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Review

STEM, STEAM and Makerspaces in Early Childhood: A Scoping Review

Kelly Johnston [1], Lisa Kervin [2,*] and Peta Wyeth [3]

[1] School of Education, Faculty of the Arts, Social Science and Humanities, University of Wollongong, Wollongong, NSW 2522, Australia
[2] School of Education, Early Start, Faculty of the Arts, Social Science and Humanities, University of Wollongong, Wollongong, NSW 2522, Australia
[3] Faculty of Science, Queensland University of Technology, Brisbane, QLD 4000, Australia
* Correspondence: lkervin@uow.edu.au

Abstract: STEM has emerged as a key area of importance for children, highlighting the value and relevance of integrated understandings of science, technology, engineering and mathematics in both educational contexts and everyday life. The need for innovation and creativity is also recognised, which emphasizes the important role the arts can play as STEM is extended into STEAM. This scoping review investigated what is known about STEM, STEAM and makerspace experiences and opportunities for children aged birth to eight. The review found that early childhood experience with STEM, STEAM and makerspaces is an emerging field of research. Findings suggest that STEAM holds more relevance to learning and experiences in the early childhood years, and perhaps across the lifespan. The review also highlights the need to shift the starting point to the earliest of years and create greater intentionality in STEAM experiences with infants, toddlers and preschool aged children, recognizing the relevance of STEAM and maker mindsets in the lives of young children. Additionally, the scoping review identified the value of informal and community contexts as a means to invite broader participation. Such opportunities provide scope to challenge inequity in opportunity and to overcome intergenerational aversion towards STEM/STEAM-related learning. Further research is needed to understand the professional learning needs of early childhood educators and facilitators of STEAM and makerspace experiences.

Keywords: STEAM; STEM; makerspaces; early childhood; education; play-based learning; young children

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1. Introduction

The integration of science, technology, engineering and mathematics (STEM) is increasingly recognised as a core educational component for children. However, the focus tends to be on primary school education and beyond, rather than early childhood. As an example, the *National STEM School Education Strategy 2016–2026* in Australia [1], identifies the need to focus on STEM in schools to ensure that children develop skills and knowledge for academic success. While this Strategy focuses predominantly on school contexts, it also acknowledges that important foundations for STEM are developed in early learning and community contexts [1]. Donohoe [2] identifies an uptake in research relating to STEM in early childhood, the dissemination of which positively influenced the development of guidelines and policy relating to early childhood pedagogy and practice from 2016 onwards. The emerging policy, guidance and other recommendations for including STEM in early childhood are underpinned by an assumption that educators have the necessary content knowledge across STEM domains of science, technology, mathematics and engineering. However, this is often not the case. Research indicates that early childhood educators often lack confidence and skills in STEM domains such as mathematics and science [3–5], which impacts curriculum provisions.

It is well recognised that important foundations for future learning, achievement and wellbeing are developed in the early years. While mathematical and scientific concepts and processes are encountered spontaneously in young children's everyday lives, greater intentionality is required in pedagogical approaches to build conceptual knowledge as well as positive attitudes and dispositions towards the STEM domains [6,7]. Further research is needed to understand what is known about STEM in early childhood in praxis and to investigate whether this research informs practice.

1.1. Defining STEM

STEM is a term that is now frequently used in educational contexts, but is perhaps not always understood for its complexities, nuances and possibilities. STEM relates to experiences involving two or more domains of science, technology, engineering and mathematics, occurring in an integrated way. Contemporary research shows an emerging awareness of young children's interest and capabilities with the STEM domains of mathematics and science. There is a growing body of research demonstrating mathematical understanding and abilities from infancy [6,8]. It is recognised that the mathematical skills and abilities that young children develop before they start school are predictive of later academic achievement [9]. Similarly, children show a natural sense of scientific inquiry from birth with a strong need to understand how the world works [10]. However, as with mathematics, the potential, curiosity and capabilities of young children are often underestimated and not adequately supported in the early years.

Research also reinforces young children's propensity for engineering, which is a dynamic process of design thinking and problem solving. Davis, Cunningham and Lachapelle [11] note that the engineering processes include researching, brainstorming, planning, testing and revising ideas. This can be condensed to a simpler process of exploring, creating and improving, which is a process all children engage with.

