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Usability of Iranian Math Apps for Kids

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Abstract

Background and Objectives: The widespread use of mobile apps among children has introduced both opportunities and challenges, particularly in the realm of educational tools. Usability is critical for these apps, as it ensures that young users can easily engage with and benefit from educational content. The objective of this study is to evaluate the usability of Iranian Android math apps designed for children.
Methods: This study is the expert review research and focuses specifically on Android applications designed to teach mathematics to children aged 6-9 years (preschool to grade 3). The apps were selected from two popular Iranian app stores: Bazar and Myket. A total of 100 math apps were intentionally chosen. Each app was tested for 15 minutes by the researcher to evaluate usability based on 39 usability factors derived from the literature on human-computer interaction. Non-functional, non-interactive, paywalled, or text-only apps were excluded, leaving 44 apps for detailed analysis.
Results: 98% of the apps showed consistency in navigation and visual elements. 77% of the apps provided feedback to users, indicating when a mistake was made or when a task was completed. However, only 9% offered positive feedback. 86% of the apps had appropriately sized icons and text, making them accessible to children. However, about 40% of the apps needed improvement in terms of simplifying the language and instructions to suit young children's comprehension levels. 89% of the apps offered little to no personalization options. Most apps (56%) relied heavily on text prompts rather than audio or visual cues, making navigating difficult for younger children without adult assistance. 75% of the apps did not encourage children to engage in online transactions and 73% were free of advertisements, creating a safer and less distracting learning environment.
Conclusion: While many Iranian math apps for children adhered to basic usability principles, there was a gap between research recommendations and their practical application, particularly in areas related to engagement, feedback, and personalization. Developers could partner with schools and education organizations to create apps that align with specific curriculums, have more personalized features, engage children using cartoon characters, and include interactive educational tools. Educational tools and platforms should provide environments that allow students to interact more with content, teachers, and classmates. This can be achieved through live chats, group discussions, and increased interactions with digital content such as quizzes and interactive assignments. Further, using gamification elements such as scoring, badges, and challenging levels can make learning process more engaging.

Introduction

Mathematics is a fundamental subject for science and technology, which is necessary for the growth of countries and progress in fields such as medicine and engineering. However, many students struggle with mathematics. Research shows that a strong foundation in

elementary school is critical to success at higher levels of mathematics. In addition, students' academic success in mathematics positively and significantly predicts the level of their computational thinking skill [1]. Traditional teaching methods focus too much on memorization and can hinder students' deep understanding and interest. To solve these problems, the use of digital teaching methods is suggested to strengthen students' mathematical and problem-solving skills [2].

On the other hand, usability plays a key role in the design and development of digital products and interfaces, as it directly impacts user satisfaction, efficiency, and overall experience [3]. The main aspect of usability is ensuring that a system is intuitive and easy to use, allowing users to navigate and interact with it seamlessly. By prioritizing usability, designers can enhance user engagement and retention, reduce errors or frustration during interactions, and increase productivity and efficiency. Overall, the importance of usability lies in its ability to create positive user experiences, ultimately contributing to the success and effectiveness of digital products and services[4], [5].

The ever-increasing popularity of touchscreen devices and virtual apps has caused a significant increase in the utilization of touchscreen interfaces by children both for gaming and educational purposes [6]. Studies show that globally, over half of children under the age of 3 regularly use touchscreen devices [7]. Fig. 1 shows the result of a survey on U.S children's engagement with digital devices [8]. However, the usability of software plays a crucial role in children's engagement with these applications. Research in Human-Computer Interaction (HCI) and Interaction Design and Children (IDC) has demonstrated that the design of interfaces significantly shapes children's interactions with touchscreen apps [9]. However, several existing mathematics applications focus more on the content, and the usability of applications is ignored [10].

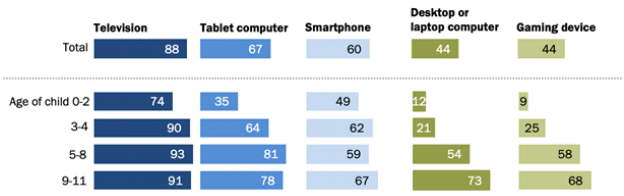

Fig. 1: Children's engagement with digital devices [8].

Therefore, the usability of kids' apps is of vital importance, due to the unique characteristics and needs of young users. Children, especially those in the early stages of development, require interfaces that are intuitive, engaging, and easy to navigate to effectively interact with digital content [11]. The usability of educational apps is essential to ensure they effectively facilitate learning and engagement among children [12]. Usability considerations such as clear navigation, age-appropriate language, and interactive elements tailored to children's cognitive abilities are crucial in ensuring that kids can fully benefit from and enjoy educational or entertainment apps. By prioritizing usability in the design and development of kids' apps, developers can create safe, engaging, and enriching digital experiences that cater to the specific needs and preferences of young users, ultimately contributing to their overall growth and development [13].

However, there is a lack of thorough evaluations on the usability of children's apps that are promoted with different educational goals [14]. Without a clear evaluation framework, parents and educators struggle to determine which applications provide both a user-friendly experience and effective educational support. A comprehensive review is necessary to establish usability benchmarks, ensuring that digital learning tools meet the developmental needs of children. Additionally, as many children's apps seem to prioritize generating advertising revenue or collecting user data over usability, this raises concerns regarding ethical design practices and children's digital safety [15].

Given the abundance of Iranian apps designed for children, examining the usability of these apps and how they align with the principles of Human-Computer Interaction is paramount. Iranian children grow up in an environment where their language, culture, and learning styles differ from those of children in other countries. Therefore, they should be designed in simple Persian and use familiar symbols for Iranian children. Moreover, in many countries, there are strict regulations to protect children in the digital space. However, this is not the case in Iran. Examining this issue as a usability parameter, can help policymakers and developers establish better standards for children's digital safety.

