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The ”besTech” Technology Practice Framework for Early Childhood Education

Dr. Safia Malallah, Kansas State University

Safia Malallah is a postdoc in the computer science department at Kansas State University working with Vision and Data science projects. She has ten years of experience as a computer analyst and graphic designer. Besides, she’s passionate about developing curriculums for teaching coding, data science, AI, and engineering to young children by modeling playground environments. She tries to expand her experience by facilitating and volunteering for many STEM workshops

Joshua Levi Weese, Kansas State University

Dr. Josh Weese is a Teaching Assistant Professor at Kansas State University in the department of Computer Science. Dr. Weese joined K-State as faculty in the Fall of 2017. He has expertise in data science, software engineering, web technologies, computer science education research, and primary and secondary outreach programs. Dr. Weese has been a highly active member in advocating for computer science education in Kansas including PK-12 model standards in 2019 with an implementation guide the following year. Work on CS teacher endorsement standards are also being developed. Dr. Weese has developed, organized and led activities for several outreach programs for K-12 impacting well more than 4,000 students.

Mr. Khaled Nasser Alsalmi, The Public Authority for Applied Education and Training

Computer instructor level ’A’ .

The besTech Framework for Early Childhood Education

Safia A. Malallah, Kansas State University, safia@ksu.edu
Joshua Levi Weese, Kansas State University, weeser@ksu.edu
Khaled Nasser Alsalmi, Kansas State University, alsuelmi@ksu.edu

Abstract: Effective development of children's computational thinking (CT) skills necessitates their exposure to experiences that require the application of CT to build technological solutions. However, the integration of technology into early childhood education is often challenging due to concerns about potential harm to young children. This paper presents a best-practices technology framework constructed from the contributions of early childhood professional organizations and experts. The framework consists of nine elements (Child, Pedagogy, Context, Content, Facilitators, Environment, Evaluation, Tools & Innovations, and Screen Time) that must be understood in the context of technology usage to intentionally extend and complement early childhood learning while minimizing its harm. In addition, the paper proposes a holistic view of technological classification, age groups around technology usage, and input-device literacy.

Introduction

The development of computational thinking (CT) skills is essential to prepare students for their future professions [1], but mastering these skills requires extensive practice and, unfortunately, current CT applications are inadequate [2]. Therefore, efficient development of CT skills must start early with unplugged and age-appropriate technology [3]. However, the concerns of many early childhood educators regarding children’s technology usage [4] often impedes CT integration [5]. Additionally, educators may lack the necessary knowledge to use technology efficiently in the classroom due to the absence of mandatory courses in some college programs [4]. Educators often rely on previous screen usage studies and incorrect practices, which can have negative effects [6]. However, a complete ban on technology use is not a viable option, given the growing dependency on technology in everyday life [7, 8]. Therefore, technology should be intentionally and appropriately utilized to improve children’s CT skills, while being mindful of its potential negative aspects. Current technology resources also must be improved, and increased collaboration between technologists and educators is essential to assemble safe and effective technology practices.

To help educators use technology intentionally and ensure children develop essential technology literacy in a healthy environment, this paper presents a new besTech framework that was developed from best practices for technology inclusion based on more than 60 documents from early childhood proficiency and scientific experiments. This framework identifies nine key elements (Child, Pedagogy, Content, Context, Facilitators, Environment, Evaluation, Tools & Innovations, and Screen Time) within a holistic approach, including best practices for parents and educators according to early childhood experts and professional organizations. This paper also supports the increased literacy of input devices, a holistic view of technological classifications, and age groups with technology.

Method

Design

The research method for this paper is a combination of the conceptual framework approach [9] and the Colaizzi Analysis technique [10]. Figure 1. illustrates the research stages.