Parallels exist between engineering and technology. This includes tools and resources that are used to investigate, explore and achieve outcomes. The *Shorter Oxford English Dictionary* defines technology as "a branch of knowledge that deals with the mechanical arts of applied sciences", with "high technologies referring to information technology or new technologies" [12]. Fleer and Jane [13] further delineate the distinction between 'high' or 'low' technology in work with young children. They define high technology as technology that is screen-based, needs a power source, or includes programs, and low technology as tools that are not digital, or requiring power—such as a brush or spray can. Technology in STEM relates to both high and low examples of technology as a tool and a resource to support engagement and inquiry.

Digital technology is increasingly embedded as a sociocultural tool in everyday life; however, there are often disconnects in how technology is defined and conceptualised. Johnston, Kervin and Wyeth [14] provide a contemporary and comprehensive definition, identifying digital technology as it pertains to research in early childhood spaces. They specifically aim to provide foundational awareness of the breadth and depth of digital technology that is experienced in everyday life. This includes objects or systems that can create, transmit or store data spanning resources such as computers, tablets and digital toys, as well as items that are integrated into our lives such as touchscreens and scanners at the supermarket or tapping a travel card at the train station. Their definition also extends on the idea of less-tangible forms of technology and invites consideration of how digital technology features in a complementary and supplementary with more-traditional resources in children's play. They note that "imaginary and non-digital technologies, including props used in dramatic play, can help children develop knowledge, skills and understanding about digital technologies" [14].

Research indicates that children begin to interact with apps and touchscreen devices from infancy [15], with around 94 percent of children in Australia accessing the internet by four years of age [16]. While digital technology presents new opportunities in children's play-based learning [17], the interest and confidence that children show with digital technology may not always reflect a deeper understanding. Children require effective guidance to develop the necessary skills to be safe and competent users and creators with technology. Donohue [2] suggests a developmental progression of learning digital handling skills before learning how to use technology as a tool or resource for learning and inquiry. Learning how to create with technology is presented as a third developmental progression, where children become active users of technology [18].

1.2. Defining STEAM

STEAM includes the Arts with other STEM domains, recognising that creativity and the arts are key elements of learning and pivotal to innovation [19,20]. STEAM can be defined as a way to build understanding through engaging with an artform with connections between the arts and STEM elements, effectively supporting growth across all areas [21]. Huser [19] notes that including the arts provides greater opportunity for STEM experiences to be socially and culturally relevant, and for children to have voice and agency. The arts are recognised as a space for open-ended investigation, individual expression and diverse communication opportunities. In this way, STEAM provides children with greater opportunity to choose resources and approaches that build on and are responsive to their previous knowledge, experiences and understandings across the STEM domains. As such, the inclusion of the arts can demonstrate authentic respect for diverse ways of knowing and being, thereby supporting equity in contribution and engagement [19]. Creativity that underpins the arts is a characteristic of the early years, and it is important to foster this creativity so that it is supported throughout the lifespan.

1.3. Defining Makerspaces

Contemporary literature reinforces the need for settings that support STEM thinking and learning. A recent report notes the need for "learning environments in which children's curiosity about the world can thrive via systematic, authentic, investigations that utilize a range of design thinking skills and scientific knowledge processes" [22]. While makerspaces are an emerging area of focus in early childhood spaces, clear alignments can be seen for opportunities to support STEM and STEAM learning, for example, use of high and low technologies as well as children engaging in engineering processes.

The makerspace movement focuses on how people use tools to create, innovate and collaborate [23]. Contemporary makerspaces aim to foster creativity and innovation through the provision of environments that support exploration and investigation for all involved [24]. Makerspace environments are carefully constructed in terms of resources and pedagogical approaches. Facilitators or teachers are positioned as guides and collaborators, and rather than adopting an expert/novice dyad approach makerspaces enable children to lead experiences and provide equitable opportunities for involvement [24]. Community members may also be invited to share expertise or interest, in particular, and the underpinning respect for knowledge, skills and experience of others creates more-equitable and inclusive environment [23].

Parallels are evident between STEM, STEAM and makerspace approaches. Each approach has a focus on inquiry and investigation and positions the child as an active, agentic learner. Dougherty and Conrad [23] draw attention to tinkering within makerspaces as an invitation to play, while also promoting the value of play in the learning process. Similarly, contemporary literature suggests the value of STEM and STEAM learning in play-based contexts. This strongly suggests the value of integrating STEM, STEAM and makerspace pedagogical approaches to support the learning and development of young children. The affordances of such an integrated approach need to be further investigated and understood.

1.4. The Current Study

This scoping review focuses on what is known about STEM, STEAM and makerspaces in early childhood, what is needed and what the possibilities are. The review builds on emerging thinking that STEM needs creativity for innovation and investigates how STEAM and makerspaces feature in research relating to early childhood.

