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RESEARCH ARTICLE

An evaluation of educational apps for preschool-age children in Android and iOS

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Abstract: Applications (apps) available as educational in digital app stores for preschoolers claim that they offer to learn content on a wide range of basic academic skills, including counting, reading, and pattern recognition. This research aimed to investigate the educational quality of a range of educational applications for Android and iOS Operating Systems aimed at preschool-age children, i.e., children from 3 to 5 years old. The evaluation was done using two scientific tools: the rubrics published by Lee & Cherner entitled "A Comprehensive Evaluation Rubric for Assessing Instructional Apps" and by Papadakis, Kalogiannakis & Zaranis entitled "Designing and creating an educational app rubric for preschool teachers". The research results showed that most proclaimed educational applications did not have a real educational value. Research extensions are discussed.

Keywords: preschool age, education, applications, mobile learning

1 Introduction

Nevertheless, the digital world is present and has invaded our lives (Skaraki & Kolokotronis, 2022). Thus, it cannot be said that we accept it or oppose it. We begin with the hypothesis that the impact of digital technology on education must be measurable (Poultsakis et al., 2021).

The digital world provides many opportunities for the younger generation to develop skills, knowledge and a perspective to overcome dissatisfaction through formal and informal educational settings (Barianos et al., 2022). Today's kids use a range of touch devices, such as smart boards, smartphones, tablets, iPods, video games, offering them the ability to play, learn and communicate in new ways. Recent research findings show an increase in the ownership and use of tablets in very young children. Since the introduction of the first tablet device (iPad) in 2010 by Apple, the popularity of tablets has proliferated among young children (Papadakis & Kalogiannakis, 2017(a)).

Given the educational categorization of applications in significant application stores, parents can expect their children to develop their first academic skills using these applications, as advertised by the app developers (Verawati et al., 2022). In interviews about children's media use, parents often express confidence in their children's ability to learn from educational applications better than from traditional educational practices. However, experts worry that these commercially available applications may not be designed to make the best of children's learning and not achieve the advertised benefits.

Young children's exposure to digital technology is increasing, and there is a growing interest in using this technology to create innovative educational tools. Due to the widespread use of smart mobile devices and the internet, all people, regardless of age group, especially young children, have direct contact with the applications offered by technology (Skaraki, 2021). This has been particularly prevalent in digital app markets, with more than half of all educational applications advertised for preschoolers. Nevertheless, children's educational applications are prevalent, with some reporting more than one hundred million downloads around the globe. A reason is that educational applications can tailor the content and challenges to align with users' current knowledge and skills. Content can become more complex as students do well in an application or reduce the challenge when students seem to be doing poorly (e.g., they answer incorrectly several times in a row) using pre-programmed algorithms.

Kids-focused app designers do not start with a blank page. Instead, they are influenced by current trends in technology and design, their interactions with technology, their experiences and intuitions about learning better, or what children will find most enjoyable about them. While this is understandable, this approach is often influenced by misconceptions about learning and education, as evidenced by the success of the "Baby Genius" video series and related "educational" television in the early 2000s. Despite the explicit and tacit marketing claims

for effectiveness, scientific studies have revealed that young children have not become more effective after exposure to these television programs and DVDs (Walker, 2013).

Only a handful of applications have been designed based on how children learn. A small number of developers in both small and large gaming/media companies have used research-based approaches with preliminary research results. For example, a recent study found that interaction with a vocabulary-focused application increased the vocabulary of low-income young children by up to 31% over two weeks. While this may sound encouraging to developers and application users, few details have been offered about the study's design, making it difficult to assess its scientific impact. Thus, there is a need to propose principles for designing appropriate applications that are more likely to provide educational benefits (Ok et al., 2015).

The majority of applications in today's market can be considered part of the "first wave" of the digital revolution. In this wave, applications are merely digital worksheets, games and puzzles that have been reproduced electronically without any explicit consideration of how children learn or how the unique benefits of e-learning can be harnessed. Ways need to be found to help parents evaluate the applications that exist in this first wave. Although there is no way to scientifically study every application in the market, a set of science-based principles can be developed and used to evaluate the current application cut (Hirsh-Pasek et al., 2015; McClure et al., 2017) (see Figure 1).

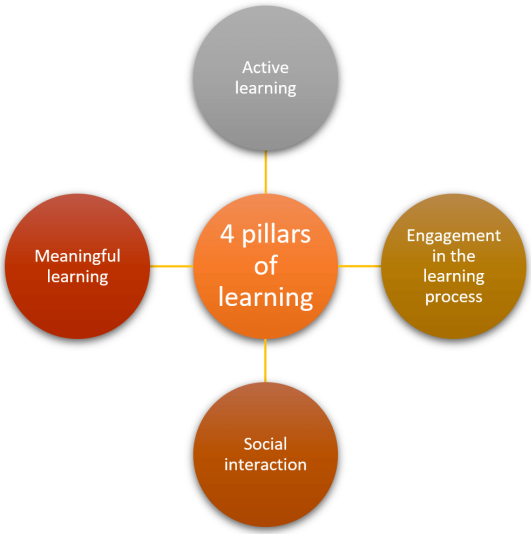

Figure 1 The four pillars of an educational app (Hirsh-Pasek et al., 2015)

Some preliminary steps have already been taken with introducing rating systems from Children's Technology Review, Common Sense Media and a set of parent-oriented application services. For example, Common Sense Media uses 5-point scales to evaluate individual media pieces for "ease of play", "violence and terrorism", "sex", "language", "consumerism", "drink, drugs, & smoking" and "privacy and security". The reviewers also give an overall score for the "quality" and "learning" categories and select the age of the children for whom the application is appropriate. While these rating systems have not been scientifically evaluated, they are widely used in this field (Chen, 2016).