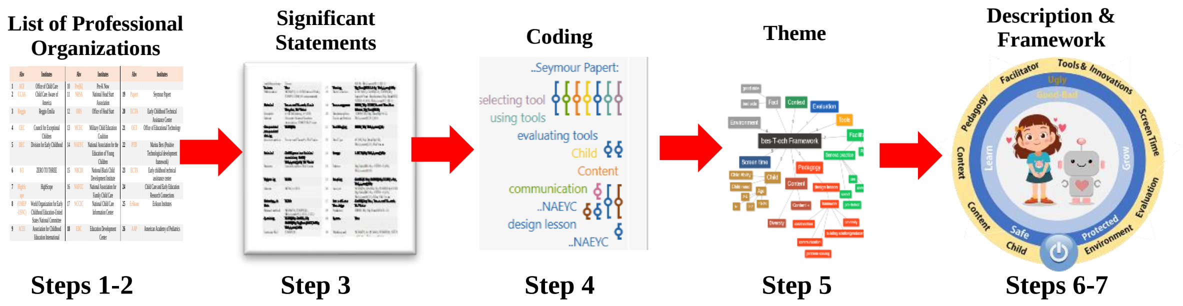


Figure 1. Design Steps for the besTech Framework

- **Step 1: Identify a List of Early Childhood Professional Organizations**. List development involved a search for notable professional early childhood institutes.
- **Step 2: Literature Review of Professional Organizations and Technology.** Using the developed list from step 1, this research created a pool of papers (literature review 1) from suggestions, recommendations, and conference statements related to technology in early childhood education.
- **Step 3: Significant Statements.** Each document in the pool was read and reread to obtain a general sense of the entire content, and then significant statements related to technology and early childhood were identified, extracted, and added to a Significant Statements file.
- **Step 4: Coding.** Segments of the Significant Statements file were highlighted by their purpose and labeled.
- **Step 5: Theme.** The labels were then clustered with a parent label (theme) according to their characteristics.
- **Step 6: Description.** An exhaustive description was created after reading the themes and codes to clarify the finding.
- **Step 7: Build the Framework.** Finally, a fundamental structure was produced by connecting the elements.

Keywords, Database, and Criteria

The search keywords in step 1 were “Early childhood” + “known||famous||distinguished” + “organization|| institutes|| Foundation||Center||Association.” In step 2, the list of early childhood organizations was used as keywords + “Technology.” Keywords in step 6 included all identified elements + “Early childhood || young children|| preschoolers|| toddlers ||infant ||kindergarten.” A second round investigated the pool of references using Google and IEEE Xplore search engines as well as conference papers and proceedings, blogs, government and official websites, scholarly journals, and books. The results were filtered according to their abstracts, introductions, titles, or web pages and search boxes that did not match search criteria. Any study that did not include technology usage for early childhood was excluded.

Results

Table 1 summarizes the quantitative analysis results of this study. As shown in the table, step 1 identified 22 organizations that have collected statements and publications, yielding a pool of 63 documents after filtering. Further analysis generated 210 significant statements that were grouped into one document and then reviewed to identify the codes, resulting in a total of 403 repeated coded segments with 34 distinct segments. Nine themes were generated from the distinct codes, and a description was developed for each element in the theme. in addition to researching more information, if needed, create a pool of 210 documents to construct the framework. The MAXQDA tool was used for the analysis.

Table 1. Summary of the Quantitative Analysis of the Study

Step 1	Step2	Step 3	Step 4		Step 5	Step 6
Organizations	Documents	Significant Sentences	# Codes	Coded Segments	Theme	Description
22	63	210	34	403	9	210

List of Early Childhood Professional Organizations

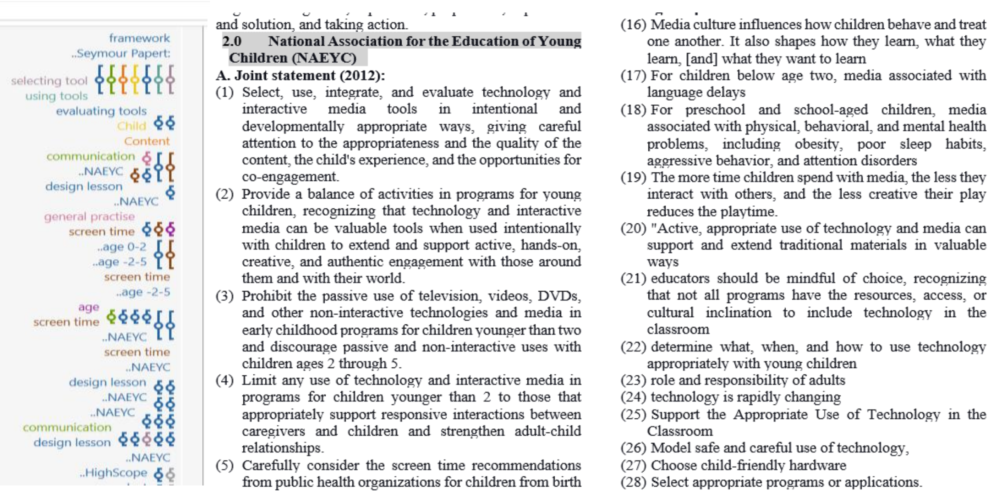
Table 2 lists 26 professional organizations identified from steps 1 and 2 in the framework development. The first 17 organizations were selected after exploring various resources until data saturation was reached. The remaining organizations were identified in the references of the published works and statements. Institute numbers 8, 12, 13, and 15 in the table were eliminated because they contained no statements related to early childhood and technology. The professional organization contributed 74 documents that were filtered to 63 documents.