Hence, the purpose of this research is to see if there is a gap between research and practice in Iranian educational apps developed for children. To narrow the scope of this research we focus on those Iranian Android apps that teach mathematics to children. Therefore, the question of this research is: to what extent do Iranian educational android math apps adhere to scientific usability principles. We should clarify that this study does not assess the educational effectiveness of these apps but solely their design principles. The result of this research can highly be useful for designers and developers of educational apps in Iran. Besides it can give parents and educators a comprehensive insight to select proper educational apps for children.

Review of the Related Literature

The first step in evaluating applications is finding a suitable framework for analyzing them [16]. Researchers [17], identify a scarcity of reliable evaluation tools for

educational apps, with existing tools often being either too complex, outdated, or lacking scientific backing. Overall, the literature review underscores the necessity for effective evaluation tools to navigate the vast array of educational apps and ensure they provide genuine educational benefits. In this part, a review of evaluation tools is presented as well as research that analyzed interface design practices based on design recommendations in the literature.

In the user experience design process for children, the designer should first attract the child by appealing to their imagination, interests, and motivation [18]. Then, the designer should provide a high degree of freedom for the child to explore and experiment in the new world [19]. Finally, the designer should plan how the experience in the virtual world can be integrated into the real world for a holistic and engaging experience [20]. The best practices in user experience design for kids include showing respect by considering child thinking [21], using clear and consistent interfaces, sticking to plain talk with simple language and design elements, and gaining trust by providing safe and secure products [22], encouraging interaction through interactive features, and rewarding loyalty with virtual goods and incentives. These practices aim to create a positive and engaging online experience for children while also promoting repeat purchases and customer retention [23].

Soni and her colleagues developed a framework called TIDRC [9]. The TIDRC framework consists of 57 design suggestions that are divided into 19 interface dimensions and seven overarching categories depending on the impacted interface features. It provides practical design suggestions based on research for meeting the cognitive, physical, and socio-emotional needs of children in touchscreen interaction design. It includes advice on visual design, audio features, interactive elements, application responsiveness, informational features, physical gestures, target features, and socio-emotional contextual features. These recommendations are tailored to different age groups, from 2-7 years old to 7-11 years old, and aim to help create engaging and effective interaction.

In another study, a collection of 23 usability guidelines was established for designing mobile-based Augmented Reality (AR) apps intended for kindergarten-aged children. Researchers carried out a thorough literature review to pinpoint existing usability principles from various sources. They then organized expert meetings to evaluate and enhance these principles. Lastly, they utilized factor analysis to group the refined principles into four categories: cognition, orientation, design, and support. Cognition features focused on cognitive and intellectual elements like learnability, efficiency, and minimizing memory load. Orientation emphasized user comprehension and interaction, such as enjoyment and customizability. Design principles centered on application usage, for instance, interactivity and simplicity, and finally support Geared towards user assistance, including error management and early testing. These guidelines aim to direct the development of more engaging, easy-to-learn, and user-friendly AR apps made for kindergarten children [24].

There is another instrument called the E.T.E.A. (Evaluation Tool for Educational Apps) [17]. It is designed to assess the quality of educational apps targeted at children aged 3 to 6 years. The instrument was developed based on a review of existing rubrics and checklists for evaluating educational apps, and it underwent Exploratory Factor Analysis (EFA) to confirm its validity and reliability. The E.T.E.A. aims to provide a simple, valid, and reliable tool for parents, custodians, and educators to make informed decisions when selecting educational apps for young children. The E.T.E.A. consists of a thirteen-item assessment questionnaire that evaluates four key dimensions of educational apps including usability, efficiency, parental control, and security. Usability assesses how easy the app is to use for children, including the clarity of instructions, consistency of visual elements, and the overall ease of navigation. Efficiency evaluates how effectively the app facilitates learning and engagement for children. Parental Control examines the features that allow parents to monitor and control their child's use of the app, such as providing feedback on the child's progress and ensuring no disruptive advertisements are present. Security focuses on the app's privacy policies and how it manages personal data, ensuring that children's information is protected.

Besides papers that discuss dimensions for evaluating apps, other researchers recommend some points to enhance the usability of apps for children. For example, Anthony and her colleagues recommend providing visual feedback, especially for children, wherever possible during surface gesture interaction on mobile devices [25]. Another key issue that Meyer and his colleagues raise is the frequent use of annoying video ads and the fact that children are often tempted to watch these ads in exchange for rewards [26]. These distractions are annoying and can cause users' dissatisfaction. Besides they can pull young users away from the real learning objectives of the app, making it harder for them to focus on what they should be gaining from the experience [27].

To assess the usability of Iranian math applications created for children, the researcher combined and categorized various dimensions and aligned them with HCI guidelines and principles, as suggested by Shneiderman and Plaisant [4], who advocate for designing interfaces for children as if they are new or inexperienced users. This led to 39 parameters including criteria such as

consistency [9], [12], [17], [23], [24], [28], informative feedback [12], [17], [28], design adapted to children's skills and interaction styles [9], [17], [24], [28]. Table 1 presents these criteria in detail.

Besides considering general usability guidelines for novice or first-time users, limiting the vocabulary to a few commonly used concept terms is crucial [23], [28]. It is also important to keep the number of actions minimal to ensure that new and inexperienced users can complete basic tasks successfully [9], thereby reducing anxiety, boosting confidence, and offering positive reinforcement. Providing informative feedback on task completion is beneficial, and offering clear, specific error messages when users make mistakes is essential [12], [17], [28]. Thoughtfully crafted video demonstrations and online tutorials can also be effective [4].