Recent decades of research in learning science have transformed how we think about learning and teaching. By merging these parallel concepts, media developers can access knowledge that allows them to create better educational applications, and parents can evaluate the learning potential of applications for their children (Buckler & Peterson, 2012).

2 Smart mobile devices in Preschool Education

Although Apple did not introduce the iPad as an educational tool in 2010, it found its way into education issues that spread around the world. Digital devices are part of the culture in which children grow up, and these devices are penetrating their home and school life. As a result, society pressures teachers and parents to provide digital literacy to young children. iPad and other tablets are becoming commonplace in schools today, as they are regularly used for teaching (Nikolopoulou, 2021).

According to the World Bank, education policymakers allow tablets to be purchased in many education systems worldwide, as these devices are considered powerful and emblematic symbols of modernity in an education system. In the UK, at the end of 2014, over 70% of primary and secondary schools had tablet devices in their classrooms, and 900,000 tablets were expected to be in schools by 2016 (Drigas & Kokkalia, 2016).

In classroom settings, tablets are better than interactive whiteboards; their fixed position often makes them inaccessible to wheelchairs and other physical supports children. Lynch & Redpath (2014) found that students from 2 years old can use iPad regardless of features and Beschorner & Hutchison (2013) also showed that young students can browse the iPad independently. If children cannot use educational technology effectively, they certainly can not learn through it (Bratitsis, 2018). Even children as young as five years old may have difficulty completing an activity using the mouse. On the contrary, research by Aziz et al., (2013) shows that all children aged four and over can use the seven common gestures, such as click, drag-and-drop, slide, pinch, spread, spin, rotate and flick, where they are generally used in mobile applications (Papadakis et al., 2017(b)). The rapid influx of interactive smart screen devices poses a particular challenge for the early childhood community (Foti, 2021). Early Childhood Educators are beginning to think about the role of this new technology in their classrooms, and many preschool programs are starting to buy tablets for use in the classroom (Chaldi & Mantzanidou, 2021). One of the reasons is that smartphones provide "significant opportunities to support differentiated, autonomous and personalized learning truly". Previous research suggests that developmentally appropriate technology can encourage young children's cognitive and social development (Papadakis et al., 2021).

Touch devices present unique opportunities to enhance young children's understanding of abstract concepts through the presentation of dynamic representations, opportunities for built-in learning and the inclusion of interactive elements. Yelland & Gilbert (2011) found in a study that using a tablet in three different settings with children aged 2 to 6 years represents a sustainable learning environment in different ways for the children involved. Other emerging studies from the US and Australia have shown that young children's learning can be enhanced by using educational applications with real educational value. These mobile devices and their accompanying applications can enhance the acquisition of knowledge through three different forms of learning (learning style) where are the following (Yusop, & Razak, 2014):

(1) Visual learning;
(2) Acoustic learning;
(3) Kinesthetic (or physical, tactile) learning.

In 2012, the National Association for the Education of Young Children (NAEYC) stated that they encourage children from birth to the age of 8 to use tablets and appropriate educational applications to support the early development of literacy (). Tablets can provide fun activities to allow children to express their creative perspectives, enhance interest in the research process, and provide a path to informed consent (Papadakis et al., 2021).

These include tacit learning of the game, mastery of explicit learning tasks (e.g., matching, counting) embedded in the game's narration, and the use of skills and models learned and applied in other types of games and their levels. Engaging in creative application activities often removes the child's focus from the subjective experience of winning or losing a competition. While thousands of applications are available today, selecting the most appropriate educational applications for children is complex and problematic for teachers and educators (Drigas & Kokkalia, 2016).

3 The digital app markets

Mobile applications have become a fast-paced enrichment tool for the software industry. Since the launch of the iPhone in 2007 (the first smart touchscreen mobile device), mobile applications have evolved and become an integral part of the economy itself. This fast-growing mobile app industry is worth billions of dollars. Apple's digital app store, called the App Store, first opened on July 10, 2008, providing free or paid apps for the iPhone and later for iPod touch and iPad. In 2011, more than $ 2.5 billion was "paid" in the software industry, while in 2014, applications brought in more than $ 10 billion in revenue for developers (Drigas et al., 2016). By the end of 2014, users had downloaded 75 billion apps and visited the App Store 300 million times a week, according to Apple's CEO. Three models of paid apps, in-app purchases and ads boosted the mobile app business. Total application revenue is expected to increase from $ 45.37 billion in 2015 to $ 76.52 billion in 2022. In 2012, in-app purchases accounted for 11.4% of global mobile application revenue and were expected to increase to 48.2% in 2022. Revenues from in-app purchases will reach $ 28.9 billion by 2022 (Papadakis et al., 2018).