2. Materials and Methods

A scoping review approach was employed for this study. Arksey and O'Malley [25] identify scoping reviews as an effective way to explore emerging areas to clarify understanding and to identify where there are gaps in knowledge. The study follows the five stages of Arksey and O'Malley's [25] scoping review framework. These include:

1. Identifying the research question;
2. Identifying relevant studies;
3. Study selection;
4. Charting the data;
5. Collating, summarising and reporting the results.

2.1. Identifying the Research Questions

The scoping review was underpinned by the following research questions:

1. What is known about STEM, STEAM and makerspace learning for young children (birth to eight years of age) in terms of experiences, content, opportunity, resources and engagement with others?
2. Who is involved in STEM, STEAM and makerspace experiences with children and where do they take place?
3. What are the affordances and challenges of teaching and learning with young children in STEM, STEAM and makerspace contexts?

The scoping review seeks to identify the main themes around STEM experiences for young children, with a particular focus on children in the birth to five age range and prior to school contexts, as well as how STEAM and makerspaces features in contemporary literature relating to young children. The review also aims to identify current gaps in practice as well as gaps in research and literature relating to STEM, STEAM and makerspace learning and experiences for young children.

2.2. Identifying Relevant Studies

Searches were conducted across Education Research Complete, Scopus and ProQuest databases. Given the emergence of STEM, STEAM and makerspace related literature in relation to early childhood, searches for the three topics were initially conducted separately and the results collated. Initial searches were of abstract, title and keywords. The full text was reviewed as required to determine age eligibility. STEM search strings included: "early child*" OR "young child*" AND "STEM learn*" OR "STEM Educat*" OR science AND math* AND technology AND engineering. STEAM search strings included: "early child*" OR "young child*" AND STEAM. Makerspace search strings included: "early child*" OR "young child*" AND makerspace OR makerspaces OR "maker space" OR "maker spaces" OR "maker movement".

The STEM and STEAM acronyms form words with meanings unrelated to our search. For STEAM including "young child" or "early child" in the search string helped to remove irrelevant articles. However, for STEM, this strategy was not sufficient in narrowing to a field that met the search criteria and included many medical articles relating to stem cell research. The search strings were extended in two ways: (1) extending the search term to STEM learn* and STEM educ* to ensure there was an education focus; and (2) listing the four domains of STEM to capture child-related research that did not include terms relating to education or learning.

2.3. Inclusion and Exclusion Criteria

Inclusion and exclusion criteria were developed and applied to ensure the relevance of articles in the scoping review. To be eligible for inclusion sources had to be peer reviewed as a measure to support academic integrity [25]. The inclusion criteria also required articles to be published within the previous 10 years. This limitation on timeframe reflects the rapid changes in digital technologies. An example is the release of the iPad in 2011 which resulted in increased opportunities for digital engagement for children due to its touch screen and portable nature. Only articles that predominantly focused on children in the birth to eight age range were included. Articles were excluded if the children under the age of eight years featured in the research in a minor or non-significant way.

Eligibility for inclusion also required specific reference to STEM, STEAM or makerspaces in relation to young children's learning and experiences. The STEM-related inclusion criteria drew of the definition of STEM as the domains of science, technology, engineering and mathematics experienced in a cross-disciplinary way [1]. As such, two or more STEM domains had to be included in potential studies and discussed in an integrated way, aligning with a STEM approach. Articles that talked about only one domain or did not make the connection between multiple domains or make a specific connection with STEM were excluded. A similar inclusion criterion was employed for assessing eligibility of STEAM-related articles. At least one of the STEM domains had to feature as a key research focus along with an element of the arts. Elements of the arts included: fine arts (such as drawing, painting, photography); language arts (such as creative writing and storytelling); and physical arts (such as dance and movement).

2.4. Study Selection

Applying the search strategies outlined above resulted in the identification of 497 potential sources. After removing duplicates and screening for inclusion and exclusion criteria, 195 relevant studies were identified. Most articles related to STEM, and fewer related to makerspaces and STEAM. However, there were intersections where articles reported on more than one of the identified foci and these were only recorded once depending on the main focus of the article (See Table 1). Full details of the articles identified in this review are include in the Supplementary File.

Table 1. Key focus of articles.