Method

The method of this research is expert review. In this method, the researcher is an expert in usability studies and evaluates objects systematically based on standard parameters. This method doesn't require direct testing on users. A natural way to evaluate interfaces is to show them to users and gather their feedback. While informal demos with test subjects can offer some insight, formal expert reviews are generally more effective. Expert review enables faster and more standardized evaluation. Experts can analyze applications using design principles and scientific criteria without being influenced by children's behavioral variables. Young children may not be able to provide precise or logical feedback. Utilizing experts in this field ensures that analyses are based on well-established and scientifically valid criteria. Many usability evaluation studies have employed expert review, as it offers more efficient methods for systematically analyzing the design features of applications. [4].

In this study, the usability of Iranian Android math apps designed for children aged 6 to 9 (preschool to grade 3) was evaluated. Given the restrictions on iOS usage in Iran, the apps were selected from two major Iranian Android app stores: Bazar[1] and Myket[2]. These platforms are widely used due to their accessibility. To ensure to have a representative sample, we started by manually searching for 100 apps using keywords like "teaching math to kids," "math learning apps," and "kids math education" in Persian. It helped to find a diverse range of apps that directly focused on teaching math to children. Since it was aimed to explore a broad range of apps, no limits were set on the number of downloads, which varied from just 10 to over 500,000. Between July 22 and August 5, 2024, we selected 100 apps, intentionally excluding any older versions of apps already on the list. Bazar and Myket don't offer an option to filter app search results based on what users specifically need. On top of that, the "number of hits" shown includes not just the apps themselves but also every time the search term appears in the app titles and descriptions. This means that searching for something like "teaching math to kids" often brings up a lot of irrelevant results.

The researcher, applied strict criteria to decide which apps would move forward for testing. Only apps that worked properly and offered interactive features were included for detailed usability analysis. Interactive applications are programs that allow users, especially children, to actively engage with them rather than merely viewing static content such as text or videos. Therefore, Apps that didn't function correctly, required purchases before offering any meaningful content or lacked interactive elements (such as text-only apps) were excluded. Additionally, apps that were simply videos or non-interactive presentations, were excluded, as these didn't meet the goal of helping children actively engage with math learning. After this filtering process, it ended up with a final sample of 44 apps, which were then put through a detailed usability review.

Each of the 44 apps was tested for around 15 minutes. The decision to use a 15-minute window came from the average time children tend to spend on educational apps in a single session. During the testing phase, the apps were assessed based on 39 usability factors drawn from existing research on Human-Computer Interaction (HCI) and educational app design. These factors included how easy the app was to navigate, the clarity of its instructions, how well it used visual and auditory feedback, and whether the content was appropriate for the target age group.

For each app, the researcher tried to complete as many tasks as possible within the 15-minute timeframe. If an app was more complex, extra time was given to make sure all its features were thoroughly assessed. Throughout the process, we noted any design issues or problems with responsiveness and made observations about how intuitive the app was for a child to use. The researcher made notes explaining how the gameplay aligned with the criteria for each score.

To evaluate the apps, each usability factor was rated from 0 to 4. A score of 0 indicated that the app failed to meet usability expectations, while a score of 4 showed that it fully complied with usability guidelines. For each program, each of the 39 items shown in Table 1 was investigated and a number between 0 and 4 was assigned to the App for that parameter. Finally, the percentage of programs that scored 3 or higher on each parameter was determined, as reported in Fig 2.

Each app was assessed on several key areas:

[1] https://cafebazaar.ir/?l=en
[2] https://myket.ir/

Table 1: HCI Guidelines for designing interfaces for kids

HCI Guidelines	Details
Strive for consistency	Metaphors, navigation, content, and visual elements [9], [12], [17], [23], [24], [28].
Providing informative feedback	Children know if they make a mistake [28] Visual/audio [9] Appropriate, and clear [12], [17], [28]]
Considering kids skills	The use of animation and images matches with children's skills [28]. Instructions in apps are presented in a manner suitable for children [17] The app is user-friendly for children, allowing for easy scrolling and navigation [17], [24], [28] Icon sizes are appropriate and manageable for children [28] Interactive widgets are intentionally designed to be visually larger [9] The language used is simple and suitable for the target age group [23], [28] Abstract signs and symbols are eliminated [9] Avoidance of visually complex backgrounds in applications is recommended [9] Use a minimum of 14-point font size and appropriate spacing [9], [28]
Reduce user frustration	Avoid App crash, hanging, or freeze [24], [28] Fast load [12]
Attract users	An engaging design with clear visuals [24], [29] Bright colors that attract children [28] Stimulation of children's imagination, interests, and motivation [23] Incorporation of interactive cartoon characters on the screen [23]
Getting the users' attention	Use sound effects and voice to get users' attention [9]
Consider Learnability and Retention overtime	Once they receive help from adults, children should be able to use it on their own. The app should be easy to use without requiring special training. [12], [24], [28] Reduce short-term memory load [5], [23]
Legal and security concerns	The app does not encourage children to engage in any online transactions [23] The app is free from advertisements, such as pop-up messages [17]
Personalization	The application should be flexible enough to get customized based on user requirements [9], [24], [28] Easily users can start or stop any activity at any time [28] The application should allow users to bypass instructions or content that isn't part of the gameplay [24] The app should offer children a significant level of freedom to explore and experiment within the new environment [23]
Interaction Styles	Clearly distinguish clickable items from other elements on the screen [9]. Restrict the functionality of clickable items to their intended purpose [9]. Avoid using extensive menus in apps designed for children [9]. Ensure the menu is suitable for touchscreen use [28]. Minimize the use of text prompts [9]. Include audio prompts alongside visual cues [9]. Use animated prompts to illustrate gestures [9]. Provide audio support for text labels and instructions [9]. Avoid implementing rotation gestures [28]. Do not utilize pinch-to-zoom gestures [28]. Avoid drag-and-drop gestures [28].