According to a report by the Federal Trade Commission (FTC), an independent agency of the US government, entitled "Mobile Apps for Kids: Current Privacy Disclosures Are Depointing", smartphones in 2008 could choose from about 600 applications each. In 2012, more than 500,000 apps were on the Apple App Store and another 380,000 on Google Play. As of June 2015, 1.5 million mobile applications were available on the Apple App Store. As a result, the number of applications available in the Google Play Store, formerly known as the Android Market, exceeded 1 million applications in July 2013 and in February 2016, it was placed in the category of 2 million applications (Nikolopoulou, 2021). Figure 2 and Figure 3 provide information on the number of apps available in the Apple App Store and Google Play Store from 2008 to 2020 and 2009 to 2021, respectively.

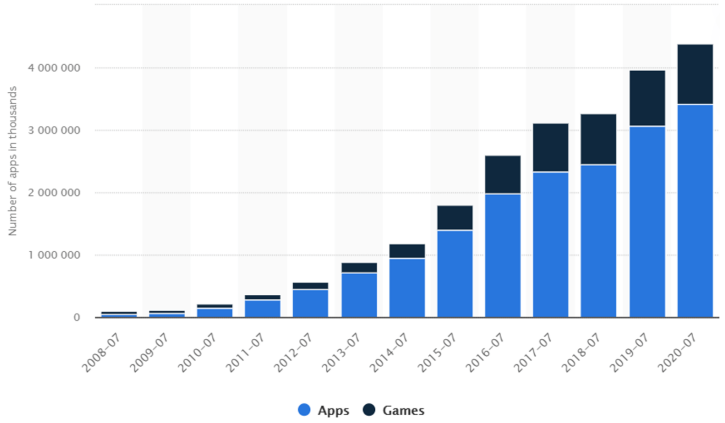

Figure 2 The number of applications available in the Apple App Store from 2008 to 2020 (source: Statista, 2021(a))

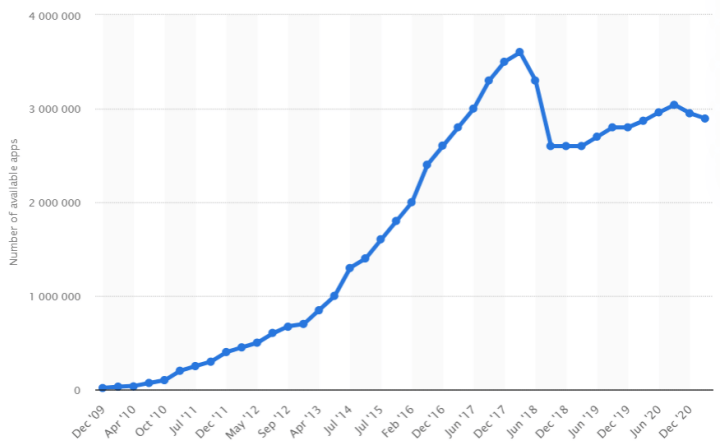

Figure 3 The number of applications available in the Google Play Store from 2009 to 2021 (source: Statista, 2021(b))

Even in infancy, smart screen technologies have dominated the lives of many young children, and there has been a rush to fill this new space. The preschool and primary education applications market gained children's attention due to their attractive graphic and interactive elements. As children become more familiar with new technologies, targeted marketing of this age group with new products has become inevitable. Developers aimed at this specific educational category, and as a result, the market of educational applications is an ever-growing industry and has become one of the few sectors whose number is improving every year (Chatzopoulos et al., 2021).

Children of all ages embrace smartphones for recreational and educational purposes; they browse and download thousands of applications daily, either for a fee or for free. In mid-2013, Apple announced a new Apple Kids Store for children under 12 years old. Applications that comply with this category must be made specifically for children aged five and under, aged 6-8 or aged 9-11. According to Apple, the company's goal is to give parents a place to find applications suitable for their children's age (Nikolopoulou, 2021). Figure 4 shows the number

of app downloads from Apple and the Google App Store from 2016 to 2021.

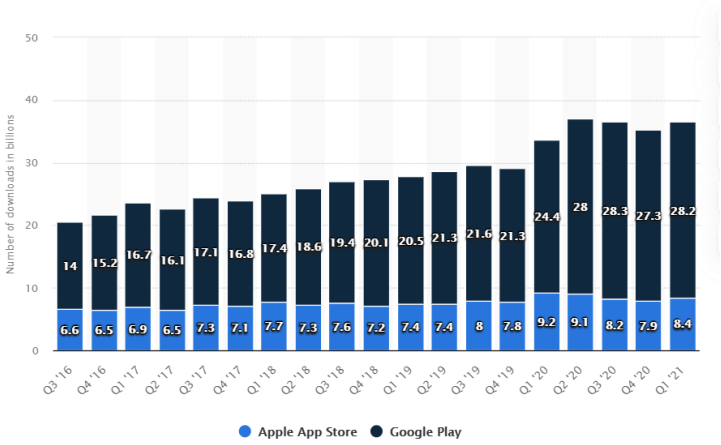

Figure 4 The number of Apple App Store and Google Play app downloads worldwide from the 3rd quarter of 2016 to the 1st quarter of 2021 (source: Statista, 2021(c))

4 Aim of the research

Due to the widespread use of smart mobile devices and the internet, all people, regardless of age group, especially young children, have direct contact with the applications. For this reason, the present research aims to investigate Android, and iOS Operating System (OS) applications addressed to preschool children, i.e., children from 3 to 5 years old. The research questions asked in this research section are as follows:

(1) Do the applications available in Android OS receive the same rating compared to the applications in iOS OS if they are evaluated with two different objective tools?

