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A BIBLIOMETRIC ANALYSIS OF TECHNOLOGICAL MANAGEMENT TRENDS IN PRESCHOOL EDUCATION AND META-ANALYSIS OF THE UTILIZATION OF TECHNOLOGICAL TOOLS IN CLASSROOM

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ABSTRACT

Although the usage of technology tools in education has been a much-debated topic in recent years, there has been less research on the factors that may affect their effectiveness in preschool settings. The current study methodically collected 264 empirical publications that examine the correlation between technology tools and children's development, specifically focusing on learning performance. This was achieved using a bibliographic analysis that utilises the VOSviewer software. After conducting a systematic review, a total of 6 empirical research studies were evaluated using the OpenMEE programme and ATLAS.ti 9. Researchers are particularly interested in studying the bibliographic networks related to children's development, preschool environment, and technological utilisation. The meta-analysis results indicate that establishing and maintaining engaging and influential technological activities in the classroom can lead to improved individual development. Future research is recommended to investigate the role of various parties, such as families, as moderators in influencing children's development on integrating ICT into education. Encouraging the early use of technology in the classroom can support national policies focused on fostering communities with advanced digital skills and cultivating competent future leaders.

Keywords: **Computer-Supported Collaborative Learning; Computational Thinking; Early Years Education; Educational Game**

INTRODUCTION

Technology and education are becoming increasingly intertwined in today's world. According to Eirland et al. (2023), people at various points in their learning journey view integrating technology into education more as a routine process than anything exceptional. In the last 20 years, there has been growing data demonstrating the beneficial effects of technology in education at both classroom and advanced practice levels (DiVall et al., 2013; McClearn & Crowe, 2017; Smith & Benedict, 2015; Stolte et al., 2011). Surprisingly, in early April 2020, schools in numerous countries were closed because of the COVID-19 outbreak. Over 1,598,099,000 students globally, representing 91.3% of total enrolled students, cannot attend school in person owing to school closures, impacting children from pre-k to university education (UNESCO, 2021). Interestingly, several academic studies undertaken over 5 years have demonstrated that the impact of COVID-19 has resulted in a rise in the use of technology in the realm of education (Courtney et al., 2022; Winter et al., 2021). Due to this favourable influence, learners engaged in activities such as using technology for homework assignments and online test preparation (Yan, 2021).

In recent years, research has concentrated more on psychological elements of technology use, with fewer discoveries regarding physiological repercussions (Afifi et al., 2018). To provide effective and evidence-based guidance, recently published and rigorous research in social science should be supplemented with evidence from the biological sciences to get a more comprehensive view (Gottschalk, 2019). For evidence, consider the research done by Wickramasinghe and Jayatilleke (2021) on the impacts of technology use on the psychological well-being of learners. Two findings are presented which are 1) internet usage has a large beneficial impact on psychological well-being, whereas 2) video gaming has a considerable negative impact. Looking deeper into the preoperational views of utilizing technological tools in increasing the interest of children to learn psychologically, educators tend to use tablets and computers more than mobile phones and televisions in pre-k settings, according to a study by Dore and Dynia (2020). Significantly, Patchan and Puranik (2016) emphasised that utilising tablet computers is the most effective method for enhancing children's development.

Many countries such as the United States of America (Staiano et al., 2018), China (Weng & Li, 2018), Australia (Hatzigianni et al., 2023), Sweden (The Swedish National Agency for Education, 1998) and Malaysia (National Curriculum Development Centre, 2007) have implemented policies to encourage the use of technology in preschools, particularly among educators, to enhance the effectiveness of the classroom setting. The utilisation of technology is highly emphasised by various stakeholders in education policy for three main reasons, according to researchers from India. Promoting educator-led professional learning organisations is one of these motivations. In addition, it strengthens relationships between local communities and educational institutions. Lastly, it entails bringing people outside of the traditional school setting into children's learning (Mishra & Joseph, 2012). Alternatively, Sulistyaningtyas et al. (2023) found that teachers' use of technology improved classroom monitoring and management. Given the abundance of previous research highlighting the benefits of ICT in education, particularly preschool education, this study will focus on two areas:

i. Is the use of technological tools for children better compared to traditional learning?
ii. Is there an empirical gap in empowering the use of technology in preschool?

LITERATURE REVIEW

Technological Management in Affecting Pre-schoolers' Classroom

Management of ICT in education has been extensively examined in global studies. As time goes by, the ICT usage is widely adopted at all stages of schooling. Starting from the beginning of preschool to higher education, governments have granted a considerable allocation so that the culture of integrating ICT into education is preserved (Nordin & Bacotang, 2021). In Malaysia particularly, the Malaysian Education Development Plan 2013-2025 which has been initiated and planned by the Malaysian Ministry of Education (MoE) is a move to meet the current demands and

difficulties of today's challenges (MoE, 2012). One of the main issues that must be addressed in the education sector is the impact of the Industrial Revolution 4.0, which emphasises the widespread use of the Internet in all aspects, often known as the Internet of Things (IoT). By that, in the development strategy, the MoE has outlined an important shift which is to harness ICT to boost the quality of education in Malaysia (MoE, 2013). According to Masoumi (2015), the use of ICT in preschools allows educators to effectively handle and organise the development of children's portfolios. This portfolio will thereafter be assessed to track the child's progress. In addition, Hooker's (2019) research discovered that educators maintain video documentation of children's learning, which aids in their retention of taught material and may be utilised for ongoing assessment of children's progress.

Furthermore, a study by Rahman et al. (2013) found that teachers in Malaysian national preschools had favourable views towards ICT utilisation for instructional purposes. The use of ICT in educational activities is encouraged to facilitate the teaching and learning process. It allows students to access information, engage with study materials independently, communicate with their classmates, and enhance their learning experience (National Curriculum Development Centre, 2007). In 2001, the importance of the ICT education programme was recognised, and it was integrated into the National Preschool Curriculum (KPK) as a significant component. Additionally, the use of ICT in teaching and learning was given priority (MoE, 2001). If viewed from the perspective of Middle Eastern countries, such as the UAE, it has also enhanced its ICT policies in its education systems. The study by Halabi and Hill (2024) demonstrated the widespread integration of technology in education. Consequently, assessing appropriateness, sustainability, and support is crucial. ICT possesses the capacity to revolutionise the learning environment, but it is crucial to comprehend, execute, and supervise it in a responsible manner. If ICT is not focused on at an early stage, then it has a negative impact on the development of education itself. Insufficient integration of ICT into the curriculum can have a detrimental effect on children's creativity, as noted by Haugland (1992).

A number of important functions can be served by national ICT policies (Kozma, 2003). An educational system's future with ICT and the potential advantages to students, teachers, parents, and the wider community at all levels can be better envisioned with the help of a well-thought-out strategic plan. A nation's educational objectives can be advanced through the use of these strategies, which can promote, alter, and coordinate various actions. Programmes that provide resources for these modifications can be established as companion operational policies. According to a World Bank (2003) evaluation, ICT has the ability to facilitate a more equitable distribution of resources, increase access to industries for rural populations, enhance public services, and facilitate the sharing of expertise necessary to achieve the Millennium Development Goals.

Bibliometric Mapping in Technological-based Learning Settings

Recently, literature studies using bibliometrics in the field of social science (Filippo & Sanz-Casado, 2018; Gao et al., 2022; Raman et al., 2021) have become a trend for researchers to see research gaps based on the field. Bibliometric indicators are pieces of information used to 1) assess the outcomes of scientific research, 2) look at how science and technology interact, 3) map out scientific domains, 4) monitor the growth of new knowledge in a specific field, and 5) provide more competitive advantages and strategic planning indicators for the future (Tupan et al., 2018). The number of publications, which indicates efficiency, and the number of citations, which indicates the impact of the articles produced respectively, are the two general methods used in formulating bibliometric indicators. These are typically calculated over some time amount (typically 3–5 years) (Devos, 2011). Technically, Glanzel (2003) discovered there are three components to bibliometric mapping. The first one is bibliometrics for bibliometricians. It is the primary domain of bibliometric study and has traditionally served as a research approach. Second, bibliometrics for scientific disciplines (scientific knowledge). It recalls that the researchers operate scientifically, thus their passion in their field of specialisation is high, allowing for collaboration with quantitative research in the quest for knowledge. The third option is bibliometrics for science policy and management. It is the domain of research evaluation across a variety of research issues.