Table 2. List of Early Childhood Professional Organizations

	Abv	Institutes		Abv	Institutes
1	ACF	Office of Child Care	14	NAEYC	National Association for the Education of Young Children
2	CCAA	Child Care Aware of America	15	NBCDI	National Black Child Development Institute
3	Reggio	Reggio Emilia	16	NAFCC	National Association for Family Child Care
4	CEC	Council for Exceptional Children	17	NCCIC	National Child Care Information Center
5	DEC	Division for Early Childhood	**18**	EDC	Education Development Center
6	0-3	ZERO TO THREE	**19**	Papert	Seymour Papert
7	HighScope	HighScope	**20**	ECTA	Early Childhood Technical Assistance Center
8	(OMEP-USNC)	World Organization for Early Childhood Education-United States National Committee	**21**	OET	Office of Educational Technology
9	ACEI	Association for Childhood Education International	**22**	PTD	Marina Bers (Positive Technological development framework)
10	Pre[K]	Pre-K Now	**23**	ECTA	Early childhood technical assistance center
11	NHSA	National Head Start Association	**24**		Child Care and Early Education Research Connections
12	OHS	Office of Head Start	**25**	Erikson	Erikson Institutes
13	MCEC	Military Child Education Coalition	**26**	AAP	American Academy of Pediatrics

Significant Statements

Figure 2 shows an example of significant statements in a document from the 210 significant statements generated from the pool. The statements were compiled into one document and labeled Significant Document (SD).



and solution, and taking action.

2.0 National Association for the Education of Young Children (NAEYC)

A. Joint statement (2012):

(1) Select, use, integrate, and evaluate technology and interactive media tools in intentional and developmentally appropriate ways, giving careful attention to the appropriateness and the quality of the content, the child's experience, and the opportunities for co-engagement.

(2) Provide a balance of activities in programs for young children, recognizing that technology and interactive media can be valuable tools when used intentionally with children to extend and support active, hands-on, creative, and authentic engagement with those around them and with their world.

(3) Prohibit the passive use of television, videos, DVDs, and other non-interactive technologies and media in early childhood programs for children younger than two and discourage passive and non-interactive uses with children ages 2 through 5.

(4) Limit any use of technology and interactive media in programs for children younger than 2 to those that appropriately support responsive interactions between caregivers and children and strengthen adult-child relationships.

(5) Carefully consider the screen time recommendations from public health organizations for children from birth

(16) Media culture influences how children behave and treat one another. It also shapes how they learn, what they learn, [and] what they want to learn

(17) For children below age two, media associated with language delays

(18) For preschool and school-aged children, media associated with physical, behavioral, and mental health problems, including obesity, poor sleep habits, aggressive behavior, and attention disorders

(19) The more time children spend with media, the less they interact with others, and the less creative their play reduces the playtime.

(20) "Active, appropriate use of technology and media can support and extend traditional materials in valuable ways

(21) educators should be mindful of choice, recognizing that not all programs have the resources, access, or cultural inclination to include technology in the classroom

(22) determine what, when, and how to use technology appropriately with young children

(23) role and responsibility of adults

(24) technology is rapidly changing

(25) Support the Appropriate Use of Technology in the Classroom

(26) Model safe and careful use of technology,

(27) Choose child-friendly hardware

(28) Select appropriate programs or applications.

Figure 2. Significant Statements and their Coding in MAXQDA

Coding

The right side of Table 3 presents the 34 unique codes from a total 403 code segments and the number of times code appeared in the significant document. The left side of Table 3 shows the number of codes identified for each organization as well as the top two repeated codes and the appearance counts.