Focus of Article	Number	Intersections
STEM articles	152	including 20 that crossed over with STEAM
STEAM articles	19	not including 20 that were counted for STEM and 1 that was counted for makerspace
Makerspace articles	23	including 3 that crossed over with STEM and 1 that crossed with STEAM
	194	

2.5. Charting the Data

The relevant articles were reviewed for common themes in a process of 'sifting, charting and sorting' [25]. Charting was led by one researcher in collaboration and discussion with the research team. Charting included:

- Item type (peer-reviewed journals article, book, chapter, conference proceedings) (See Table 1 above in study selection);
- Study population (young children);
- Year of publication;
- Research themes (including contexts).

2.6. Collating, Summarising and Reporting the Results

Once charted, the data were reviewed again to collate the identified codes into broader overarching categories. Following the Arksey and O'Malley [25], a numerical summary and analysis of themes was then undertaken. Numerical tables were developed to map the prevalence of key codes of the review across the three focus areas of STEM, STEAM and makerspaces, following Saldaña's [26] code to theory approach. In this approach codes are identified from the data, collated into categories, and then further refined to develop an overarching theme (See Figure 1).

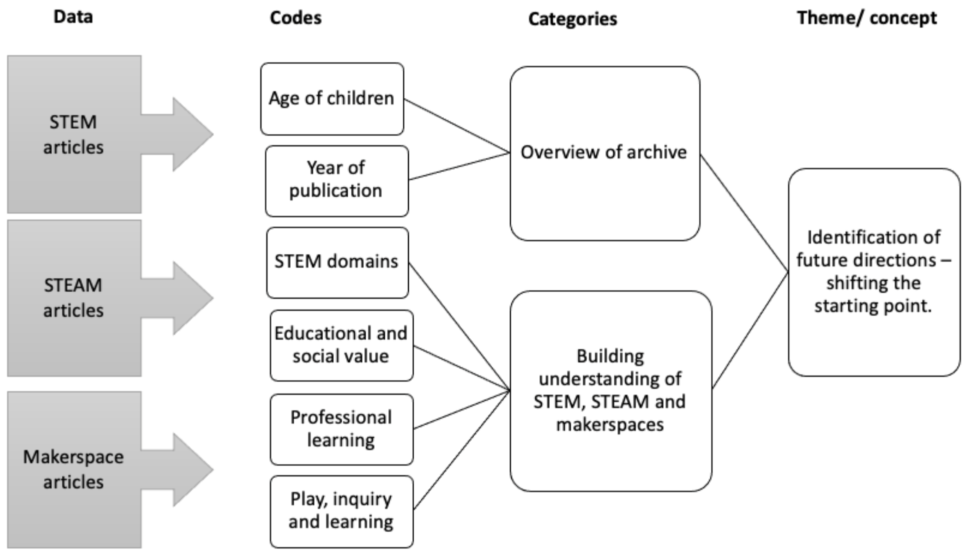

Figure 1. Codes, categories and theme. Adapted from Saldaña's (1995) [26] code to theory approach.

3. Results

The results are reported in relation to the categories identified in Figure 1: Overview of archive, and building an understanding of STEM, STEAM and makerspaces.

3.1. Overview of the Archive

The database search sought articles with a focus on children birth to eight, a widely accepted age range for the early childhood years. It also sought articles published in a ten-year period from 2012 to early 2022 (when the scoping review was undertaken). The previous decade has seen significant technological advances that have increased accessibility for young children, such as touch-screen devices and mobile internet. This timeframe was selected to encapsulate research that reflects children's experiences with contemporary digital technology. Findings relating to age of children and years of publication provide an important foundation for this scoping review and are explained in the following sections.

3.1.1. Age of Children in the Study

The inclusion criteria for the scoping review specified that articles must focus on the early childhood years (birth to eight). Many articles did not specifically identify the age of the children, instead using terms that are not globally consistent in terms of age ranges, such as kindergarten or reception, or referring more generally to early childhood and young children. Where ages were clearly noted they were categorised as infant/toddler, preschool or school aged. Where age groups crossed age divides, they were coded as early childhood (general—0–8 years span) or early childhood (older—3 to 8 years). This last category was applied where the article content clearly demonstrated a focus on children preschool age or older.

Articles focusing on children between three and eight years of age (30%) were the most common, though children aged three to five (25%) and the broader birth to eight years of age range (24%) were only slightly lower in representation. Primary school aged children as an exclusive category made up only 17 percent of articles. A lower amount was expected, given the search focus on early childhood and young children. Of high interest was the very limited reference to children in the youngest age bracket (less than 1%). General reference to the early childhood age span of birth to eight years was more common for makerspace-related articles (46%), as opposed to STEAM (26%) and STEM (20%), though infants and toddlers were not an individual focus in makerspace articles. Table 2 provides a summary of the focus age groups across the articles.