Ethically, past researchers conducted a bibliometric analysis of the use of technology in education as part of their literature review, and the final conclusions of each study differed. For instance, Baako and Abroampa (2023)

analysed papers through the Dimensions academic research database, and 1790 relevant publications spanning 2014 to 2023 were identified as such. The significance of this research extends to both the academic realm and its practical application. Academics understand study topics and patterns, while professionals obtain valuable knowledge for making educated decisions about integrating educational technology. This study utilises bibliometric analysis and knowledge mapping to effectively track the progress and advancement of research. The significance of Ioseliani et al.'s (2023) analysis has been discussed where they indicated the fact that the majority of research is conducted within the framework of a technology approach that centres on learning through the use of the keywords of digital learning environment(s) and digital educational environment. Prior to providing a quantitative explanation of this discussion, they gathered information from 61 publications that fell under the purview of the study. It was then analysed using bibliometrics in six different categories which are quantity of articles and citations, most cited articles, most frequently used keywords, most influential nations, most significant institutions, and the most significant journals.

Furthermore, Md Din et al.'s (2024) biomimetic mapping analysis signifies that education authorities globally, particularly in developing countries, should focus on increasing technology usage in teaching and providing training for educators and students to use modern technological methods. Before obtaining this comprehensive and methodical result, they analysed 3,603 research papers in Scopus to identify the most prominent topics navigated by these journals. The final results revealed that technology has become an essential component of modern life in a variety of fields, including education.

Bibliometric Analysis of Technological Management Trends in Preschool Education

Researchers exclusively utilised the Scopus database to identify research gaps due to its reputation for providing scholars with reliable and pertinent research findings. It also assists them in selecting the most suitable publication for their research paper. This database consists solely of reputable, high-performing, high-impact, and peer-reviewed periodicals (Manuscriptedit, 2021). We initiated the exploring process by utilising two keywords that reflect the study's title; 'technology' and 'preschool' respectively. We limit the publication years from 2020 to 2024 due to the large number of publications (almost 9.5 thousand publications) from 2004 to 2024. The final count is 264 documents exported successfully using the CSV Export format offered by its database.

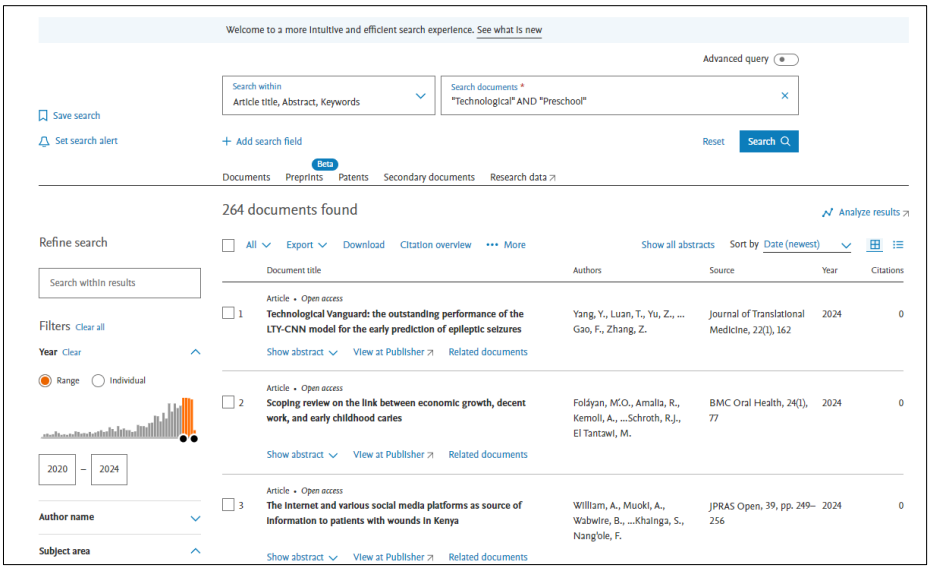

Figure 1. Home Screen of Scopus Database

Once the data has saved in Microsoft Excel, we have started the second step which is to upload the data into the VOSviewer software. It is a free computer programme created for building and visualising bibliometric maps.

VOSviewer stands out from other bibliometric mapping software by focusing on creating visually appealing graphical representations of bibliometric maps (van Eck & Waltman, 2010). In this second step, there are several important phases carried out by researchers. These phases are as below:

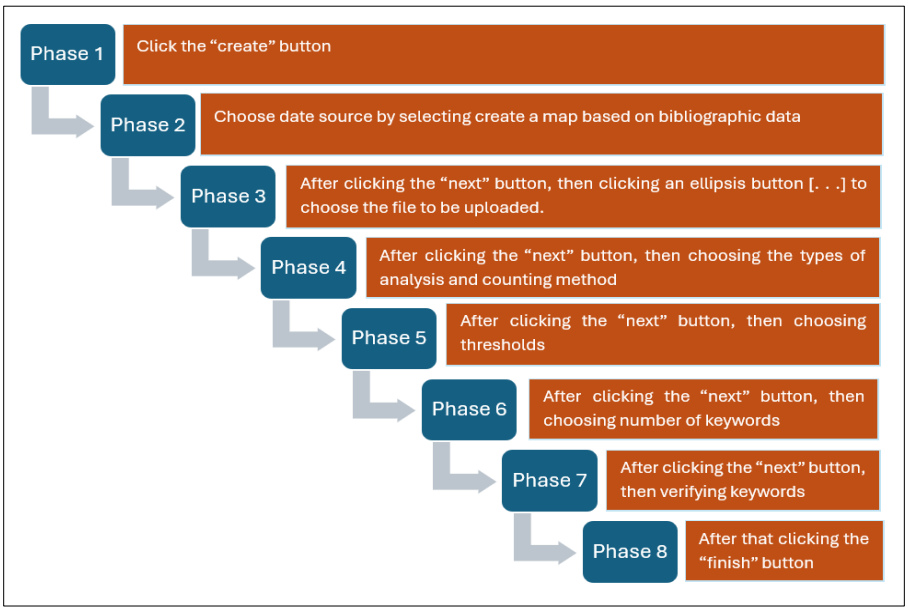

Figure 2. 9 Phases for Bibliometric Analysis using VOSviewer

To ascertain that the data mapping process progresses ethically, the reviewers have followed these 8 phases. For Phases 1 to 4, researchers only follow these processes without making any options based on specified criteria. For Phases 4 through 7, researchers must provide the required details to enable the analysis to explore the necessary gaps in this study. In Phase 4, researchers selected the Co-occurrence analysis type, author keywords as the unit of analysis, and full counting as the counting method (Refer to Figure 3). In Phase 5, researchers established thresholds by setting the number of keywords at 2. So instead of (n=925) keywords produced, only (n=109) fulfil the thresholds (see Figure 4). After that, for Phase 6, researchers need to identify a number of keywords. In this part, researchers did not filter each of the keywords, hence all keywords (n=109) were utilised for analysis (see Figure 5). Next, for Phase 7, namely verifying selected keywords, researchers have checked all the keywords using a list illustrated by the software (see Figure 6). All of them can be used for analytical purposes.

