and experiences of its user community.

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