Navigation and Interface Consistency: how smoothly the app's design and navigation flowed, helping children move easily through different sections without getting confused.

Feedback Mechanisms: how well the app informed users about mistakes or task completion, such as through visual cues or sounds.

Engagement and Attractiveness: how visually appealing and engaging the app was for children. This included elements like animations, vibrant colors, and fun tasks to hold their attention.

Personalization Options: whether the app allowed users to adjust settings like difficulty levels or themes to cater to individual learning preferences.

Cognitive Design: whether the app's language and instructions were simple and clear enough for children to understand without adult assistance, and if it used helpful audio or visual cues to support learning.

After completing the usability testing of all 44 apps, the scores were compiled and analyzed. The frequency of scores for each usability factor was calculated to help identify patterns. This analysis helped to highlight where most apps were doing well and where improvements were needed. For example, apps that scored below 39 points (out of a possible 156) were flagged as having significant usability problems. Based on Table 1, 39 parameters were examined for each App, when an App is

scored below 39, it means that in most of the questions it had gained one or less.

Before starting the full usability evaluation, a pilot test was conducted with five randomly selected apps. This pilot phase helped fine-tune the evaluation process, making sure that the chosen usability factors were appropriate for the apps being tested. It confirmed that 15 minutes was an appropriate amount of time for testing most apps, as children typically use educational apps in short bursts.

Since no children were directly involved in the study, there were no ethical concerns related to user participation. However, each app was carefully reviewed to ensure that it was age-appropriate and that no harmful content or in-app purchases were present that could exploit children. Apps that included excessive advertisements or encouraged online transactions were flagged and excluded from the final sample to protect children from potential risks.

Results and Discussion

A quick overview of math apps for kids on Bazar and Myket reveals that most of them are free, with full versions accessible, and only a small number require payment. About 96% of the apps, largely released or updated between 2019 and 2024, don't cost anything. The developers of most of these apps are freelancers or private companies.

When it comes to math apps for kids, nearly 12% of them don't work at all! 11% just display text to teach kids math!! 18% aren't interactive and only provide videos for teaching math to kids. Some videos are simply recordings of a classroom lesson, while others are more creative and designed as animations. However, none of them create any interactive tools for the child. Besides 15% asked kids in-app purchases or register and provide some information such as their mobile phone number without even letting the user examine a demo of the application to decide whether he wants to use it or not. All these apps were excluded and the remaining 44 ones were analyzed.

From the remaining 44 teaching math to kids' apps that we explored, 18% of them only have one main function mostly counting or clock. About 28% offer two features such as adding and subtraction, and 40% provide three or four functionalities mostly adding, subtraction, multiplication, and division. Apps with five or more functions make up just 14% and add functionalities such as clock, shapes, and pattern recognition to the functionalities mentioned above. These apps generally aim at two groups: children and parents or teachers. Most are designed for kids, while only 8% are specifically created for parents or teachers. Besides, user ratings vary from 2.2 to 5, with an average of around 4.

Results show that nearly 98% of apps "strive for consistency" and follow the same navigation and visual elements around the app. This finding aligns with other research emphasizing the importance of a consistent interface for usability in educational apps. For instance, Soni and her colleagues developed a framework (TIDRC) that includes design suggestions for cognitive and physical needs, which supports the need for consistency in app design [9].

Regarding providing feedback to users, the majority of the apps (77%) in our sample "provide feedback" and let the kids know about their mistakes. This finding is consistent with recommendations from other studies, such as those by Anthony and colleagues, who advocate for visual feedback during interactions to enhance usability for children [9]. However, only 9% of apps use positive phrases such as "My dear try again" to inform the user of his mistake. Others, just create a text, sound, vibration, or a changed color, among them, 4% make harsh sounds and that may cause kids to experience stress. This indicates a significant gap in the quality of user interaction. This discrepancy suggests that developers are more focused on visual consistency than on increasing user motivation through positive feedback. The impact of positive on children's learning and motivation is significant, influencing their engagement and persistence in educational tasks. Positive feedback has been shown to enhance motivation, self-efficacy, and skill acquisition, while negative feedback can lead to decreased motivation and increased anxiety [30], [31].

Concerning the parameter of "considering children's skill levels", more than half of the apps meet this criterion. Specifically, in regards to icon and text sizes, about 86% of apps designed icons and texts large enough to be suitable for kids. It is also notable that almost none of the studied apps used abstract signs and symbols that are vague for kids and avoid complex backgrounds. All the apps we explored were easy to use and children could learn to start working with them without the help of adults. However, instructions and language used in nearly 40% of apps need to be edited to be more understandable for kids. This difference suggests that more attention was paid to visual design than to the simplicity of language.

The Average score for the recommendations to help attract users is 2.1 which shows apps are not attractive enough and don't stimulate children's imagination, interest, and motivation. Since visual appeal and effective interaction play an important role in children's learning, this deficiency can negatively affect children's concentration, motivation, and information retention. Research has shown that the use of interactive elements such as cartoon characters [23] , and gamification [32] can increase children's engagement with educational content, which ultimately improves understanding of concepts and increases the duration of interaction with educational apps [33]. However, Only 16% of apps use interactive cartoon characters which is recommended to

engage. This low rate suggests that most developers have not paid enough attention to the psychology of children's learning and the role of engagement in enhancing their cognitive performance. As mentioned earlier, 15% of the 100 apps we selected to analyze, asked kids in-app purchases before allowing them to do any interaction and we excluded these apps. However, fortunately, 75% of 44 apps studied in this research do not encourage children to engage in any online transaction and 73% are free from advertisements. This is a positive finding compared to other studies [26] that have highlighted the negative impact of intrusive ads on children's focus and learning objectives. However, while these numbers represent a positive trend in creating a safe environment for children, 25% of apps still have in-app features and 27% have ads, which can be distracting for younger users.