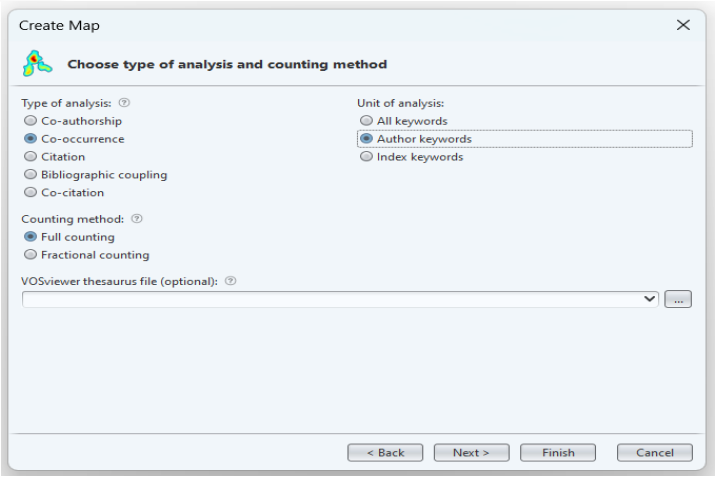

Figure 3. Phase 4 (Choose Type of Analysis and Counting Method)

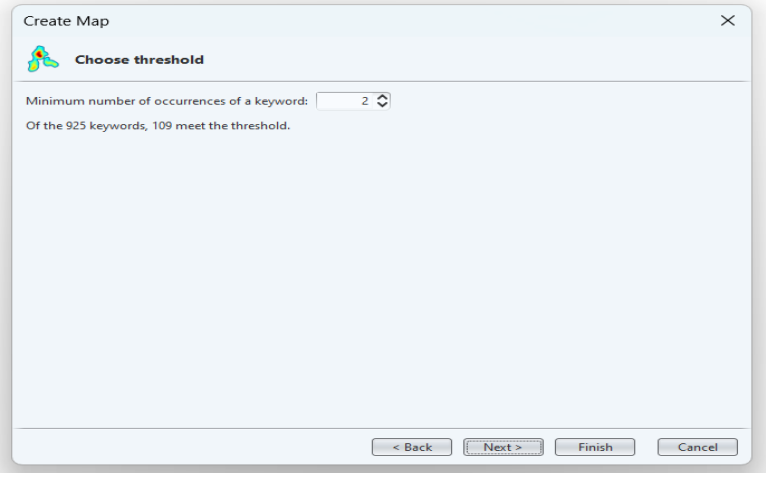

Figure 4. Phase 5 (Choose Threshold)

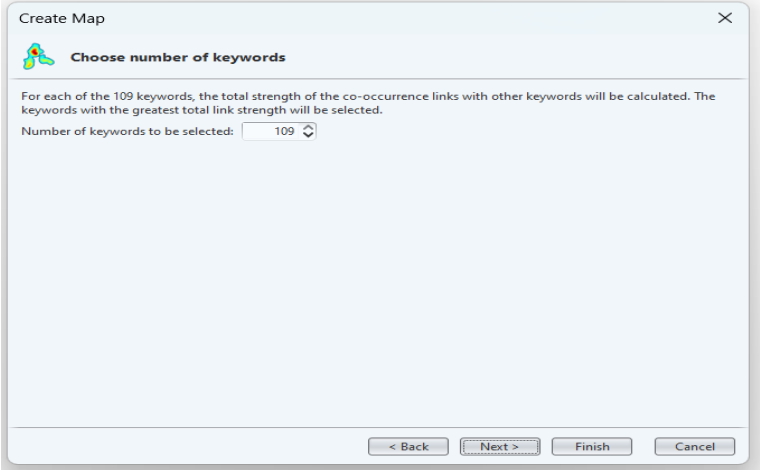

Figure 5. Phase 6 (Choose Number of Keywords)

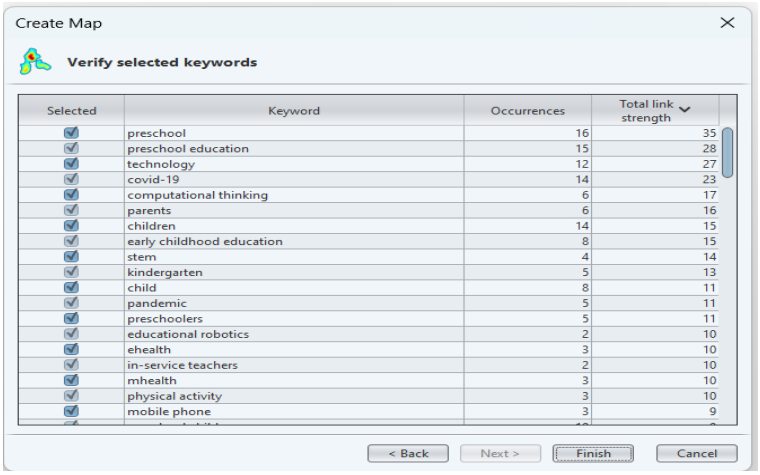

Figure 6. Phase 7 (Verify Selected Keywords)

RESULTS AND DISCUSSION

Data Collection Results from the Scopus Database

Researchers identified (*n*=264) relevant publications by conducting a targeted search in the Scopus database using the keywords 'technological' and 'preschool' for years 2020-2024. Table 1 below summarises the details of these publications.

Table 1. Summary for Scopus Database Search

No.	Type of Publication	%	Language	%	Open Access	%
1.	Article	80.68	English	89.39	Open	61.36
2.	Book Chapter	1.89	German	0.38	Non	38.64
3.	Conference Paper	6.82	Italian	0.38		
4.	Note	0.76	Portuguese	0.38		
5.	Review Paper	9.09	Russian	4.17		
6.	Conference Review	0.76	Slovenian	0.38		
7.			Spanish	4.92		

For the type of publication, researchers managed to note that the article-type publication was the most published in the span of 5 years. A total of (*n*=213) articles from all publications were successfully published. In addition, the fewest publication types published are note-type publications and conference review publications where both of them were published just only (*n*=2) publications respectively. Based on additional research completed by the researchers, many researchers publish article-type publications since most universities require students, especially postgraduate students, to publish at least one article to fill up their studies' requirements. This led to the Scopus database getting a significant volume of article submissions. In addition, in line with examining the publications published by language, English recorded the largest percentage where there were (*n*=236) publications published. Interestingly, language becomes an important part of attracting readers to read any publication. Factually, English is the principal international language and is used by many countries globally. Therefore, many publishers including the ones from the Scopus database received numerous manuscripts written in English and it causes the number of publications in English to be higher.

Next, analysing deeper about the comparison between Open and Non-Open Access, Open Access records a higher percentage where there were (*n*=162) publications successfully published. This happened since numerous researchers decided to publish in the Open Assess Journal due to various advantages such as short time or reviewing process and limitless accessibility for readers. Furthermore, the year trend for all publications has exhibited a substantial difference over the past five years. Researchers conducted a detailed examination of the publication trends depicted in Figure 2.0 to gain better clarity.