(2) Is the evaluation of users (stars in online stores) related to a subjective evaluation system for the sample applications on Android and iOS OS?

(3) If the same application is available in both Operating Systems (Android and iOS), does the choice of the different Operating Systems affect the educational value of the application for preschool children based on the two objective assessment tools?

5 Methodologyv

5.1 Sample research

The research sample consisted of 40 applications (apps) in Android and iOS OS by random sampling (see Table 1). Some of the app descriptions were adapted from the Educational App Store website (https://www.educationalappstore.com/app-lists/best-preschool-apps).

5.2 Research tools

The collection of evaluation data was done using two scientific tools, which are the rubrics published by Lee & Cherner (2015) in the article entitled "A Comprehensive Evaluation Rubric for Assessing Instructional Apps" and by Papadakis, Kalogiannakis & Zaranis (2017b) in the article entitled "Designing and creating an educational app rubric for preschool teachers". The tools made it possible to evaluate each application individually in different items, such as educational content, design, functionality and technical features. Finally, the evaluation of the applications was compared with the two specific objective evaluation tools concerning the subjective evaluation criteria, such as the system of stars in the online stores and the users' comments.

6 Results

As can be seen from the overall rating of the applications based on the two tools, there are minimal differences in the final rating as the difference is only 0.11 points. This average was

Table 1 App descriptions

A/A	App name	App description
1	Alphatots	This ABCs app teaches young children to address letters by interacting with active verbs. The age range of this application is for children three years and older.
2	Fruit Punch Music	The child can choose from various child-friendly stations with themes spanning different genres and decades. Designed specifically for preschoolers, it comes with smart parental controls, which allow time limits to be set and stations that are not suitable for children to be excluded. The age range of this application is for children three years and older.
3	Monkey Preschool Lunchbox	It teaches preschoolers to develop essential skills that will help them prepare for kindergarten and beyond. They will learn matching and arithmetic by working through various fun activities. The age range of this application is for children three years and older.
4	PBS	Shows like PBS have already been shown to improve cognitive, language and social outcomes for three- to five-year-olds, but research shows that preschoolers who watch PBS content in more interactive ways, such as in games, benefit even more.
5	Sesame Street	It is an application with various clips from performances, with many fun, quality games based on added favourite characters.
6	Wheels on the Bus	It adds an interactive touch by letting children tap and drag the device screen to make the bus roll along the road, open the doors and even make the wipers spin as they sing.
7	Hungry Caterpillar Play School	Bring children the favourite characters of the famous author and teach them shapes and colours through five fun areas of activity. Activities include songs, arithmetic and matchings.
8	LEGO	This construction app encourages kids to create their own LEGO virtual vehicles before driving and flying them through fun lessons and collecting coins along the way. LEGO fans can create explosions with tons of cute places to choose from to build their creations.
9	Homer Reading	It helps preschoolers start reading early, focusing on eight skills areas. It was created by literacy experts and consultants and tested in preschool classes on 82 students. The app provides an excellent way for children to acquire writing awareness, letter sounds, and phonetics skills.
10	Khan	The children's edition offers early learning activities from the "Head Start Early Learning Outcomes" and "Common Core" standards. Activities include topics such as math, creative expression and learning.
11	Elmo Loves 123s	The app teaches children numbers with the help of the beloved characters Elmo and Abby. After selecting a number, children can spot it on the screen before being rewarded with a classic Sesame Street video clip that incorporates numbers to increase children's observation. Each issue includes three videos and activities, including puzzles and games.
12	Hopster Coding Safari	It offers young children an excellent introduction to "pre-coding", without the need for prior coding knowledge to get started. For example, children start using logic to place a bear in a cave via horizontal and vertical paths.
13	Thomas & Friends Minis	Children can make their trains, and they can let their creativity flow as they choose between pre-made and DIY layouts and a wide variety of trains and landscapes. Furthermore, when the track is finished, they are taken to the train from the coordinator's point of view.
14	Daniel Tiger's Grr-ific Feelings	It teaches children to recognize their emotions, process them, and express them healthily. Children are asked to analyze their feelings and then name them. They can even take pictures of their faces to help them understand how they feel.
15	PBS Kids	Preschoolers can watch their favourite episodes of Daniel Tiger, Sesame Street and other favourites directly from their devices.
16	Epic	Kids can find many fun, exciting and educational stories at Epic! to enhance these early reading skills before kindergarten.
17	Kids Academy	The app has over 5,000 learning activities for preschoolers, including educational games, animated videos, interactive stories, worksheets, songs and puzzles. This app is aimed at preschoolers on critical topics such as early literacy, reading, writing, language and math while encouraging creativity and building socio-emotional skills.
18	Preschool Games	This interactive application has 24 educational games that encourage preschoolers to learn letters, shapes, colours, numbers, pattern recognition, etc.
19	Ludi	Their application shows objects and ideas from the world around them and asks them to categorize and match them. The lack of casual elements in the toys will help children develop their concentration and focus.
20	Numberita	It helps the preschooler identify numbers and count while feeding friendly monsters who visit the cafeteria as customers.
21	Kokoro Kids	Preschool games are grouped by skills (count to 5, positions, colours, patterns, addition, subtraction, etc.) and categories (science, music, arts, language & math).
22	ABCmouse.com	It focuses on the main subjects of the curriculum, mathematics, the general world (basic sciences and social studies), as well as art and colours.
23	Preschool Math - Math Galaxy	Children can play math games. Their games cover early math concepts such as numbers and shapes, addition, subtraction and most importantly, fun.
24	Reading Eggs	Based on scientific research and designed by education experts, it has been shown to help children read using interactive reading games, guided reading lessons, fun activities and over 2,000 digital storybooks.
25	Edudadoo	The activities of the application focus on speech, vocabulary and creativity as they provide a diverse gaming experience that includes customizing the user's photos and recording voices and sounds.
26	KidloLand Kids Games	The app contains 2000+ educational songs, games, stories, children's rhymes and activities related to early learning, math, reading, writing, coding, etc.
27	Letter School	Teaches preschoolers how to write letters (uppercase and lowercase) and numbers (from 1 to 10) in a playful and fun way.
28	Zoolingo	Games and educational puzzles teach the alphabet, arithmetic, colours, shapes, spelling, math and more.
29	Hopster Preschool Learning	It helps children learn through performances, games, music or books.
30	My Very Hungry Caterpillar	It is an interactive book application for preschoolers to explore their imagination with beautifully illustrated scenes based on Eric Carle's book.
31	Artie's World	A colouring application for preschool children provides drawing experience with a dot-to-dot system.
32	ABCya	The games are designed by parents and educators, who understand that children learn best if they have fun.
33	Dr Panda Town	It is a fun role-playing application for preschoolers.
34	Daniel Tiger's Day & Night	The child should help Daniel get ready for school in the morning and go to bed at night through imaginative play. This application includes eight games related to day and night routines. They sing songs and even a music timer to keep kids' routines on track.
35	Busy Shapes	An early learning application that allows children to practice their problem-solving skills by dragging and dropping various shapes, colours and objects into their designated hole.
36	Color Quest AR	It is an augmented reality application for preschoolers that supports healthy eating in fun and inspiring way.
37	Narrator AR	It is an augmented reality application that supports preschool writing fun and inspiring.
38	Curious World	The subscription unlocks hundreds of books, games and videos for every child to enjoy.
39	Lingokids - English for Kids	An app that helps preschoolers learn English words.
40	Daniel Tiger's	Neighborhood Five mini-games in which preschoolers can explore Daniel Tiger's home and neighbourhood. Daniel Tiger shares relevant discoveries and challenges with friends, neighbours and family in the Make-Believe neighbourhood.