In regards to personalization, 89% of apps don't provide customization options to users. Others allow very limited personalization features. Just 2% of apps let the user change difficulty level. Further, in 2% of apps, the user can choose between the automatic process of the app and the user-based selection process.

Only 7 % of apps let the user connect or disconnect the background music and in 2% of apps, the user can ask for the repetition of instructions. This statistic shows that developers have paid less attention to the individual needs of users, while personalization options can help improve the user experience and increase children's engagement with the app. Finally, analyzing interaction style parameters, shows that nearly in all apps, clickable items are clearly distinguishable and their functionality is restricted to the intended purposes. Extensive menus are not used and menus are suitable for touchscreen use. However, more than half of the apps (56%) use text prompts extensively instead of audio or visual cues and 82% don't provide audio support for text labels and instruction. Moreover, 73% don't include audio cues with visual prompts, and 91% don't employ animated prompts to illustrate gestures. This shows that many apps are not designed optimally for interaction with younger users, who may not have reading skills. This shortcoming can reduce accessibility and ease of understanding of content for children.

Fig. 2 gives a visual view of the results explained. While most apps meet basic usability standards, there are still some significant shortcomings in areas that could impact how well children can learn and stay engaged with these tools.

A. Adherence to Basic Usability Principles

Most of the apps (98%) followed the key usability principles, particularly when it came to consistent navigation and visual elements. This consistency helps children use the apps more easily, reducing confusion and making it simpler to complete tasks. The apps also generally did well in terms of physical accessibility, like having buttons and text that were the right size for children's small hands and developing motor skills. These design elements are crucial because they allow children to interact with the apps without getting frustrated, helping them focus more on learning rather than figuring out how to use the app.

B. Feedback and Engagement Issues

While many apps (77%) provided feedback when children made mistakes or completed tasks, only 9% offered positive, encouraging feedback. Most apps relied on simple cues like text or color changes, and a few even used harsh sounds to indicate errors, which can cause stress for young users. The lack of supportive feedback is a missed opportunity to motivate children and encourage learning. Positive reinforcement is especially important in educational settings, as it can boost a child's confidence and willingness to keep trying.

The apps also scored low on how engaging they were, with an average score of 2.1 out of 4. Most apps lack the interactive features that make learning fun for kids, like cartoon characters or exciting visuals. Only 16% of the apps used such engaging elements. Without these, children are less likely to stay focused on the math content, which reduces the app's overall effectiveness.

C. Challenges with Cognitive Design

Another major issue was the cognitive design of many apps. While over half of the apps did take into account the skill levels of young children, about 40% still used complex language and instructions that would be difficult for a 6- to 9-year-old to understand. This presents a significant barrier to effective learning since kids may struggle to comprehend what they're supposed to do.

Additionally, more than half of the apps (56%) relied too much on text prompts and didn't offer enough visual or audio cues to help non-readers navigate the content. Effective app design should consider children's developmental stages, and many of these apps failed to offer the necessary supports for younger users. Apps that don't offer clear guidance or break things down into manageable steps are harder for children to use independently, limiting their learning potential.

D. Limited Personalization

A key shortcoming in many of the apps was the lack of personalization. Only 11% of the apps allowed users to tailor their experience, such as adjusting the difficulty level or changing the feedback style. Personalization is essential because it allows the app to cater to each child's unique learning pace and needs. Without this flexibility, the apps are less likely to meet the diverse learning styles of children effectively. This is especially important for kids who need extra support or, conversely, those who may require more challenging tasks.