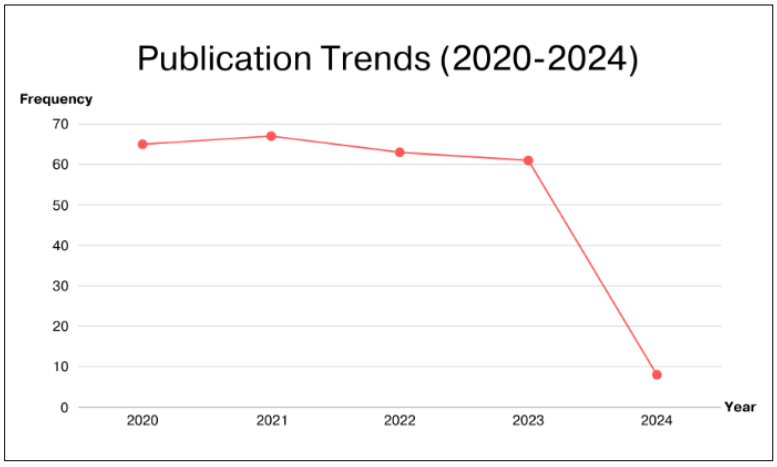

Figure 7. Publication Trends based on Year and Frequency

In 2020, there were (*n*=65) publications or 24.62% that have been published based on this Scopus database search. In 2021, there were (*n*=67) publications published, accounting for approximately 25.38%. In 2022, the number of publications was as many as (*n*=61) publications which is comparable to 23.86%. And in 2023, the number of successful publications published was (*n*=61) or 23.10%. In 2024, the number of publications was (*n*=8) or 3.03%. To examine more thoroughly, between 2020 and 2023, there is no substantial difference in terms of publishing frequency. But in 2021, it recorded the highest percentage among all four years. Based on past research conducted by searching various databases, they also demonstrated that in 2021, numerous researchers produced publications on the use of technology in early childhood education settings. This is because, in that year, the use of technology became the dominant option when many schools were closed because of COVID-19. On the other hand, in 2024, the number of publications is the least. Researchers are unable to estimate an early presumption because this biometric analysis was done in March 2024. Most likely, the number of publications is going to rise because there are 3 more quarters of this year's total.

Data Collection Results from the VOSviewer

The data obtained yielded the following findings. Researchers identified 98 terminologies in 12 clusters. This highlights a potential gap for further research. Figure 8 below shows multiple connected lines. Each spherical size carries its meaning. As the size of the sphere expands, it means that there has been extensive research using this terminology. In contrast, when the sphere decreases, the terminology is employed in less research. In addition, Figure 8 shows that the terminologies of 'preschool', 'children', 'technology', 'covid-19', and 'preschool children' have the biggest sphere sizes if compared to any other terminologies. This signifies that each sphere's nomenclature has been widely used in diverse publications. For example, the terminology of 'preschool' has 22 relationships to other terminologies, including 'ict' and 'technology'. Aside from that, the terminology of 'technology' has 21 relationships to other terminology, and one of the relationships is tied to the terminology of 'computational thinking'. Furthermore, 'covid-19' appears to be one of the significant terminologies. It has 17 relationships with other terminologies, including 'china', 'distance learning', and 'remote working'. Previous studies have shown that the use of technology is significantly related to the COVID-19 outbreak, and this has resulted in numerous new discoveries about the use of technology in China for early childhood learning (Hong et al., 2021; Su & Deng, 2023;

Wu et al., 2023). Furthermore, educators from numerous nations have experienced teaching online, and students are studying from home through technology.

Nevertheless, looking deeply, some gaps can be concluded by researchers through this network visualization analysis. Among the terminology that has the smallest sphere size are 'neurosurgery', 'pediatric', 'technological pedagogical content knowledge', and 'educational technology'. Plus, according to the analysis conducted, only two relationships occur for each item. In addition, the relationship distance between these terminologies is also very out of reach and noticeable with the terminology of 'technology'. This can be summed up that these terminologies have been very little studied by past researchers and need to be implemented for future studies.

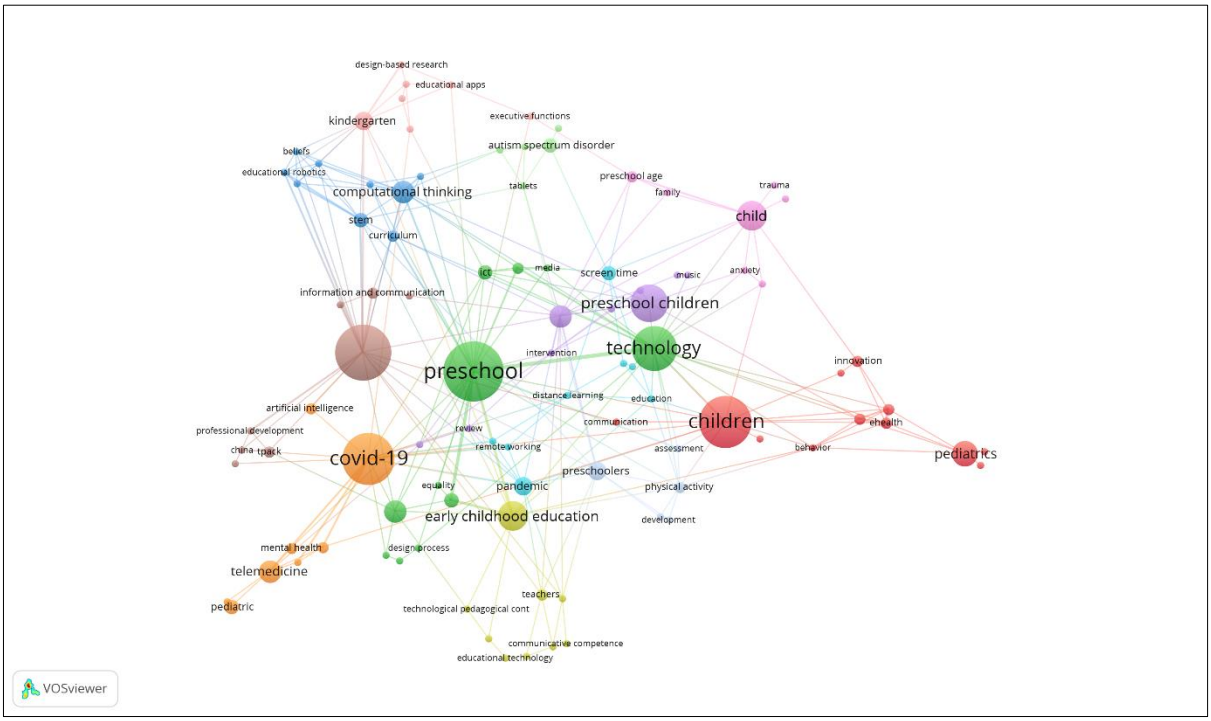

Figure 8. Network Visualization

As a result of the overlay visualization (see Figure 9), the development of the selection of terminology in the publications during the 5 years is significant. As proof, in 2020, the terminology of 'mobile phone' has been used and it has been closely related to 7 other terminologies including 'preschool children' and 'technology.' It has been shown that, in 2020, many researchers are doing research related to the use or application of mobile phones in preschool settings. In addition, 2021 recorded many studies conducted on the terminologies of 'preschool', 'technology', and 'children' within the scope of the application of technological tools. However, in 2024, there were no new terminologies recorded. Surprisingly, for the terminology 'educational technology', it is only stuck in 2021.

Researchers recommended that this terminology needs to be studied more deeply because the impact of using any technological tools in the environment of education is based on the education method itself. Thus, technological advances that are spreading globally have begun to invade the field of education. It is fast revolutionizing the way children learn, and as a result, technology is predicted to enhance the face of education by rendering it more economical and readily available (Qureshi et al., 2021).