Table 2. Focus age group in articles.

	STEM (n = 152)	STEAM (n = 19)	Makerspace (n = 23)	Total (n = 194)
Infant/toddler (1–2 years)	5	1	0	6
Preschool aged (3–5 years)	46	1	2	49
Early childhood (General—0–8 years span)	31	5	11	47
Early childhood (older—3 to 8 years)	48	5	6	59
Primary school age (5–8 years)	22	7	5	34

3.1.2. Year of Publication

A marked increase in articles relating to STEM, STEAM and makerspaces is evident across the five-year period preceding this review (See Table 3). This increase is indicative of the relatively new focus on STEM for young children and the associated connection with STEAM and makerspaces. The review was undertaken in March 2022, which accounts for the low numbers for 2022.

Table 3. Year of Publication of Articles.

	Number of STEM Articles (n = 152)	Number of STEAM Articles (n = 19)	Number of Makerspace Articles (n = 23)	Total (n = 194)
Jan–Mar 2022	3	3	0	6
2021	40	3	7	50
2020	34	3	6	43
2019	18	0	4	22
2018	11	4	5	20
2017	19	2	1	22
2016	12	2	1	15
2015	4	1	0	5
2014	4	0	0	4
2013	5	1	0	6
2012	2	0	0	2

The earliest STEM articles relating young children found through the scoping review process were published in 2012, and the first STEAM article in 2013. The first makerspace article relating to young children identified in this review was published in 2016. Older articles identified in the review were more descriptive and introductory in nature. Over time articles became more nuanced showing the progression of STEM and STEAM in early learning pedagogy and practice.

3.2. Building an Understanding of STEM, STEAM and Makerspaces

The overarching categories that emerged from the coding process provided an insight into how STEM, STEAM and makerspaces are understood and conceptualized in relation to the early years. The key categories identified in Figure 1 are further explained the following sections.

3.2.1. STEM Domains

Two or more specific STEM domains of science, technology, engineering and mathematics were frequently featured as a key focus of STEM-related articles but were rarely at the forefront in STEAM or makerspace articles. Table 4 reports on the number of articles that specified one or more STEM domains as the key focus of the paper.

Table 4. Articles that specified STEM domains as a key focus.

STEM Domains	Number of Coded References in STEM Articles	Number of Coded References in STEAM Articles	Number of Coded References in Makerspace Articles	Total
Mathematics	31	2	0	33
Science	26	2	2	30
Engineering	15	0	0	15
Technology	14	0	0	13
Total times specific domains were the main focus				92

Content relating to mathematics was most common and included spatial skills, geometry, measurement and elements of computational thinking such as calculation in algorithms, data collection and analysis and pattern recognition [27,28]. Science also features as a common subject while engineering and technology were far less-frequently included as the key focus.

Table 5 shows where there was a clear reference to digital technologies or non-digital technologies, or where articles acknowledged both digital and non-digital as relevant to the T in STEM and STEAM. Where technology was included in articles with mathematics as a key focus, it was predominantly digital technology. Articles that related to science and engineering that also included technology had a focus on both digital and non-digital technology. Interestingly, digital and non-digital technology jointly featured in articles where other STEM elements were the key focus rather than technology itself. Several articles referred to technology only when expanding STEM or STEAM acronyms, and therefore did not provide a clear definition of how it was interpreted within their research.

Table 5. Articles reference to technology.

STEM Domains	Reference to Digital Technology	Reference to Non-Digital Technology	Reference to Both Digital and Non-Digital	Technology Not Defined/Not a Focus
Mathematics (n = 33)	19	0	1	13
Science (n = 30)	10	5	6	10
Engineering (n = 15)	4	2	2	7
Technology (n = 14)	13	0	1	0

Digital technology was often included as an integral part of other activities and experiences. Table 6 outlines how technology featured in articles relating to technology integration across the three categories of STEM, STEAM and makerspaces.

Table 6. Examples of how technology was included as an integrated feature in the research.

Integrated Inclusion of Digital Technology	Number of Coded References in STEM Articles	Number of Coded References in STEAM Articles	Number of Coded References in Makerspace Articles	Total
Digital literacies and multimodality	0	1	10	11
Digital games and apps	6	0	0	6
Interactive technology and digital handling skills	0	8	0	8
Popular culture and the influence of media	1	3	0	4
Computer programming and coding	21	0	0	21
Manipulable/concrete	5	2	0	7
Total of embedded references to digital technologies				57

Computer programming, coding and robotics were the most prevalent examples of integrated technology. Coding was presented in terms of different programming languages [29] and was often connected with computational thinking [28,30,31]. Mathematics and engineering were noted in relation to computational thinking, with a focus on using algorithms to solve problems and to develop fluency with technology [27,28,32]. Overall, robotics was positioned as an effective way to teach coding to young children [33] and a hands-on way to solve problems [34]. Additionally, coding and robotics featured as a tool to support creativity and engagement with the arts [31,32,35–38].