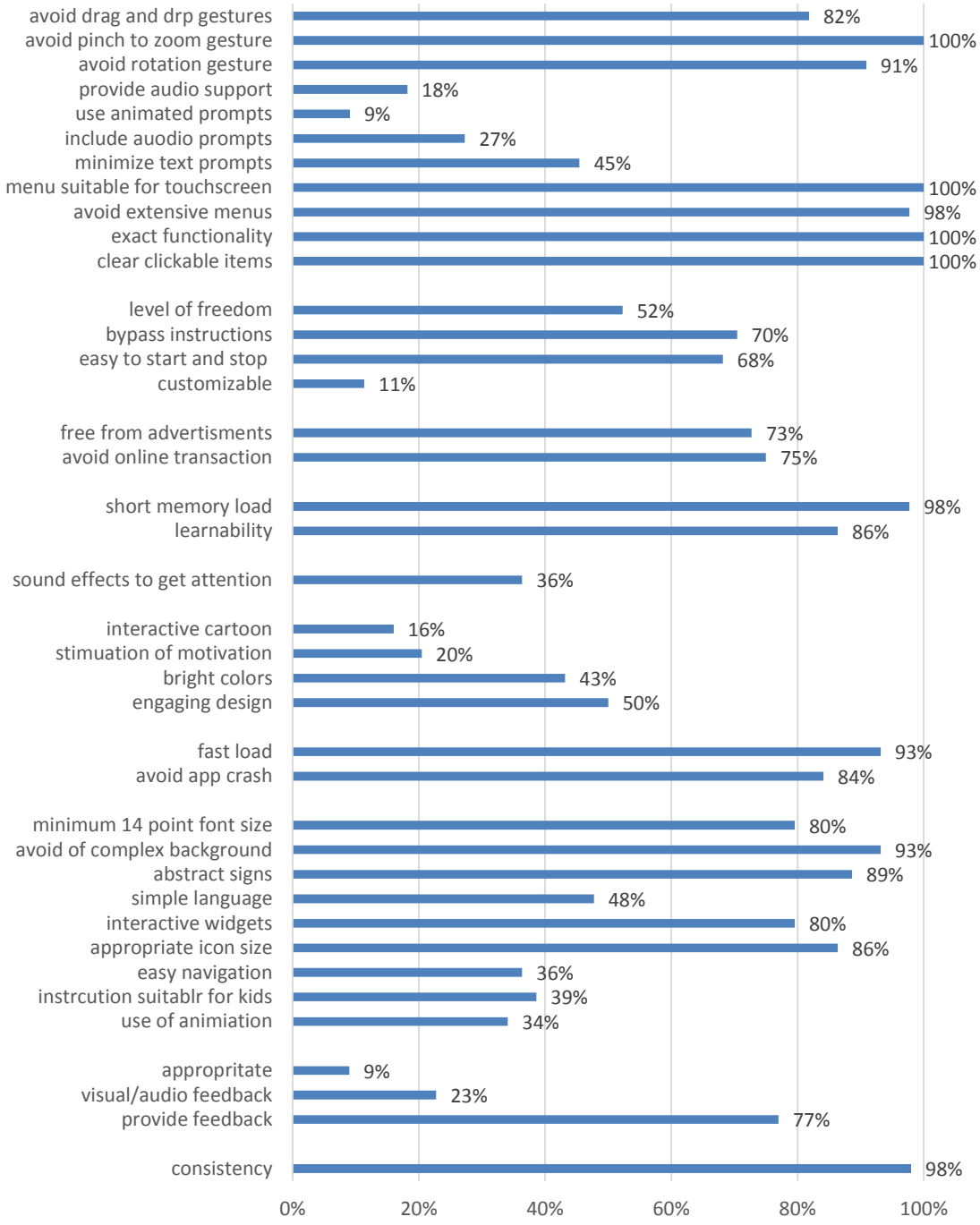

Fig. 2: The rate of apps' adherence to HCI factors.

E. Safe and Distraction-Free Learning

On a more positive note, 75% of the apps did not push for online transactions, and 73% were free of ads. This is a huge plus for parents and teachers, as it means the apps provide a safer, less distracting environment for learning. Ads and in-app purchases can take away from the educational experience and introduce risks for children, so their absence in many of the apps is a strong point.

F. Gaps between Research and Practice

One of the key findings from this study is the gap between what research suggests for educational app design and what's being implemented. While many apps followed basic physical usability guidelines, they often didn't perform well in areas like cognitive design, engagement, and feedback—all of which are essential for effective learning.

In terms of cognitive design, about 40% of apps used complex language and instructions that were difficult for children to understand. In addition, more than 56% of apps relied heavily on text messages and did not use audio or visual prompts appropriate for illiterate or low-literate children. Good cognitive design helps children understand new concepts with minimal mental effort and not get discouraged from using the app [34], [35]. Developers should use simple language, meaningful icons, audio prompts, and educational animations to help children.

Regarding engagement, the average user engagement score was 2.1 out of 4, indicating low engagement for most apps. Furthermore, only 16% of apps used interactive cartoon characters, even though research has shown that interactive characters help increase attention, motivation, and enjoyment of learning. Effective learning happens when children are actively involved. The lack of engaging features can make children lose interest in the app [33]. Developers can make the learning experience more engaging by adding gamification elements (scoring, badges, and challenges) and using animated characters.

Concerning providing positive feedback, although 77% of apps provide some form of feedback, only 9% provide positive, motivating feedback. This means that most apps use neutral or even negative methods when providing feedback on user mistakes, which can make the learning experience stressful. Research has shown that positive, motivating feedback increases children's self-confidence and improves the learning process [30], [31]. Developers should use positive statements and engaging visual feedback to motivate children to learn more.

Developers need to understand the importance of adding more interactive features, offering positive feedback, and simplifying language for younger users. By following research-based recommendations more closely, developers can create apps that not only meet usability standards but also enhance the learning experience for children.

Conclusion

This research sheds light on how Iranian Android math apps for children are performing in terms of usability, uncovering both strengths and areas for growth. The results are relevant for various groups—app developers, educators, parents, and policymakers—who all have a stake in improving educational technology for young learners.

This study found significant gaps in how the apps engage with children, provide feedback, and support their cognitive development. Developers can use these findings to create better, more user-friendly educational apps. Many of the apps were too text-heavy or complicated for young children. Developers should focus on making apps simpler and more intuitive by using age-appropriate language, visuals, and sounds. Only 9% of the apps provided positive feedback, which is crucial for motivating kids. Positive feedback helps build confidence and encourages children to keep learning, making the experience more rewarding [36]. With just 11% of the apps offering any customization, there's a big opportunity for improvement. Developers should consider adding features like adjustable difficulty levels or options for different learning styles. This way, each child can have a personalized learning experience that fits their unique needs, helping them learn more effectively. Developers could partner with schools and education organizations to create apps that align with specific curriculums, have more personalized features, use cartoon characters to engage children, and include interactive educational tools. By doing so, they can ensure that their apps meet both educational and usability standards, increasing their appeal and credibility within the educational community.

Educational tools and platforms should provide environments that allow students to interact more with content, teachers, and classmates. This can be achieved through live chats, group discussions, and increased interactions with digital content such as quizzes and interactive assignments. Further, using gamification elements such as scoring, badges, and challenging levels can make the learning process more engaging.