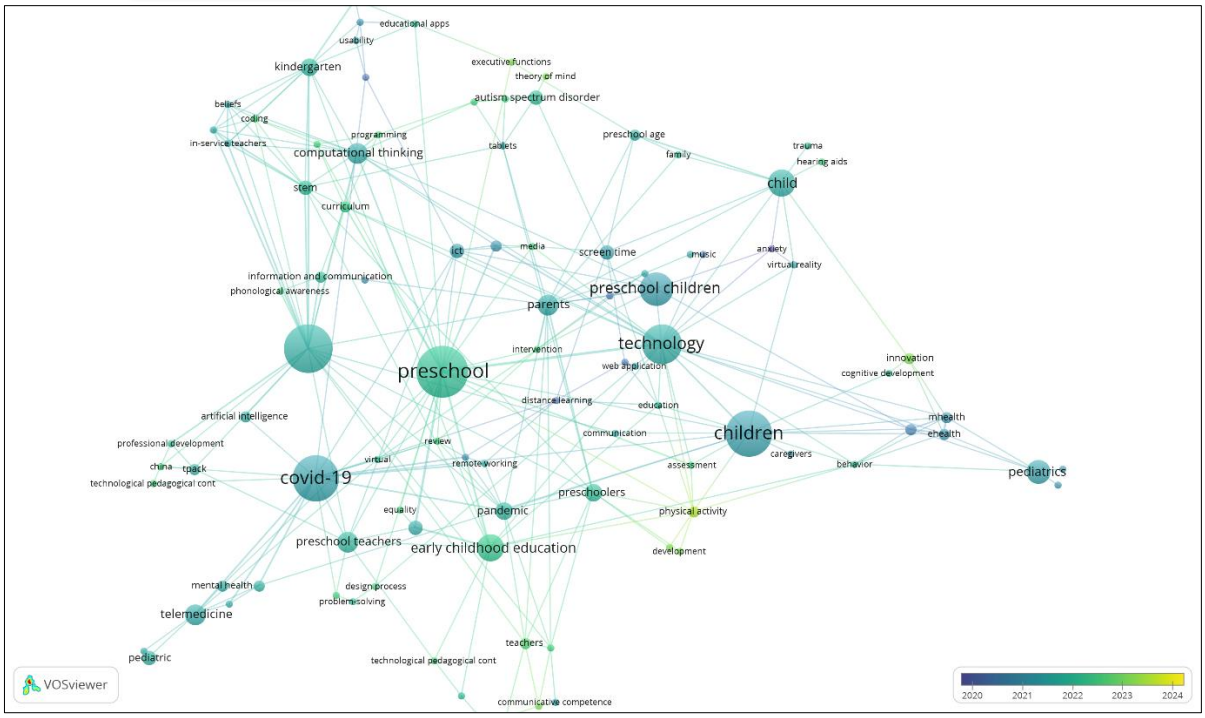

Figure 9. Overlay Visualization

Researchers did a study on bibliographic coupling analysis and document analysis unit based on the density visualisation analysis from Figure 10. The researchers followed the procedure depicted in Figure 7, although steps 4 to 7 were modified by the researchers. The reason why this analysis was done is to explore the overlap in the reference lists of publications by one author(s) with another author(s).

Through these findings, it has shown the publication from Liverpool et al. (2020), has become the most cited publication with 130 citations. In addition, this publication also has a positive relationship with six author(s) within the scope of this analysis. Through further exploration, his study titled 'Engaging Children and Young People in Digital Mental Health Interventions: Systematic Review of Modes of Delivery, Facilitators, and Barriers' is one of the most interesting studies to be discussed in depth. The findings of this study also reveal that out of 71 interventions, six modes of knowledge delivery can be done, namely (1) websites, (2) games and computer-assisted programs, (3) apps, (4) robots and digital devices, (5) virtual reality, and (6) mobile text messaging.

In addition, the publication with the highest citation is a study conducted by Wong et al. (2020). A total of 30 citations were recorded and it had a significant relationship with the publication of 10 other author(s). Through a personal analysis of 'Parent Technology Use, Parent–Child Interaction, Child Screen Time, and Child Psychosocial Problems among Disadvantaged Families', it is determined to be an interesting study to read because it has summarized that increasing use of digital technology by parents was linked to decreased relationships between parents and children, as well as more screen time and psychological challenges in disadvantaged families. These findings indicate that restricting parents' use of electronic devices in the presence of their young children may have a positive impact on childhood psychosocial development.

Figure 10. Density Visualization

The researchers recommend future studies focus on investigating the correlation between computational thinking and children's interactions with robots in a more rigorous manner. This is because, through the study of Bakal et al. (2020) titled 'Exploring the Ecology of Child-Robot Interactions in The Development of Computational Thinking', no citations were registered. Although, it is notable that it has ties with articles from other studies. This suggests that both variables of computational thinking and child-robot interaction are very significant for children's growth in education. This is supported by the study of Gerosa et al., (2022) where task engagement plays a significant role in children's learning and our robotic intervention successfully promotes computational thinking for children participating. In summary, based on the researchers' bibliometric study, there are five major areas that need to be explored and focused on in the future to understand the influence of technology management in various situations, as indicated in Table 2. below:

Table 2. Future Potential to be Investigated in Future Studies

No.	Name of Terminology	Dependent Variable
1	Websites	
2	Games And Computer-Assisted Programs	
3	Apps	Preschool Children
4	Robots And Digital Devices	
5	Virtual Reality	

METHODOLOGY

According to the hot topics identified by bibliographic maps, we further implemented meta-analysis to comprehensively review whether these variables have the potential to influence children's development which is discussed in detail through the above research question. The current review focused on how technological tools affect children's learning outcomes, so the meta-analysis is most suitable for quantifying and retrieving the previous research findings. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) (see Figure 11) provided a reporting guideline for our current meta-analysis.

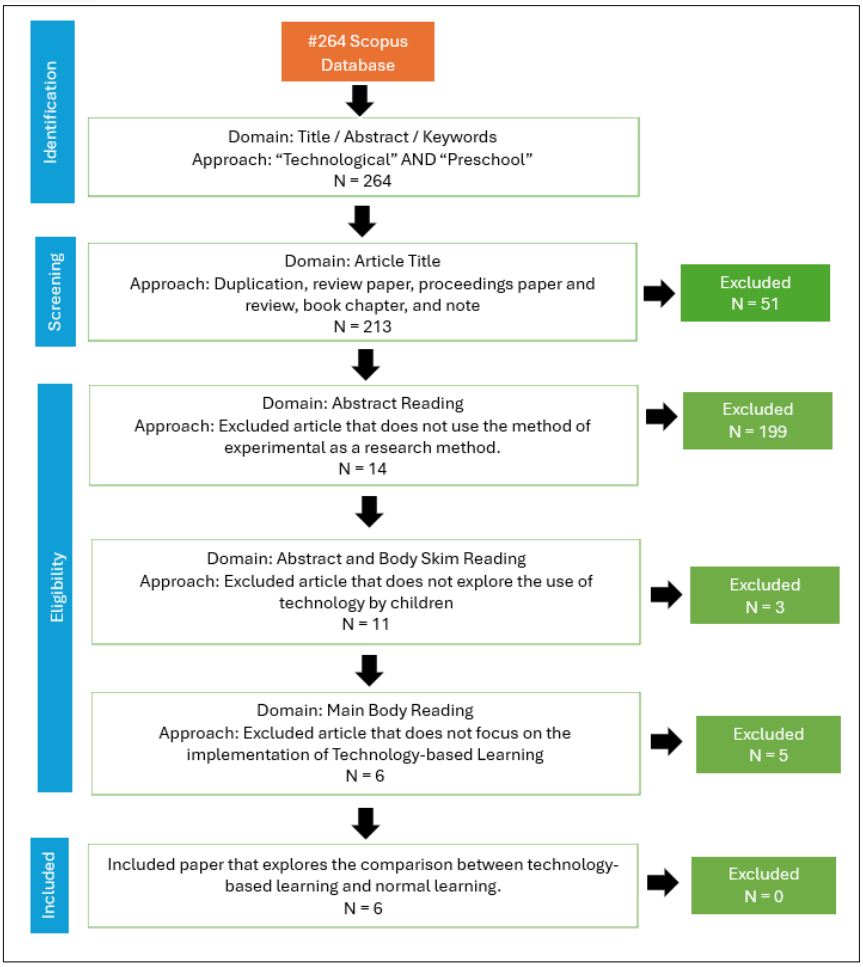

Figure 11. A Flowchart based on PRISMA Method

Table 3. Inclusion and Exclusion Criteria were Applied in the Performed SLR Methodology

Inclusion	Exclusion
Written in English	Written in any other language
Documents that address specifically technology use in preschool	Documents not relevant for research
Documents publication year after 2020	Documents publication year before 2020

There are four steps done by the researchers in performing this meta-analysis. The steps are identification, screening, finding eligibility, and making the final selection of publications that will be selected for the analysis process (Díaz Caselles & Guevera, 2024; Kabir et al., 2023; Peimani et al., 2020). Before beginning the SLR process, researchers ought to emphasise the inclusion and exclusion criteria (see Table 1) in order to confirm that the selected articles can address the study objectives. For the first step, which is to make identification, the researchers only use one database, namely Scopus. According to Bramer et al. (2017), an SLR study can employ a single database, however it is advised to use numerous databases.