calculated based on the difference between the two tools' scores, resulting in 0.262 points. Due to their poor design and development, the applications are too low in their rating (around two stars). The comparison of the application's rating based on the two tools is presented in Table 2.

Table 2 The comparison of the application's rating based on the two tools

Name of the app	Average rating of the apps		Difference between the applications between the two tools
	Evaluation Table 1	Evaluation Table 2	
Alphatots	3.25	2.5	0.75
Fruit Punch Music	3	2	1
Monkey Preschool Lunchbox	2.5	2.5	0
PBS Kids Games	1.75	1.5	0.25
Sesame Street	2	1.75	0.25
Wheels on the Bus	1.25	1.5	0.25
Hungry Caterpillar Play School	2.25	2.75	0.5
LEGO Juniors Create	1.5	1.5	0
Homer Reading: Learn to Read	1	1.75	0.75
Khan Academy Kids	1.75	2	0.25
Elmo Loves 123s	1.25	1.5	0.25
Hopster Coding Safari	1.5	1.5	0
Thomas & Friends Minis	1	1.5	0.5
Daniel Tiger's Grr-ific Feelings	1.5	2	0.5
PBS Kids	1.75	2	0.25
Epic	1.5	1.25	0.25
Kids Academy	1.75	1.5	0.25
Preschool Games	1	1.25	0.25
Ludi	1.5	1.25	0.25
Numberita	1.75	2	0.25
Kokoro Kids	1.5	1.5	0
ABCmouse.com	1.75	1.75	0
Preschool Math - Math Galaxy	1.75	1.75	0
Reading Eggs	1.75	1.25	0.5
Edudadoo	1.75	2	0.25
KidloLand	1.5	1.5	0
LetterSchool	2	2	0
Zoolingo	1.5	1.5	0
Hopster Preschool Learning	1.5	2	0.5
My Very Hungry Caterpillar	2	1.75	0.25
Artie's World	2.5	2.25	0.25
ABCya	2	2	0
Dr Panda Town	1.75	2	0.25
Daniel Tiger's Day & Night	2	2	0
Busy Shapes	2.25	2.25	0
Color Quest AR	1.5	1.75	0.25
Narrator AR	1.75	2	0.25
Curious World	2.25	2.25	0
Lingokids - English for Kids	2	1.75	0.25
Daniel Tiger's Neighborhood	1.5	2.5	1
A total score of the applications	1.93	2.04	0.11