The review identified a continuum of coding skills and abilities for young children. A foundational understanding of coding and computer programming begins with unplugged coding approaches, including concrete symbols, to represent coding language, or physical blocks such as with the LittleBits or KIBO resources [29,36,37,39–42]. The importance of coding language was also identified from very early engagement with coding, for example, the use of "if/then" statements [39]. Resources such as Lego Robots, Dash Robots, Bee Bots and Oz Bots were included as examples of early coding activities that enabled children to have concrete, hands-on experiences to build their understanding of digital coding [31,41,43,44]. Further progressions included block coding through Scratch Jr and KIBO [29], or web-based programs such as Scratch that build understand of visual programming followed by syntactic programming languages [41]. In other examples coding and robotics featured with drama, music and dance, further demonstrating the broad potentials of STEAM pedagogies [37,38].

STEM, STEAM and makerspace-related articles were found to have complementary and overlapping themes. Digital literacies and multimodality emerged as a prevalent topic, but this was predominantly positioned in research relating to makerspaces [45–47]. STEAM was recognised as a way to increase creativity and innovation and includes a focus on the arts and multiple modalities as a way to communicate, express ideas and deeply investigate. The value of manipulable and concrete resources also emerged as a common focus in STEM and STEAM articles and included a particular focus for mathematical thinking and learning [48,49]. Tangible tools such as CRISPEE were also identified as a way to support scientific inquiry (bioengineering) with young children and as a means to increase positive dispositions towards STEM [50,51].

Physical items, hands-on resources and visual cues were found to be of great value and one of the benefits of STEM and STEAM-based experiences for children [39,52]. Creating while using concrete materials is a key tenant of the maker mindset and features in all makerspace-related articles identified in this review. This included a focus on making with both physical and digital resources and processes of making and remaking [53–55]. Intersections between the makerspace and STEAM ethos are evidence with a strong focus on building that uses both hands and minds [56] rather than prioritizing the development of a final product [57].

Digital games and apps were not often the key focus of STEM articles but were interwoven as an operational feature of other digital technologies, such as the use of apps for block coding in robotics play [58]. Similarly, the relevance of popular culture and media emerged as a less-common theme [59–61] but raised important questions relating to the impact of digital characters in children's lives. However, clear intersections are evident with other themes that emerged such as social and emotional development, gender stereotypes and issues of equity.

3.2.2. Educational and Social Value of STEM in the Early Years

The educational value of STEM is frequently promoted in terms of academic and long-term career potential for child. Findings from this review reinforce this value, but also outline a wider range of benefits for children in terms of self-efficacy and confidence and the potential to challenge systemic inequities in society [37,62]. Benefits of STEM, STEAM and makerspace involvement extended beyond classrooms or formal early learning settings to also include family and community contexts [63,64]. Table 7 outlines various ways STEM, STEAM and makerspaces were seen to be of value for young children.

Table 7. Number of articles that focused on the value of STEM, STEAM and makerspaces.

Benefits of STEM, STEAM and Makerspaces in the Early Years	Number of Coded References in STEM Articles	Number of Coded References in STEAM Articles	Number of Coded References in Makerspace Articles	Total
General value of STEM/STEAM in the early years	23	1	0	24
Informal learning opportunities and community spaces (such as libraries and museums)	0	23	5	28
Connection with family	19	0	4	23
Collaboration	10	3	0	13
Diversity and equity in participation	17	0	6	23

The review presents insights into the collaborative nature of STEM, STEAM and makerspace experiences, and the potential for connections between peers and the wider community with a focus on group membership and community building. Examples were also given of dynamic opportunity with the more-knowledgeable older children helping younger children. Opportunities afforded for collaboration with families emerged as a recognised value in STEM [65]. The research provides multiple examples of family participation in STEM experiences with children [66]. It also recognised the wealth of knowledge and experience that families can bring to STEM/STEAM and makerspace collaborations, as well as acknowledging the need to provide all participants with guidance and support, whether they are children, adult family members, educators or community members [63,67]. The value of families and adults as co-learners with children is presented as a clear value of STEM and STEAM approaches. Makerspace literature included a focus on reconceptualizing the role of teacher as a collaborator and guide, rather than a leader, and introduced the value of intergenerational collaborations [68,69].