The researchers' major goal is to use the Scopus database exclusively because it has a variety of high-quality papers from various journals. Some scholars have determined that searching only one database is sufficient because examining additional databases has no effect on the conclusion (van Enst et al., 2014; Rice et al., 2016). For the

search process carried out, the researchers have made the same process when conducting a search for bibliometric analysis (see Figure 1). In addition, for the second step, which is screening, the researchers have explored the titles of the publications first. The result is that there are 51 publications that are included in the group that will be issued such as duplication of publications, review publication, proceedings publication and review, note, and book chapter. Once this process is complete, it has gone through the third step, which is to check eligibility. This process is done to ensure that the selected publications are interrelated to explore the development of children's learning through the use of technological tools.

After making an abstract and body skim reading, the researchers determined there are 199 publications that fail to meet the specified criteria which is an empirical study that conducts experimental research method. The researchers specifically consider studies that focus on studying two distinct instructional methods to compare the conclusions depending on those circumstances. The researchers reviewed 14 publications that utilized the 'experimental' research approach in detail by doing a thorough main body reading of each publication. In total, it was revealed that only 11 publications did research about the use of technology by children. Unsparingly, there are three fascinating publications that may be included but due to the limits of obtaining those publications, the researchers need to designate them as an exclusion group of criteria. Next, for the next publication selection criteria, the researchers determined that only journals that perform studies in schools are designated as an inclusion group. Studies that looked at the effects of using technology equipment at home, hospital, or other places were not used as a sample in this meta-analysis. Only 6 publications were selected, with 3 being quasi-experimental studies and the other 3 being real experimental research.

Researchers establish this criterion to effectively address research question 1. A quasi-experimental design aims to establish a causal relationship between an independent and dependent variable, similar to an actual experiment. A quasi-experiment does not rely on random assignment, unlike a true experiment. Groups of participants are created based on certain criteria, not randomly (Miller et al., 2020). After carefully evaluating the publications, only 5 publications were found to meet the qualifying requirements, while two publications were omitted from the meta-analysis. The researchers will evaluate two distinct outcomes utilizing OpenMee software to explore the final results of 3 quasi-experimental investigations in the next data analysis procedure. The researchers utilized ATLAS.ti software to identify various themes related to comparing learning outcomes between Technology-Based Learning and traditional study techniques.

RESULTS AND DISCUSSION

The findings of the study of the data listed from 3 articles that utilized quasi-experimental methods were calculated for effect size values to see the effect of utilizing pedagogical methods, then categorized into groups of large effect, medium effect, and small effect. The calculation and grouping data are shown in Table 2 as follows:

Table 4. Effect Size Grouping Data Based on Category

Code Publication	Author/Year	Effect Size	Category
S1	Yalcin (2022)	0.247	Small Effect
S2	Panesi & Ferlino (2023)	0.738	Large Effect
S3	Emen-Perlatan et al., (2023)	0.624	Large Effect

The grouping of the effect size calculation results, namely large effect and small effect groups, refers to criteria (Kadir, 2017). From the table above, the reviewers found no effects in the small category. The results of the analysis revealed that the overall average effect size of the learning model used in quasi-experimental research reached more than 0. Two publications, namely S2 and S3, recorded a large effect category, while the S1 publication recorded a small effect category. It can be concluded that learning using the learning model in the experimental class as a whole has a big influence on improving the development of preschool children.

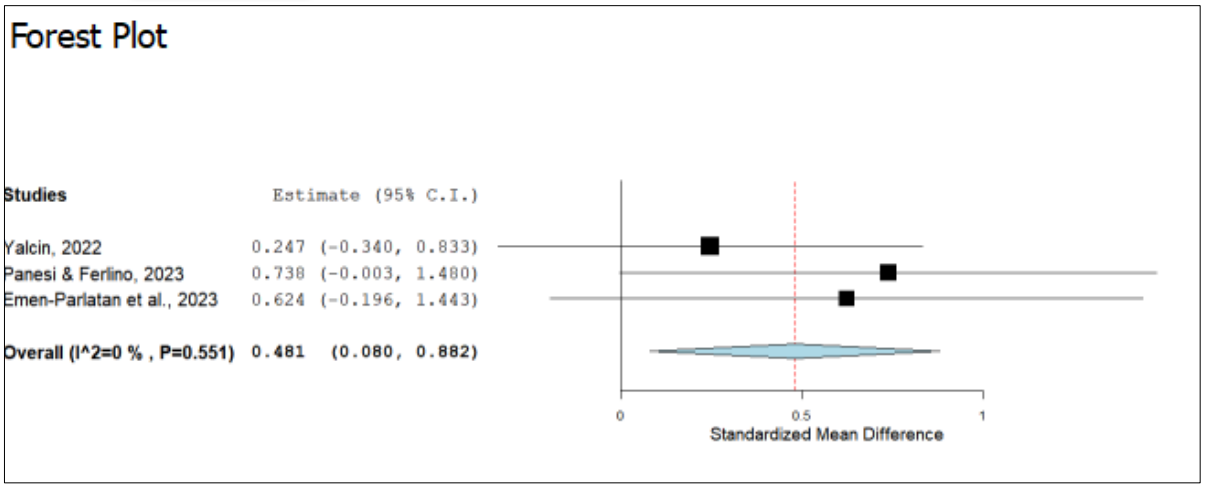

Figure 12. Overall Effect (Black Plot is the Effect Size of Each Study; The Yellow Plot is the Average Effect Size of Each Subgroup; The Blue Plot is the Overall Average Effect Size)

Figure 12 shows that the entire effect size of using learning models based on technological tools is on the positive side. It can be concluded that the use of Technology-based Learning implemented in preschool settings shows that the experimental class has higher learning outcomes than the control class. If the plot is further to the right, the greater the influence of the use of technological tools.

Table 5. Overall Model Results

Estimate	Lower Bound	Upper Bound	Std. Error	P-Var
0.481	0.080	0.882	0.205	0.019

From Table 3 above, researchers can see that the estimate is the overall average effect size of 0.080. The overall lower limit is 0.882, the overall upper limit is 0.992, and the overall standard deviation error is 0.205, and the p-var is = 0.019 which can be said that the overall impact of using technological tools in preschool settings is effectively implemented because of the p-var value is smaller than 0.05.

Table 6. Overall Heterogeneity

tau^2	Q (df=3)	Het. P-Value	I^2
0.000	1.194	0.551	0

Table 4 shows that t Heterogeneity < 0.001, which means it is significant, proving the Q statistic from 30 diverse studies with relatively high diversity reaching 0%. This percentage does not mean that the use of technological tools hurts the care group. However, aaccording to Linden and Hönekopp (2021), if the same population effect size is investigated, heterogeneity will be zero. Even in this case, the sampling error will create differences in observed effects across studies. Zero heterogeneity is inferred when these observed differences do not exceed the level expected as a result of the sampling error. Consider the effectiveness of using games-based application learning as an example. If heterogeneity was zero, the effectiveness of this method would be the same across all studies, regardless of the issue children present with. Apart from that, discussing the best method for improving children's development through learning using technological tools by comparing three post exam scores for each publication, he shows different size effects for each group.