Notes: The comparison for the total rating of the applications with the two tools

As can be seen from the overall rating of the applications based on the two tools, there are minimal differences in the final rating as 2 is 0.11 points; the average score of the two tools was 0.262. The applications are nasty in their rating (around two stars) due to their poor design and development. This triggers application creators and designers to study and upgrade their applications so that preschoolers can learn while having fun and achieve the ultimate goals of acquiring basic skills and abilities by integrating into the school environment and starting their immediate training.

Below (Table 3 and Figure 5) is presenting the evaluation of an app that was randomly selected. Alphatots is an excellent way for parents to give their children a start to reading. This ABCs app teaches young children to address letters by interacting with active verbs. The age range of this application is for children three years and older. This application is available on both platforms under study (Google Play Store and App Store).

Table 3 Evaluation of an app that was randomly selected

Areas of evaluation	Evaluation of the Alphatots app based on the evaluation table of Papadakis, Kalogiannakis & Zaranis (2017b)	Evaluation of the Alphatots app based on the evaluation table of Lee & Cherner (2015)
Educational content	4	3
Design	2	2
Functionality	3	2
Technical Characteristics	4	3
Average scores	3.25	2.5

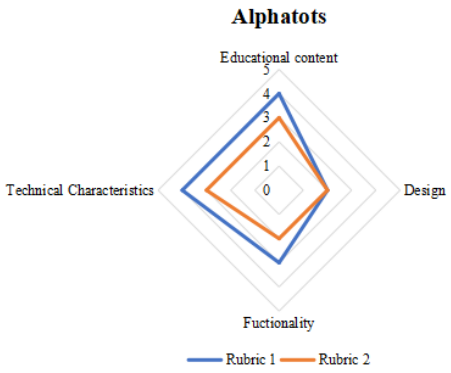

Figure 5 Evaluation of the Alphatots educational application based on the two rubrics

7 Discussion

It is observed that most of the educational applications evaluated in this study did not have the best scores based on the two rubrics. So, developers need to improve their educational applications in all areas (educational content, design, functionality, and technical features). Regarding the existing differences that may have occurred between the two Operating Systems (Android and iOS), no significant differences were observed between the scores. Some of the applications in the Android system may have had a better rating in certain areas (e.g., educational content and design), while other applications may have had a better rating in other areas (functionality and technical features). Regarding the usefulness of educational applications in the classroom and at home, most analyzed applications prepare children to have some rudimentary bases in specific areas (reading, writing, arithmetic, music, etc.) (Vaiopoulou et al., 2021).

The role of education is to provide children with new experiences, and learning occurs when children are guided with appropriate scaffolding and support (Ampartzaki et al., 2021; Papadakis, 2021). Due to their adaptive nature, digital technologies can offer support to cater to any student. Gee (2003) called it "explicit information about demand and the beginning of time."; in particular, reported technologies that can dynamically adapt content to personalize learning (Missen et al., 2019).

Technology-mediated activities that allow children to express themselves creatively can promote the developmental benefit of trust. Underlying this concept is the freedom to "transcend the traditional ideas, rules, patterns, relationships or interpretations that create and create original new ideas." For preschoolers, this type of freedom takes the form of finding purpose in what they do. According to Erikson's theory of psychosocial development, children at this age are challenged to take the initiative or feel guilty about their choices. Children need opportunities to do things independently in developmentally appropriate ways, with the proper guidance and support that create experiences. Freedom of initiative allows children to develop self-esteem and a sense of accomplishment (Kay, 2018).

8 Conclusion

With the advent of technology, the availability of cheaper mobile phones and other digital devices such as tablets and laptops, the education sector is now undergoing a change where there is a transition from traditional teaching to digital teaching. Research shows that preschoolers, especially those in the two- to five-year-old age group, adapt well to digital learning and easily handle tablets and smartphones (Zourmpakis et al., 2022).

Choosing the correct application is particularly important as it can make the difference between the "digital caregiver" and the tool that supports the learning and development of preschool children. Many of the self-proclaimed educational applications do not impact children's cognitive development. Although some parents are themselves advanced and knowledgeable technology users, this does not necessarily mean that they fully understand the impact of information technology products and services used by young children. Choosing the right technologies, such as applications that facilitate children's active and creative use, is becoming very important for parents and teachers. As not all applications are of the same quality, it is also important to note that cost is not necessarily related to quality. In the absence of an

industry-standard or formal grading system for children's applications, websites or blogs often consult parents and educators when creating applications. However, this method of selection is also problematic. The reason is that most of these blogs and websites use a methodology for evaluating "educational" applications for children, which is not of quality and does not meet the appropriate age and other pedagogical standards.