Diverse learning environments were also identified as a way to support STEM, STEAM and makerspace experiences. The review demonstrates that informal or non-academic contexts can promote more-diverse participation across communities. Opportunities for informal learning experiences within community spaces are specifically identified as a value of STEAM and makerspace approaches, but also extend to STEM learning. Examples of community or informal contexts identified in this review include museums, libraries, outdoor spaces (including bush or forest kindergartens) and other public spaces [53,70,71]. Makerspace articles often focused on the value of the environment as a teacher, Reggio Emilia philosophy and the value of museums, civic engagement and community [53,72].

Creating more-accessible and welcoming environments was identified as an equity and diversity featured as a topic in 17 percent of the papers in this scoping review (n = 33). STEM and STEAM experiences in early childhood were identified as means to challenge long-standing inequities in skills, ability and opportunity in STEM-related fields, particularly for children in lower socio-economic situations, children living in disadvantage, children with disabilities, gifted children and females [73–75]. Positive early STEM experiences were associated with long-term benefits as a result of the development of positive attitudes and dispositions towards STEM as well as self-efficacy. However, some complexities in achieving equity were identified. Even when girls were found to have positive STEM-related identities, boys retained a view of male predominance in STEM-related activities [76]. The potential for STEM and STEAM experiences to build community connections was identified as another way to challenge inequities particularly in high needs areas [77,78].

3.2.3. Professional Development and Support for Educators

This review identifies a need for professional development opportunities relating to STEM and STEAM for educators (see Table 8). More specifically, the research recognised a need to build knowledge of specific STEM domains and individual discipline areas as well as to build the skills required to teach STEM and STEAM in an integrated way [79]. Professional learning and development opportunities were found to positively impact educator dispositions towards STEM and STEAM and to help build confidence with effective pedagogical approaches [80,81]. Positive dispositions and attitudes towards STEM/STEAM were bidirectional, with improved self-efficacy for educators and improved related experiences for children [82]. However, there was little reference to professional learning and development in makerspace-related articles.

Table 8. Professional learning and support for educators.

	Number of Coded References in STEM Articles	**Number of Coded References in STEAM Articles**	**Number of Coded References in Makerspace Articles**	**Total**
Need for PD and support	33	4	0	37
PD positively impacting educator dispositions and attitudes towards STEM? STEAM	13	2	0	15
Preservice teacher education	2	1	1	5
Total of references to professional learning and support				57

Pre-service teacher education was found to be insufficient, with educators reporting they felt underprepared to teach STEM content upon completing their qualifications [83]. Additional support for pre-service and early career teachers was identified in relating to new resources (such as robotics or other digital technology), infrastructure, materials and technical support, as well as skills in pedagogy and teaching practice [84–86].

3.2.4. Elements of Play, Inquiry and Learning

Several codes were grouped to build understanding of how children's play, inquiry and learning featured in the review (See Table 9). Within this area of thematic review, STEM articles were usually focused on hands-on experiences (12), and problem solving and inquiry (13). STEAM-related articles also positioned children as active participants, rather than being consumers of technology (8). Across these themes children were positioned as agentic, with their voices valued and their ability to actively create with technology recognised.

Table 9. Elements relating to play, inquiry and learning.

Elements of Play, Inquiry and Learning	Number of Times in STEM Articles	Number of Times in STEAM Articles	Number of Times in Makerspace Articles	Total
Creative arts	0	19	0	19
Hands-on/concrete experiences	12	2	3	17
Problem solving and inquiry	13	2	0	15
Language and literacy	11	1	2	14
Creativity, innovation and design thinking	4	0	6	10
Developmental domains	8	1	1	10
Children as active, not consumers	0	8	0	8
Connection with the arts, music and story	0	3	0	3

At a more-nuanced level, problem solving and inquiry included consideration of creative thinking and real-world problems, the value of peer play and cooperation, and the role of adults in play [87,88]. The importance of community and family contexts for STEM play were also identified, highlighting the need to look beyond academic settings. The review found that narrower conceptualizations of STEM can result in a disconnection with play-based learning and experiences.