Table 7. Effect Size Grouping Data Based on Sub-Group

Code Publication	Sub-Group (Experimental Group)	Effect Size	Category
S1	Information, media and technology skills based on STEM activity	0.247	Small Effect
S2	Memorise skills based on game-based apps	0.738	Large Effect
S3	Basic robotic coding skills based on educational learning	0.624	Large Effect

Based on Table 5, it shows that all three learning methods are positive for children. However, the highest effect was recorded by the game-based app learning method in improving memory skills where the effect size value was 0.738 percent and it exceeded 0.11d from the media method for improving basic robotic coding skills. This evidence also shows that learning through STEM activities to improve children's information, media and technology skills has a slightly positive impact on children. To see these differences, Figure 13 illustrates the gap between the three methods.

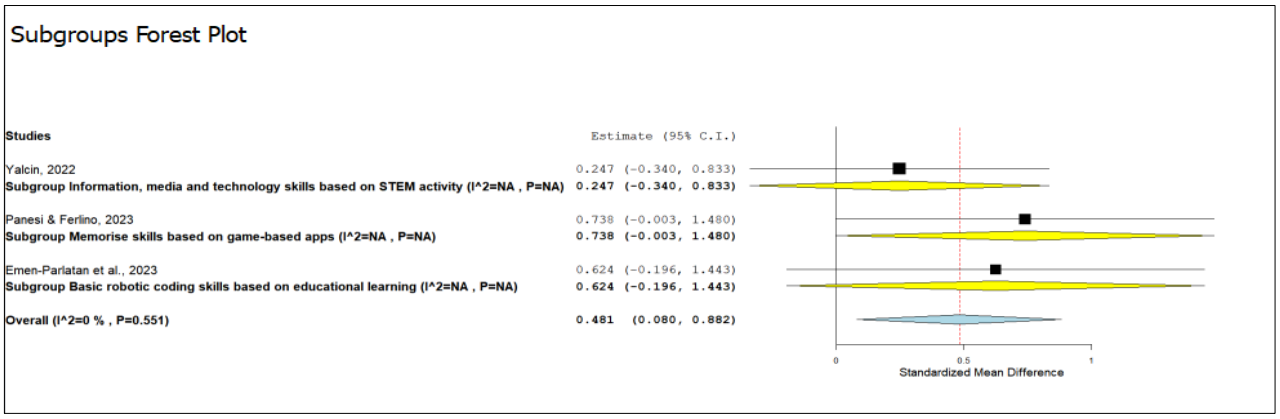

Figure 13. Effect Based on Learning Method (Black Plot is the Effect Size of Each Study; The Yellow Plot is the Average Effect Size of Each Subgroup; The Blue Plot is the Overall Average Effect Size)

After the researcher analysed the 3 quasi-experimental studies using the meta-analysis method, the researcher used another software, ATLAS.ti, to see the importance of using technology tools in preschool settings. Through the systematic review carried out (see Figure 11), six publications were selected. The information on each publication can be seen below:

Table 8. The Publications Included in Thematic Analysis

Code Publication	Author/Year	Journal	Country
S1	Yalcin (2022)	Science & Education	Turkey
S2	Panesi & Ferlino (2023)	International Journal of Information and Education Technology	Italy
S3	Emen-Perlatan et al., (2023)	The Journal of Educational Research	Turkey
S4	Veraksa et al., (2023)	Moscow University Psychology Bulletin	Russia
S5	Alamiri et al., (2020	Indian Journal of Forensic Medicine & Toxicology	Iraq
S6	Desai et al., (2021	Revista Paulista de Pediatria	India

The thematic method is used to identify and interpret patterns or themes in a data set, as it often leads to new insights and understanding (Boyatzis, 1998; Elliott, 2018). After 6 publications were analysed using the thematic method, researchers found 6 themes (see Figure 14) regarding the importance of using technology tools for preschool children. The first theme successfully recorded is the improvement of health. The use of applications in preschool can improve the health and well-being of children. Samples from publications S5 and S6 explain that learning applications can help children improve their healthcare. This can be supported by the study of Lee et al., (2024) where they explain that the use of applications can support the development of children facing chronic diseases. On the other hand, Francis et al., (2020) found that the positive effect on learners from using the health application can influence their peers in using the same application. In addition, the second theme that was successfully recorded is active cooperation in learning. Furthermore, the publication S2 has revealed that Digital-Analogical Intervention can create active cooperation in learning. This finding explains that children who participate in this intervention will show better social integration development than children who participate in regular classes. This can be proven by the findings of Dobra (2014) where a combination of digital methods and analogical aspects of communication with application can improve children's communication skills.

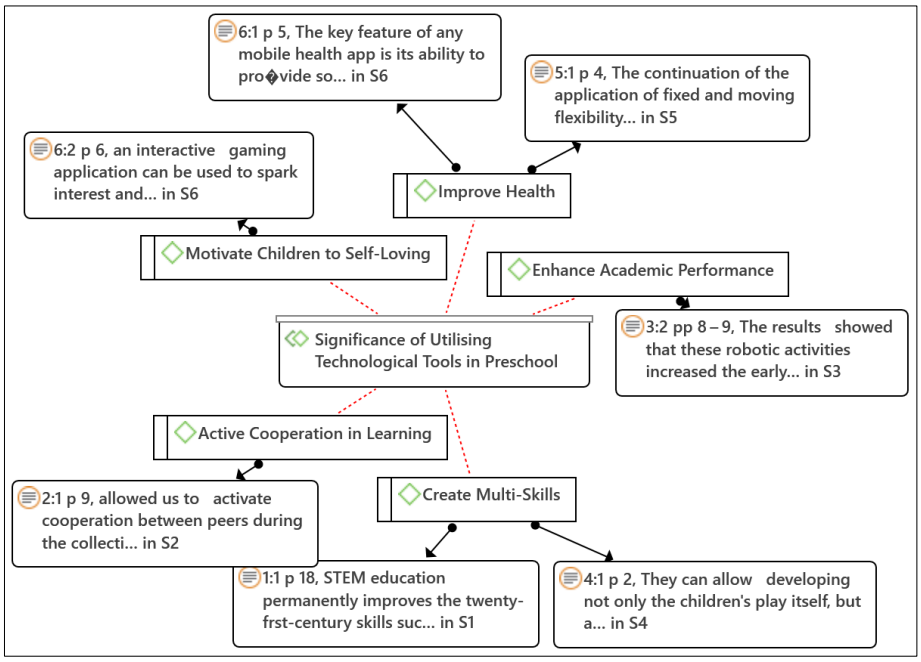

Figure 14. Theme of the Importance of Technology Use from ATLAS.Ti Analysis

In addition, through the findings of publication S3, authors have revealed that coding activities can improve the problem-solving skills of children, helping them to achieve success in their academics. This is supported by a study conducted by Papadakis (2021) which explained that children who carry out this activity can solve problems through their computational thinking and fluency. Interestingly, through the effect of these two abilities, then it can be considered a general problem-solving framework involving knowledge, skills, or solving problems approaches and coding to support these concepts and tasks (Bers, 2019; Rose, 2019). Next, the fifth and sixth themes that were successfully recorded were motivation to self-love and create multi-skills respectively. Publication S6 has explained that game applications about self-care can increase children's motivation to cultivate self-love. Interestingly, Baars' (2022) study has demonstrated that the utilization of mobile applications bolstered children's self-assurance in facilitating self-regulated learning procedures. At the same time, publication S1 has revealed that learning to use technology tools can improve children's multi-skills. This implies that incorporating technology resources, oral presentations, and group participation in classroom tasks can make learning more dynamic and engaging (Haleem et al., 2022). Additionally, it promotes participation that goes beyond verbal communication (Bilotta et al., 2021).