Teachers and parents are key decision-makers when it comes to choosing educational tools for children. This research provides them with insights on how to pick the best apps for learning. The study shows which app features make a real difference in usability and learning. By choosing apps with positive feedback, simple designs, and engaging content, educators and parents can ensure that children are using tools that help them learn. Since many of these apps still require adult help, educators and parents need to be aware of this. They might need to step in to provide additional support or guidance, especially when apps don't have enough visual or audio cues.

Policymakers and educational organizations can also use this research to set better standards for educational apps, ensuring they meet both usability and learning requirements. Based on the gaps found in this research, education authorities could develop clear guidelines that app developers must follow. These guidelines should focus on keeping the design simple, the navigation intuitive, and the content engaging and suitable for young learners. Further, policymakers could introduce a certification process that ensures only high-quality educational apps are recommended for use in schools. This would give teachers and parents a trusted way to know which apps are the most effective and safe for children to use.

In summary, the findings of this research have practical implications for how educational apps are developed,

selected, and used. By applying these insights, developers can create more engaging and effective tools paying more attention to interactive design and gamification. While educators and parents can make informed choices about which apps to use, choosing apps that provide positive feedback and voice guidance while committing to security settings. This ultimately leads to better learning experiences for children, helping them succeed in both the digital and classroom environments.

While this study offers valuable insights into how usable Iranian math apps are for children, there are a few limitations that should be considered to better understand the findings and their relevance. By recognizing these limitations, we can better understand the study's context and scope.

The research focused only on math apps from two Iranian Android app stores—Bazar and Myket. This means the study might not fully capture the broader range of educational apps available in Iran, especially those on global platforms like the Google Play Store or the iOS App Store. Additionally, since only math apps were studied, the findings may not apply to apps for other subjects, like science or reading.

Each app was tested for only 15 minutes, which might not be enough time to fully understand its usability. Some issues, like whether children get tired of the app, how easy it is to learn to use, or how engaging it remains over time, may not have been noticeable in such a short test. A longer testing period could reveal more about how children interact with these apps in the long run.

This study focused on apps designed for kids aged 6 to 9. As a result, the findings may not apply to apps meant for older children. Usability needs vary by age, so future studies could explore how apps perform for children of different ages to get a broader picture.

Since this study focused on Iranian apps, the findings are shaped by local cultural, educational, and technological factors. While some usability principles are universal, the way children learn and interact with apps can vary across different cultures, which limits how well these findings apply to educational apps in other regions.

Another limitation is that the study did not involve direct user testing with children. Instead, the apps were evaluated by a single researcher. Watching how children interact with the apps in real-life settings could have provided richer insights into how usable they are and might have uncovered more usability challenges that weren't evident through researcher evaluation alone.

Future research could expand by including a broader range of apps, and testing the apps directly with children to gather more comprehensive findings.

Since this study focused on Iranian apps, future research could look at how educational apps from other countries perform. A global comparison could uncover best practices that developers worldwide can use to improve their apps.

Educational bodies have an important role to play in ensuring these improvements are made. By setting clear standards for educational apps and promoting best practices, they can help bridge the gap between research and practical application, leading to better-designed, more effective learning tools. With ongoing research and collaboration between educators, developers, and researchers, we can improve the quality of educational apps for children, giving them the tools they need to succeed in today's digital world.

Author Contributions

N. Zanjani, designed the research, collected the data, carried out the data analysis, interpreted the results and wrote the manuscript.

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Conflict of Interest

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

Abbreviations

HCI	Human-Computer Interaction
IDC	Interaction Design and Children
AR	Augmented Reality
TIDRC	Touchscreen Interaction Design Recommendations for Children
E.T.E.A.	Evaluation Tool for Educational Apps
EFA	Exploratory Factor Analysis

References

[1] H. Özgür, "Relationships between computational thinking skills, ways of thinking and demographic variables: A structural equation modeling," Int. J. Res. Edu. Sci., 6(2): 299-314, 2020.

[2] S. Annamalai, A. C. Omar, S. N. A. Salam, " Rory's Mathematics Adventure's (ROMAAD) mobile game-based learning applicatioN: AN evaluation of usabilitY," Int. J. Edu. Psychol. Couns., 7(48): 575-85, 2022.

[3] B. S. Nugraha, M. Suyanto, E. Utami, "Innovative approaches in child-friendly user interfaces: A systematic literature review on technologies, motoric skill and evaluation," Presented at 7th International Conference of Computer and Informatics Engineering (IC2IE), 2024.

[4] B. Shneiderman, C. Plaisant, Designing the User Interface: Strategies for Effective Human-Computer Interaction: Pearson Education India, 2010.

[5] B. Al-Haimi, "Usability guidelines of mobile learning application," J. Inf. Syst. Res. Innovation, 5(9), 2013.

[6] S. Yağmur, M. P. Çakır, "Usability evaluation of a dynamic geometry software mobile interface through eye tracking" Presented at the third International Conference on Learning and Collaboration Technologies held as Part of HCI International, 2016.

[7] M. L. Courage, L. M. Frizzell, C. S. Walsh, M. Smith, "Toddlers using tablets: They engage, play, and learn", Front. Psychol., 12: 1-18, 2021.

[8] B. Auxier, M. Anderson, A. Perrin, E. Turner, "Children's engagement with digital devices, screen time", Pew Research Center, 2020.

[9] N. Soni, A. Aloba, K. S. Morga, P. J. Wisniewski, L. Anthony, "A framework of touchscreen interaction design recommendations for children (tidrc) characterizing the gap between research evidence and design practice," in Proc. the 18th ACM International Conference on Interaction Design and Children, 2019.