Table 3. Descriptive Statistics of Coding

Design lesson	Framework	Creater not consumer	Roles and responsibilites	Diversity	Bad side	Evaluating tools
28	12	8	18	18	9	13
Age	**Age 18-24**	**Age -2-5**	**Age 0-2**	**Age 5+**	**General practise**	**Handling tools**
6	3	6	7	3	21	4
Problem solving	**Design**	**Creativity**	**Collaboration**	**Communication**	**Screen time**	**Controlling tools**
6	3	4	19	37	18	7
Context	**Content**	**Content +**	**Child**	**Child need**	**Child ability**	**Teacher**
3	18	4	4	1	3	31
Using and managing tools	**Selecting tool**	**Preselect**	**Building solutions**	**PD**	**Parent**	Total
23	27	8	7	9	15	403

Organization	**ECTA**	**DEC-NAYC**	**Emilia**	**0-3**	**Pre[K] Now**
Coded Segments	7	3	36	12	7
Top code 1	collaboration	good side	good side	content	good practice
Top code 2	good practice	environment	design	good practice	design
Organization	**CEC**	**CCAA**	**ACEI**	**ACF**	**PTD**
Coded Segments	33	4	2	11	12
Top code 1	design	content	assessment	assessment	design
Top code 2	good practice	context		content	
Organization	**CCE**	**OET**	**HighScope Extension**	**HighScope**	**NAEYC**
Coded Segments	7	33	36	21	53
Top code 1	PD	Good Side	design	general practice	general practice
Top code 2	Good Side	Facilitator	Facilitator	design	design
Organization	**NAFCC**	**AAP**	**Erikson**	**DEC**	**NHSA**
Coded Segments	15	25	6	13	17
Top code 1	time	Screen Time	Facilitator	Facilitator	content
Top code 2	context	Age	good practice	good practice	design
Organization	**EDC**	**Seymour**			
Coded Segments	47	3			
Top code 1	good practice	Problem solving			
Top code 2	design	design			

Themes

Figure 3 shows the branches generated from clustering and grouping 34 codes as nodes. The connections were analyzed to create a parent-child relationship based on the link strength and the number of times the code repeated, indicating the node's importance as a theme. The ***Child*** element, which is the primary concern of all stockholders, is addressed uniquely according to each organization, resulting in three sub-elements in the figure (i.e., child ages, abilities, and needs). The ***Facilitator*** node includes parents and teachers who are technology facilitators with their responsibilities, roles, professional development training, and general practice shown as sub-elements. The code for ***Screen Time*** was mentioned by all organizations, and screen time is directly associated with age, duration, content, and context. The value of the ***Environment*** node is significant, even being described as the “third teacher” [11], so it is included as a theme in the framework development. The ***Tool & Innovations*** is connected to all the other themes, while ***Pedagogy*** includes multiple sub-elements. A second analysis of ***Pedagogy*** removed the sub-elements of evaluation, context, and partial content, and then ***Context*** and ***Pedagogy*** were joined to redefine the theme description to include early childhood pedagogy using technology as a context. The Creativity, Building Solutions, Collaboration, and Communication sub-elements are part of Positive Technological Development (PTD)frameworks [12], so they are grouped under the framework label. ***Evaluation*** then became a theme since it is not related to pedagogy and can be included to support future tool selection. Similarly, ***Content*** overlaps with pedagogy and technology to describe content needed to teach children how to safely and correctly use the tools, which adds content + and literacy as their sub-nodes. The remaining sub-elements were joined or removed, such as those diverse as part of early childhood pedagogy, so it became part of the ***Pedagogy*** element. In addition, some of the Content+ sub-element is related to security and privacy threats, which educators should know before using technology, so they are considered another dimension over the framework. As shown in the figure, the Fact element has sub-elements of good side and bad side.