Next, when explaining the gaps in this study, researchers focus on empirical gaps since the selected publications have all revealed best practices and limitations from empirical studies. Three themes were successfully recorded (see Figure 16) by the researchers. For the first theme, which is family involvement, the sample from publication S3 revealed that this study only focused on children doing coding studies in class. The researchers argue that the technological tools-based learning such as coding activities should also be implemented at school and families should play a joint role in navigating children's interest in this activity while at home. It is even more interesting when the study conducted by Stephen et al., (2013) revealed that technology-based learning activities are not able to develop children but sociocultural roles such as parents are mediators for children's engagement with the activity.

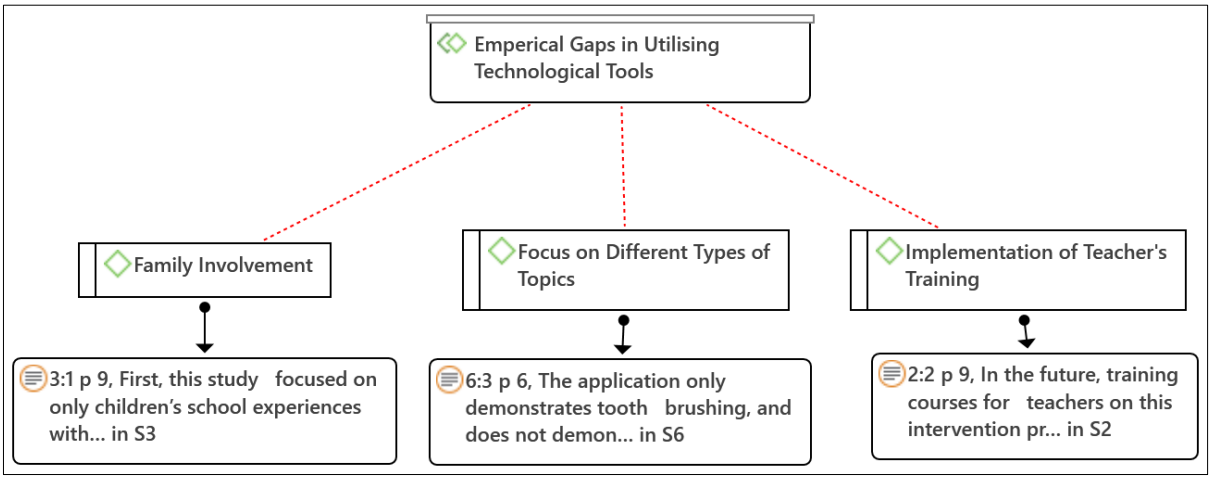

Figure 15. Empirical Gaps based on ATLAS.ti Analysis

In addition, the second theme that can be identified is to focus on different topics. A sample from the S6 publication explains that the second gap that can be identified is the use of technological equipment only focus on one topic and not interrelated with deeper and successive topics. Mupa and Chinooneka (2015) in their study explained that a learning and facilitation session did not succeed in achieving its objectives due to educators not giving extra lessons to children. In the context of the study from the S6 publication, the use of learning applications and health topics is very good. However, it is not open because children are only asked to learn one topic only. It would be better if they were given more exploration on the topic. Last but not least, the third theme that can be recorded is providing training to educators. Through the research revealed in the S2 publication, although technology-assisted activities are successfully implemented and give positive outcomes to children, the problem highlighted by the authors of the publication is the issue faced by the educator himself on how to use the technology equipment. This can be attributed to several issues, one of which is the insufficient professional development of instructors in effectively employing technology tools (Hyndman, 2018). Educators should take an active role in their training rather than just passively receiving it. Their dedication to learning is crucial for professional development and the advancement of education (Montero-Mesa et al., 2023).

IMPLICATION

Based on the topic that has been discussed, the researchers have determined that the outcomes of this study will have a good impact on empowering early childhood education policy in Malaysia from a global perspective. The supporting evidence demonstrates expanding the usage of ICT equipment at the preschool level allows children to absorb knowledge more freely through global learning and encourages them to be more successful. This can be reinforced by the circular issued by the MoE in 2024 namely 'Initiative A10: Enhancing ICT Competence and ICT Capability to Strengthen ICT' where it is claimed to be capable of fostering an intellectual literacy culture within schools (MoE, 2024). From the standpoint of a developed nation such as the United States, the incorporation of ICT

and the use of technological equipment has undergone a remarkable transformation during a span of 15 years. A study conducted by Patrick (2008) provides evidence that the emphasis on information and communication technology (ICT) in North American schools is transitioning from electronic devices to processes. Infrastructures equipped with accessible computing, wireless, high-speed connections, and digital platforms, such as educational management systems, enable greater accessibility and adaptability. These infrastructures are essential for driving a new education delivery system that relies on online learning. This elucidates the escalating impact of technology utilisation in educational institutions.

Furthermore, the research conducted by Tay et al. (2021) demonstrated that the implementation of ICT in the early childhood education system in Singapore has a beneficial effect on children's academic progress. Technology, as one of the educational tools, enhances children's learning and knowledge acquisition. Parents are concerned about the ICT use policy in the early years since it leads to a large imbalance in the period pre-schoolers spend using technology and electronic content for entertainment compared to learning. A recent study has found that excessive use of technology screens can have detrimental impacts on children, including an increased risk of obesity, physical harm, and sleep disorders (Srinahyanti et al., 2018). Furthermore, a paper edited by Cordes and Miller (2000) asserts that the use of technological devices, such as computers, at early stages can have detrimental effects on preschool children in terms of their physical, psychological, social, cognitive and moral development. Hence, the school must establish a comprehensive system for overseeing and regulating ICT usage, ensuring that youngsters utilise it solely for educational pursuits. One straightforward initiative is for schools to allocate resources towards organising awareness consultations for parents. These sessions would focus on educating parents about their children's use of technology, the advantages and threats of technology, and strategies for incorporating ICT into educational environments (Cordes & Miller, 2000).

CONCLUSION

In terms of major findings, the current review is committed to implementing a bibliographic study of technological management trends in preschool education and how the best practices recorded can reveal the significance and gaps of the management of technological tools in the classroom through meta-analysis. According to the bibliographic networks of keywords occurrence and bibliographic coupling analysis, we can summarize that the environment of preschool, the role of children, and the provision of experience by technology as three key variables that significantly impact children’s development. At the same time, through the meta-analysis that we have conducted, we can summarize that the management of technological tools in terms of education purposes can signify the quality of education.

We would inevitably ignore some publications due to the limited availability of resources. Although we tried various terms on Scopus, a database with high reliability and extensive resources, to obtain as many documents as possible, we do not ensure an exhaustive retrieve in the field. Another important influencing factor lies in a biased selection of publications concerning the language. Most publications in our current review were written in English, although we conducted a complementary search by examining the references of selected articles. Admittedly, the limited impact of the experimental research method can be attributed to the small sample size from constraints imposed by empirical evidence. The lack of empirical evidence may prevent us from doing meta-analyses on the relevance and gaps of crucial modifiers in the relationship between Technology-based Learning and individual learning.

Through the discrepancies, we recommend that the impact of technological tools closer toward children is not necessarily focused on education settings only, but it should be covered in the broader atmosphere such as the involvement of family in navigating children’s roles when learning with the technological tools. Moreover, further research is proposed if there are some treatments for teachers to increase their professional advancements in terms of managing ICT at the pre-school level so that they can alter their facilitating sessions in a larger range. As a consequence, it can break their usual in classrooms and acclimatise their education towards 21st-century learning while the policies established across the country to enable ICT can be improved over time.

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