Future research will be required to evaluate the effectiveness of self-proclaimed educational apps. People need more high-quality educational applications in more content areas and different age groups. Educators and professionals can only address the severe lack of educational applications with real application value by participating in the application development. Proposed future research would be to investigate the effectiveness of applications developed by academics and experts and possibly use the findings to suggest improvements for future versions of applications in an ongoing design-based research process.

Declaration of interest

The author declares no competing interest.

Data availability

Data generated or analyzed during this study are available from the authors on request.

References

Ampartzaki, M., Kalogiannakis, M., & Papadakis, S. (2021). Deepening Our Knowledge about Sustainability Education in the Early Years: Lessons from a Water Project. Education Sciences, 11(6), 251. https://doi.org/10.3390/educsci11060251

Aziz, N. A. A., Batmaz, F., Stone, R., & Chung, P. W. H. (2013). Selection of touch gestures for children's applications. In 2013 Science and Information Conference, 721-726.

Barianos, A., Papadakis, A., & Vidakis, N. (2022). Content manager for serious games: Theoretical framework and digital platform. Advances in Mobile Learning Educational Research, 2(1), 251-262. https://doi.org/10.25082/AMLER.2022.01.009

Beschorner, B. & Hutchison, A. (2013). iPads as a literacy teaching tool in early childhood. International Journal of Education in Mathematics, Science and Technology, 1(1), 16-24.

Bratitsis, T. (2018). An Attempt for Critical Categorization of Android Applications Available for the Greek Kindergarten. In Advances in Intelligent Systems and Computing, 56-68. https://doi.org/10.1007/978-3-319-75175-7_7

Buckler, T., & Peterson, M. (2012). Is There an App For That? Developing an Evaluation Rubric for Apps for Use with Adults with Special Needs. The Journal of BSN Honors Research, 6(1), 19-32. http://hdl.handle.net/2271/1095

Chaldi, D., & Mantzanidou, G. (2021). Educational robotics and STEAM in early childhood education. Advances in Mobile Learning Educational Research, 1(2), 72-81. https://doi.org/10.25082/AMLER.2021.02.003

Chatzopoulos, A., Kalogiannakis, M., Papadakis, S., Papoutsidakis, M., Elza, D., & Psycharis, S. (2021). DuBot: An Open-Source, Low-Cost Robot for STEM and Educational Robotics. In Handbook of Research on Using Educational Robotics to Facilitate Student Learning, 441-465. https://doi.org/10.4018/978-1-7998-6717-3.ch018

Chen, X. (2016). Evaluating Language-learning Mobile Apps for Second-language Learners. Journal of Educational Technology Development and Exchange, 9(2), 156-170. https://doi.org/10.18785/jetde.0902.03

Drigas, A., & Kokkalia, G. (2016). Mobile Learning for Special Preschool Education. International Journal of Interactive Mobile Technologies (IJIM), 10(1), 67-80. https://doi.org/10.3991/ijim.v10i1.5288

Drigas, A., Kokkalia, G., & Economou, A. (2016). Mobile Learning For Preschool Education. International Journal of Interactive Mobile Technologies (IJIM), 10(4), 57-69. https://doi.org/10.3991/ijim.v10i4.6021

Foti, P. (2021). Exploring kindergarten teachers' views on STEAM education and educational robotics: Dilemmas, possibilities, limitations. Advances in Mobile Learning Educational Research, 1(2), 82-95. https://doi.org/10.25082/AMLER.2021.02.004

Gee, J. P. (2003). What video games have to teach us about learning and literacy. Computers in Entertainment (CIE), 1(1), 20-20. https://doi.org/10.1145/950566.950595

Hirsh-Pasek, K., Zosh, J. M., Golinkoff, R. M., Gray, J. H., Robb, M. B., & Kaufman, J. (2015). Putting education in "educational" apps: Lessons from the science of learning. Psychological Science in the Public Interest, 16(1), 3-34. https://doi.org/10.1177/1529100615569721

Kay, R. (2018). Creating a framework for selecting and evaluating educational apps. INTED2018 Proceedings. 12th International Technology, Education and Development Conference. https://doi.org/10.21125/inted.2018.0106

Lee, C-Y. & Cherner, T. S. (2015). A comprehensive evaluation rubric for assessing instructional apps. Journal of Information Technology Education Research, 1(4), 21-53. https://doi.org/10.28945/2097

Lynch, J., & Redpath, T. (2014). "Smart" technologies in early years' literacy education: a metanarrative of paradigmatic tensions in iPad use in an Australian preparatory classroom. Journal of Early Childhood Literacy, 14(2), 147-174. https://doi.org/10.1177/1468798412453150

McClure, E. R., Guernsey, L., Clements, D. H., Bales, S. N., Nichols, J., Kendall-Taylor, N., & Levine, M. H. (2017). STEM starts early: Grounding science, technology, engineering, and math education in early childhood. New York: NY: The Joan Ganz Cooney Center at Sesame Workshop.

Missen, M. M. S., Javed, A., Asmat, H., Nosheen, M., Coustaty, M., Salamat, N., & Prasath, V. B. S. (2019). Systematic review and usability evaluation of writing mobile apps for children. New Review of Hypermedia and Multimedia, 25(3), 137-160. https://doi.org/10.1080/13614568.2019.1677787

National Association for the Education of Young Children. (2012). Technology and interactive media as tools in early childhood programs serving children from birth through age 8. Spotlight on young children and technology, 61-70.