[10] D. F. Murad, B. D. Wijanarko, R. Leandros, F. I. Ramadhan, Y. A. P. Siregar, "Interaction design of mathematics learning applications for elementary school students," Presented at 3rd International Symposium on Material and Electrical Engineering Conference (ISMEE), 2021.

[11] M. Martens, "Issues of access and usability in designing digital resources for children," Lib. Inf. Sci. Res., 34(3): 159-68, 2012.

[12] A. Ibrahim, M. Al-Rajab, K. Hamid, M. Aqeel, S. Muneer, M. Parveen et al., "Usability evaluation of kids' learning apps," Presented at International Conference on Business Analytics for Technology and Security (ICBATS), 2023.

[13] P. Markopoulos, J. C. Read, S. MacFarlane, J. Hoysniemi, Evaluating Children's Interactive Products: Principles and Practices for Interaction Designers: Elsevier, 2008.

[14] M. Meyer, J. M. Zosh, C. McLaren, M. Robb, H. McCaffery, R. M. Golinkoff et al., "How educational are "educational" apps for young children? App store content analysis using the Four Pillars of Learning framework," J. Children Media, 15(4): 526-48, 2021.

[15] R. Binns, U. Lyngs, M. Van Kleek, J. Zhao, T. Libert, N. Shadbolt, "Third-party tracking in the mobile ecosystem," Proceedings of the 10th ACM Conference on Web Science; 2018.

[16] C. A. C. Domínguez, D. O. Mina, V. Agredo-Delgado, P. H. Ruiz, D, M, AlSekait, "Towards to usability guidelines construction for the design of interactive mobile applications for learning mathematics," Iberoamerican Workshop on Human-Computer Interaction, 2020.

[17] S. Papadakis, J. Vaiopoulou, M. Kalogiannakis, D. Stamovlasis "Developing and exploring an evaluation tool for educational apps (ETEA) targeting kindergarten children," Sustainability, 12(10): 4201, 2020.

[18] J. H. D. Doong, Loneliness among Chinese Emerging Adults in America and the Role of the Church: A Practical Theology Inquiry: Fuller Theological Seminary, Center for Advanced Theological Study, Dissertations & Theses, 3733234, 2015.

[19] N. Vanderschantz, A. Hinze, "Designing an internet search interface for children," Presented at 32nd BCS Human Computer Interaction Conference (BCS HCI 2018), 2018.

[20] B. H. Chandana, N. Shaik, P. Chitralingappa, "Exploring the frontiers of user experience design: VR, AR, and the future of interaction," Presented at International Conference on Computer Science and Emerging Technologies (CSET), 2023.

[21] A. Banke, C. Lauff, "Usability testing with children: History of best practices, comparison of methods & gaps in literature," DRS Biennial Conference Series, DRS2022: Bilbao, 2022.

[22] G. Ragone, P. Buono, R. Lanzilotti, "Designing safe and engaging ai experiences for children: Towards the definition of best practices in UI/UX Design," arXiv preprint arXiv:240414218, 2024.

[23] A. K. Sandhu, K. Bhardwaj, "Interfaces for kids," in Proc. the 11th Asia Pacific Conference on Computer Human Interaction, 2013.

[24] N. Tuli, A. Mantri, "Evaluating usability of mobile-based augmented reality learning environments for early childhood," Int. J. Hum. Comput. Interac., 37(9): 815-27, 2021.

[25] L. Anthony, Q. Brown, J. Nias, B. Tate, "Examining the need for visual feedback during gesture interaction on mobile touchscreen devices for kids," in Proc. the 12th International Conference on Interaction Design and Children, 2013.

[26] M. Meyer, V. Adkins, N. Yuan, H. M. Weeks, Y. J Chang, J. Radesky, "Advertising in young children's apps: A content analysis," J. dev. Behav. Pediatr., 40(1): 32-39, 2019.

[27] N. Holmberg, Effects of online advertising on children's visual attention and task performance during free and goal-directed internet use: A media psychology approach to children's website interaction and advert distraction, Lund University, 2016.

[28] M. M. S. Missen, A. Javed, H. Asmat, M. Nosheen, M. Coustaty, N. Salamat et al., "Systematic review and usability evaluation of writing mobile apps for children," New Rev. Hypermedia Multimedia, 25(3): 137-60 2019.

[29] Y. Cakan, A. Kaya, C. A. Gumussoy, Usability Analysis of a Mobile Learning Application. Handbook of Research on Modern Educational Technologies, Applications, and Management: IGI Global, p. 198-212, 2021.

[30] A. Câmpean, M. Bocoș, A. Roman, D. Rad, C. Crișan, M. Maier et al., "Examining teachers' perception on the impact of positive feedback on school students," Edu. Sci., 14(3): 257, 2024.

[31] M. Merrick, E. Fyfe, "Should I stay or should I go? Children's motivation in response to feedback and its association with math self-concept, math self-efficacy, and math anxiety," 2024.

[32] M. Maryana, C. Halim, H. Rahmi, "The impact of gamification on student engagement and learning outcomes in mathematics education," Int. J. Bus. Law Edu., 5(2): 1697-1708, 2024.

[33] L. Y. Fei, M. R. Norfariza, E. H. Kazi, "Student engagement as a mediator between online classroom management and learning outcomes in Beijing universities," Int. J. Eval. Res. Edu., 14(1): 94, 2024.

[34] Q. Yu, J. Wang, "A framework design of children's educational app based on metacognitive theory," Presented at International Conference on Human-Computer Interaction, 2022.

[35] N. Blom, "Design cognition in design and technology classrooms," Debates in Design and Technology Education, Routledge, p. 209-220, 2022.

[36] A. Ani, "Positive feedback improves students' psychological and physical learning outcomes," Indones. J. Educ. Stud., 22(2), 2019.

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