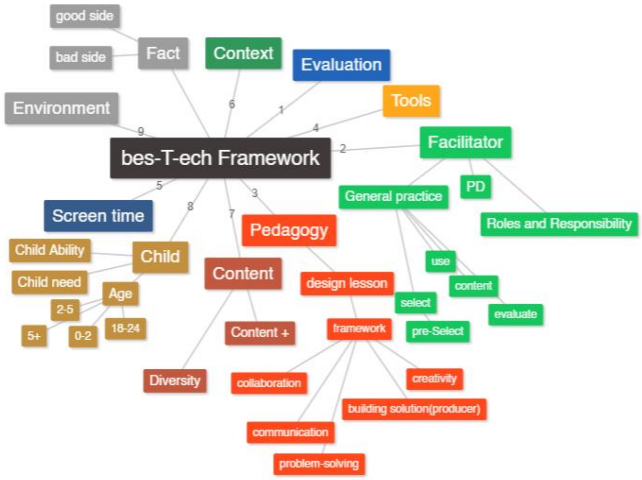


Figure 3. Generated Themes After Clustering Codes by Nature

Summary of Findings

Figure 4 illustrates the besTech framework. The uppercase "T" in the name refers to technology in STEM. As shown in the figure, the besTech framework consists of nine primary elements for technology integration in early childhood education.

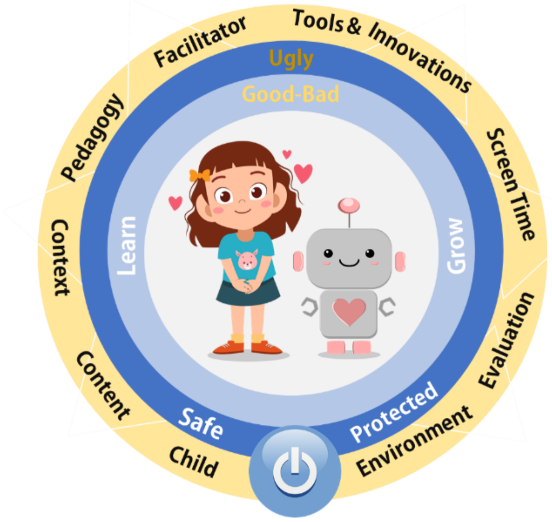


Figure 4a. The besTech Framework

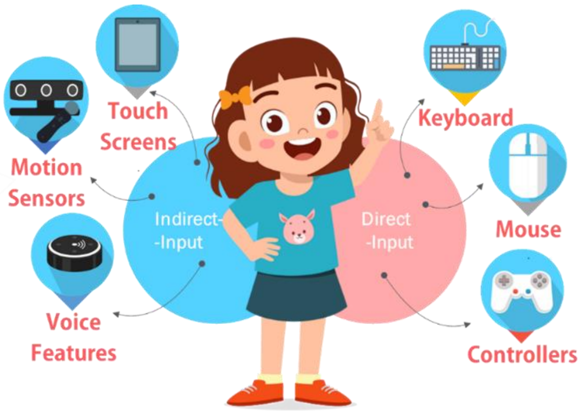


Figure 4b. The besTech Framework

Technology has become a vital and irreplaceable element, but implementing and enforcing best practices is essential to address the potential harm and create safe learning environments while maximizing the benefits of technology. The good side (Figure 3), or positive effect, of technology is that it can complement or extend learning and development for gifted [13–17], bilingual [14, 15] [18], special need [13], and normal students. Technology can also positively impact child development, including cognition [19] [20] [21–23] [24], language and speech [25] [13, 26, 27] [18, 28], visual [29, 30] [31], fine and gross motor [32–34] [35, 36], and social-emotional skills [37] [35, 38, 39] [40]. On the other hand, the bad side (Figure 3), or short-term or long-term harm, of technology can occur from unintentional misuse of technology. According to the National Association for the Education of Young Children (NAEYC), the primary negative effects of screen-based technology include disrupted sleep patterns, behavioral problems, focus issues, social and language delay, and attention [13]. Further negative effects can also occur from the intentional abuse of technology to harm others. Recent studies highlight increased occurrences of online predators, online fraud, cyberbullying, internet scams, identity theft, phishing, fraudulent advertising, and online bullying, making inexperienced children easy targets for harm from technology [41, 42] [43].