Nikolopoulou, K. (2021). Mobile devices in early childhood education: teachers' views on benefits and barriers. Education and Information Technologies, 26(3), 3279-3292. https://doi.org/10.1007/s10639-020-10400-3

Ok, M. W., Kim, M. K., Kang, E. Y., & Bryant, B. R. (2015). How to Find Good Apps. Intervention in School and Clinic, 51(4), 244-252. https://doi.org/10.1177/1053451215589179

Papadakis, S. (2021). Advances in Mobile Learning Educational Research (AMLER): Mobile learning as an educational reform. Advances in Mobile Learning Educational Research, 1(1), 1-4. https://doi.org/10.25082/AMLER.2021.01.001

Papadakis, S., & Kalogiannakis, M. (2017a). Evaluation of Greek Android mobile applications for preschoolers. Preschool and Primary Education, 5(2), 65-100. https://doi.org/10.12681/ppej.11208

Papadakis, S., Alexandraki, F., & Zaranis, N. (2021). Mobile device use among preschool-aged children in Greece. Education and Information Technologies, 1-34. https://doi.org/10.1007/s10639-021-10718-6

Papadakis, S., Kalogiannakis, M., & Zaranis, N. (2017b). Designing and creating an educational app rubric for preschool teachers. Education and Information Technologies, 22(6), 3147-3165. https://doi.org/10.1007/s10639-017-9579-0

Papadakis, S., Kalogiannakis, M., & Zaranis, N. (2018). Educational apps from the Android Google Play for Greek preschoolers: A systematic review. Computers & Education, 1(6), 139-160. https://doi.org/10.1016/j.compedu.2017.09.007

Papadakis, S., Kalogiannakis, M., & Zaranis, N. (2021). Teaching mathematics with mobile devices and the Realistic Mathematical Education (RME) approach in kindergarten. Advances in Mobile Learning Educational Research, 1(1), 5-18. https://doi.org/10.25082/AMLER.2021.01.002

Poultsakis, S., Papadakis, S., Kalogiannakis, M., & Psycharis, S. (2021). The management of Digital Learning Objects of Natural Sciences and Digital Experiment Simulation Tools by teachers. Advances in Mobile Learning Educational Research, 1(2), 58-71. https://doi.org/10.25082/AMLER.2021.02.002

Qureshi, A., & Qureshi, N. (2021). Challenges and issues of STEM education. Advances in Mobile Learning Educational Research, 1(2), 146-161. https://doi.org/10.25082/AMLER.2021.02.009

Skaraki, E. (2021). Reinforcing preschoolers' phonemic awareness through the use of tablets. Advances in Mobile Learning Educational Research, 1(1), 28-36. https://doi.org/10.25082/AMLER.2021.01.004

Skaraki, E., & Kolokotronis, F. (2022). Preschool and early primary school age children learning of computational thinking through the use of asynchronous learning environments in the age of Covid-19. Advances in Mobile Learning Educational Research, 2(1), 180-186. https://doi.org/10.25082/AMLER.2022.01.002

Statista, (2021a). Number of available apps in the Apple App Store from 2008 to 2021. https://www.statista.com/statistics/268251/number-of-apps-in-the-itunes-app-store-since-2008

Statista, (2021b). Number of available applications in the Google Play Store from December 2009 to December 2021. https://www.statista.com/statistics/266210/number-of-available-applications-in-the-google-play-store

Statista, (2021c). Number of Apple App Store and Google Play mobile app downloads worldwide from 3rd quarter 2016 to 4th quarter 2021. https://www.statista.com/statistics/695094/quarterly-number-of-mobile-app-downloads-store

Vaiopoulou, J., Papadakis, S., Sifaki, E., Stamovlasis, D., & Kalogiannakis, M. (2021). Parents' Perceptions of Educational Apps Use for Kindergarten Children: Development and Validation of a New Instrument (PEAU-p) and Exploration of Parents' Profiles. Behavioral Sciences, 11(6), 82. https://doi.org/10.3390/bs11060082

Verawati, A., Agustito, D., Pusporini, W., Utami, W., & Widodo, S. (2022). Designing Android learning media to improve problem-solving skills of ratio. Advances in Mobile Learning Educational Research, 2(1), 216-224. https://doi.org/10.25082/AMLER.2022.01.005

Walker, H. (2013). Establishing content validity of an evaluation rubric for mobile technology applications utilizing the Delphi Method [Dissertation]. Maryland.

Yelland, N., & Gilbert, C. (2012). iPlay, iLearn, iGrow. London: IBM Paper.

Yusop, F., & Razak, R. (2014). Mobile educational apps for children. In Management and Technology in Knowledge, Service, Tourism & Hospitality (pp. 51-53). CRC Press. https://doi.org/10.1201/b16700-12

Zourmpakis, A.-I., Papadakis, St., & Kalogiannakis, M. (2022). Education of Preschool and Elementary Teachers on the Use of Adaptive Gamification in Science Education, International Journal of Technology Enhanced Learning (IJTEL), 14(1), 1-16. https://doi.org/10.1504/IJTEL.2022.120556