Framework Elements

The ***Child*** element (Figures 3 and 4a) encompasses the capabilities, developmental requirements, and unique generational characteristics of children. Educators must be aware of these characteristics as they seek to incorporate CT skills into lessons. Because literature on age stages for technology have provided inconsistent and unclear age ranges, this study established the following age intervals: Baby (0–17 months) [44–51], Toddler (18–35 months) [52] [47, 53–57], Preschooler (3–5 years) [58] [59] [60] [13] [13, 26], and School Age (6–11 years) [61–63] [64] [65] [66]. Research indicates that, although babies enjoy screens, they may need help understanding the content [46], while toddlers develop fundamental cognitive skills around 18 months and can comprehend content with characters who speak directly to the audience [52]. Studies have shown that preschoolers can apply what they see on a screen to real-life situations, and as they grow older, they become more proficient with technology, leading to increased technology-based benefits [59]. Similarly, if school-age children enjoy technology, research shows they are more likely to devote time to learning it, which can increase their technological skills and abilities [66].

Different types of technology require unique cognitive skills. For example, video games require a user to understand analogies and have applicable processing speed and deductive reasoning [67], while use of an online search engine requires recall memory, spelling, and Boolean logic [68]. Typing on a keyboard requires motor skills, visual skills, and cognitive ability [69], and communication via technology requires speech and language skills [24]. Fine motor skills are necessary to control technology [40], while gross motor skills and whole-body interaction can improve somatosensory experience [37]. Similarly, social-emotional skills are required for repeated trial-and-error activities that can cause frustration and failure, as well as for group work and reliable communication [70] [71].

Each child also belongs to a unique generation that carries distinguishable characteristics. The current generation, Generation Alpha, is the first global generation aware of worldwide events and trends due to the prevalent use of technology. Children of this generation are considered “digital natives” and readily use technology to solve problems. According to the research, these children are identified by specific visual, social, mobile, global, and digital characteristics [72] [73].

The inclusion of technological ***Content*** in early childhood education requires clarification because there is currently no consensus as to the application of this content for very young children. However, content areas such as technological literacy, including digital, computer, information, technology, media literacy [74], and digital citizenship [75] are prevalent for older students. Therefore, this research focused on two content areas for young children to protect them from any harm associated with technology while they develop their CT abilities. The first content area, input-device literacy, ensures all students have access to technology and can use it within as-expected milestones to learn, communicate, and develop solutions. The objective of the second content area, digital citizenship, is to raise awareness of the ugly side of technology and the importance of rules and regulations for user safety.

As shown in Figure 4b, input-device literacy requires various skills based on a device’s sensing capabilities and a user’s physical abilities [76]. For example, the recommended age to start learning keyboarding is preschool through grade 4 [77]. Keyboarding Without Tears (KWT) is a program that teaches typing skills using four stages to develop proper keyboarding habits, finger dexterity, muscle memory, accuracy, and speed [78]. In addition, using a mouse requires the coordination of multiple muscles and hand-eye coordination [76], meaning practice frequency is often a more accurate determinant of proper mouse usage rather than a child's age. Mousing skills typically are combined with keyboarding since children must coordinate their typing and mouse movement to control computer applications effectively [79, 80]. Common foundational skills for using a mouse include "identifying parts, holding the mouse correctly, moving the mouse, pointing, hovering, clicking features (double-clicking, right-clicking, left-clicking), and scrolling" [81]. In comparison, touchscreens are user-friendly and provide interactive user interfaces that trigger multiple sensory systems [82]. Another input device, touchscreens, are lightweight and small enough to be held by young children, they are easy to control, and they augment the development of the user's abilities through usage [83]. Previous investigators suggested nine fundamental gestures for touchscreens: "tapping, scrolling, swiping, flickering, selecting, dragging, pinching, resizing, and rotating" [81]. A previous touchscreen Indigo framework established five stages in which children can progress at their own speed and abilities to train motor and cognitive skills [69]. Other input devices, such as motion sensors, are frequently used in interactive environments to recognize individual's faces, hand, and whole-body movements. However, no research was found related to progress development using motion sensors tools or play using gross motor skills. The use of motion-sensing tools in early childhood education can include interactive whiteboards, motion-based games on consoles, augmented reality apps, and virtual reality [84] [85] [86] [87].Comparatively, voice-activated assistants such as Siri and Alexa require minimal training and can be easily learned with basic instructions and practice, although utilization of these assistants requires cognitive abilities such as understanding how to activate them, phrasing questions or commands clearly, comprehending the answers, and resolving any issues that may arise. Adequate information literacy skills are beneficial to effectively utilize these assistants [88] [89]. The final input device shown in Figure 4b is controllers, which are used to control an object or character in video games. Controllers can be wired or wireless in the form of gamepads, joysticks, light guns, drum controllers, and sports controllers. Gamers commonly use two grips: traditional and claw. Classic controllers usually have 10–20 buttons, and even preschoolers can use them to play games [90] [91] [92].

The second proposed content area, digital citizenship, is an approach to prepare individuals for the challenges and opportunities of participating in an online society, promoting positive online behavior and responsible use of technology for safety, privacy, and security. Digital citizenship includes concepts such as respect, empathy, victimization prevention, digital footprints, and password protection. Harvard students have developed Digital Citizenship+ to address this content area, identifying 17 primary concepts to equip young people to fully participate in the digital world [75].

The ***Context*** element of technology (Figures 3 and 4a) refers to how technology delivers content and how adults engage with children while they consume it [26] [93] [94] [95]. A context of learning that includes a strategic technological medium to motivate engagement and active co-participation with adults can significantly impact a child's enjoyment of learning and extend the learning experience.

The ***Tools & Innovations*** element (Figure 4a) is a multifaceted term that can be uniquely understood depending on specific expert perspectives and objectives. STEM experts often view technology as "devices, processes, and systems" [96, 97], while education professionals also include media and technological strategies [98]. As presented in Figure 5, this study holistically classified technology tools used in education into four main categories: Devices/Equipment; System, Platforms & Applications; Strategies; and Digital Media. These categories, which are based on a literature review and a computer science framework [99], provide an efficient structure for understanding and selecting appropriate technology tools for educational purposes.

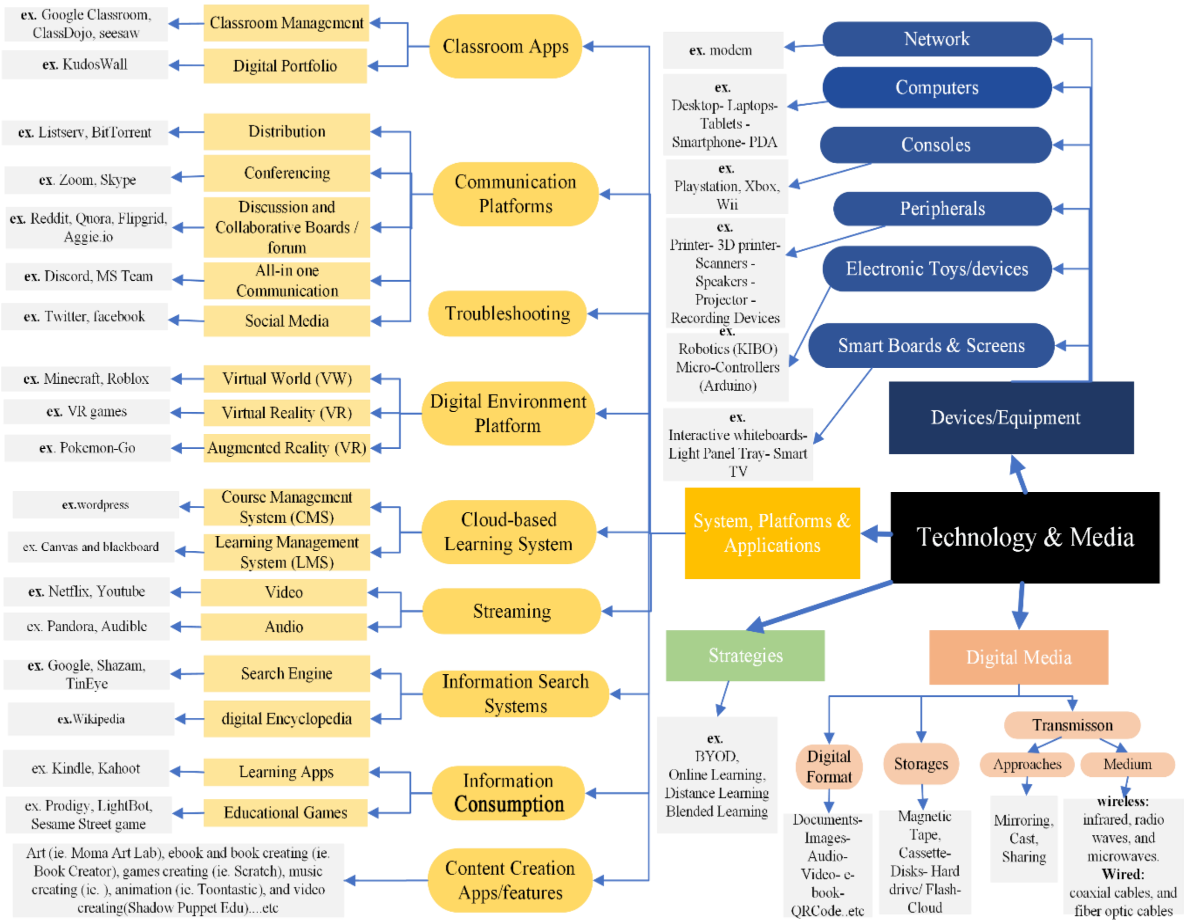


Figure 5. Technological Classifications of Educational Tools

The ***Screen Time*** element in the besTech framework (Figures 3 and 4a) refers to the suggested interval for technological screen usage depending on age, content, and social factors. For example, only video-calling applications with parents is acceptable for the Baby stage, while the Toddler stage allows no more than 1 hour with high-quality co-viewing. Children in the Preschooler stage can have 1–2 hours of screen time [100], and children in the School Age are recommend to have a maximum 4 hours of screen time per day with multiple breaks that should include physical activities [101]. The cessation of screen time for all stages depends on the child's focus and exploring while learning capabilities, meaning the facilitator should closely monitor the child to recognize when they have stopped accumulating knowledge and lost interest in the activity [102].

The ***Environment*** element in the framework (Figures 3 and 4a) includes physical, digital, and hybrid educational environments. To keep pace with technological advancements, theories related to the early childhood environment should be updated to intentionally and thoughtfully incorporate technology. Physical environments such as classrooms, libraries, and museums should be designed with appropriate technology tools to support children's learning and development [11]. The DevTech lab has developed two checklists to evaluate physical educational environments and assess children's engagement in that environment [12, 103]. Although the intangibility of digital environments distinguish them from physical environments, different digital environments can cause a child to be a producer or consumer [3]; producers create digital objects, while consumers learn through play. Figure 5 lists the various types of digital environments. Laura Beals proposes a virtual world framework for children that includes “purpose, communication, participation, play, artifacts, and policies” [104, 105]. Hybrid environments, such as augmented reality, require children to comprehend and navigate interactions in physical and digital environments simultaneously [81]. Overall, when planning lessons, educators must account for the applicable digital environment to create a comprehensive and effective learning experience for children [106].

The ***Facilitator*** element (Figures 3 and 4a) refers to any adult, such as family members, friends, or educators, who acts as a gatekeeper for technology for young children. Their determination of children’s technology access should be in accordance with appropriate selection, usage, integration, and evaluation strategies. Stakeholders are responsible for assessing educators’ capabilities and providing professional development training that includes “in-depth, hands-on technology exercises, ongoing support for the latest technology tools, and examples of successful practices to meet outcome expectations” [107].

The ***Evaluation*** element, as presented in the besTech framework (Figures 3 and 4a), should be conducted periodically to determine a technology’s effectiveness in enhancing student learning outcomes. The rapid evolution of technology increases the importance of assessing impact on student achievement and determining whether a certain technological tool is contributing positively to the teaching and learning process [108]. In response, an expert prepared a checklist for facilitators to assess the selection, usage, integration, and evaluation of technology [109].

Finally, many early childhood educators have hesitated to incorporating technology into their ***Pedagogy*** because they must consider the principles that control effective teaching and learning [110]. However, education technology experts advocate that education improvement should focus on pedagogy rather than technology [111], meaning that educators must make decisions about technology at the outset of instructional planning by specifying the objectives and methods of instruction and considering the outcomes of technology and lessons. To facilitate effective technology integration, previous research has proposed a PTD framework that leverages children’s existing pedagogies [12]. A consideration of the other eight elements of the besTech framework, in conjunction with PTD, can help educators align their lessons with established standards to leverage the benefits of technology and enhance learning outcomes for students.

Limitations and Future Work

The frameworks must be validated through qualitative research, and the work should be expanded to include integration pathways.

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