Language and literacy were identified as a focus of STEM play, inquiry and learning (11), moving beyond the recognised STEM and STEAM domain areas of science, technology, engineering, arts and mathematics (Table 9). The important synergies between mathematics, science and literacy learning were also identified in the review. Language was seen to be expanding through new STEM-related vocabularies and the recognition of coding as a new language in itself [29,42]. Storytelling, story books and non-fiction books were also identified as key elements of STEM/STEAM learning, while also highlighting that mathematics and science are pivotal to literacy development [89].

The creative arts were a key focus in all STEAM-related articles (19). A central feature was the ability of STEAM education to support children to explore, wonder and create. The visual and creative arts were embedded in digital play such as robot theatres or through storytelling and imaginary play in Conceptual PlayWorlds [90,91]. The review revealed an emerging awareness of the importance of arts and creativity within STEM and promotion of STEAM approaches, while also reinforcing the literacy focus [78,92].

Design thinking, innovation and creativity were at the core of discussion on maker mindsets and maker literacy [70,72]. Learning in makerspaces was identified as playful and child-led with the developmentally and philosophically appropriate approach of learning through movement [70,86,93]. Literacy development also features in makerspace articles and included a focus on storybooks [94].

4. Discussion

This scoping review presents STEM, STEAM and makerspaces as emerging areas of focus, identifying a swift upturn in publications from 2017. An advancement in the complexity and depth of STEM- and STEAM-related research with young children was evident over the last decade, reflecting a shift in understanding of young children's capabilities as well as the significant advancements in digital technology. In examining the literature, a clear picture emerges of children's experiences with STEM, STEAM and makerspaces in terms of content and contexts as well as in terms of opportunity for engagement. Strategies can be identified for consolidating and extending current opportunities available to children and in professional learning and develop for educators.

4.1. Understanding STEM, STEAM and Makerspaces

STEM, STEAM and makerspaces offer unique and valuable learning opportunities for children. The domains within STEM are important for early childhood education. STEAM broadens the scope and potential learning within these domains for children. Overall, the predominant age group identified in this scoping review was three to eight years (within the specified inclusion criterion of birth to eight years) and shows recognition of the value and relevance of STEM/STEAM experiences in the preschool and early school years. However, the review presented a very limited acknowledgement of the rich STEM/STEAM opportunities for infants and toddlers. This omission highlights a potential lack of understandings of the embedded nature of STEM/STEAM in everyday experiences for very young children. There is a need to shift the lens and recognise everyday experience as opportunities to extend early learning about mathematical and scientific concepts such as learning about attributes and properties of material [6,10]. Similarly, pre-tinkering, as a makerspace mindset, shows strong overlaps with young children's sensory play and explorations of their world [65], again, presenting the opportunity for recognising the STEM/STEAM learning that takes place within everyday play and experiences. Findings from this review highlight the need to shift the starting point and create greater intentionality in STEM/STEAM experiences with very young children. This intentionality must build on educators having a foundational understanding of the pathways for learning STEM domain knowledge such as relevant vocabulary, concepts and processes of inquiry, as well as the abilities to effectively include this knowledge in play-based learning experiences.

4.2. Conceptual Intersections of STEM and STEAM Domains and the Possibilities of Digital Technology

STEM has become a prevalent theme in educational discourse, and there is no doubt that it is a well-established and understood frame. However, the scoping review identifies the need for strong conceptual knowledge of each of the STEM disciplines of science, technology, engineering and mathematics for both children and educators. In this review, mathematics and science were the most frequently coded elements of the STEM domains. This is an important consideration as research indicates low self-efficacy, confidence and/or conceptual knowledge in mathematics and science for early childhood educators [3,5], and highlights the need to understand professional learning needs. Technology often featured as an embedded element in studies with other STEM elements.

Mathematical thinking predominantly featured in connection with digital technologies, showing a connection with coding and robotics. The review provides strong examples of concrete materials such as coding blocks alongside digital resources and virtual/digital content, providing important insights that challenge dichotomised thinking between digital technology and concrete manipulatives [95]. Examples of child tangible interfaces/tangible user interfaces identified within this review align with the acknowledged value of using physical objects in interactive experiences, particularly for younger children [48,49]. Coding and robotics are also presented as creative and artistic learning opportunities. Future research should further explore these potentials, and in particular, consider how technology can be used in creative ways to support imagination rather than more-prescriptive ways [96].

Scientific thinking and engineering included a more-diverse mix of digital and non-digital technologies and included simple machines and design thinking. Articles that included technology as a main focus predominantly examined digital technologies rather than non-digital, demonstrating a clear shift in how the term 'technology' is conceptualised.

Further consideration is needed on the ways that technology enables deeper investigation and inquiry through use of peripheral, yet complementary, resources such as digital microscopes or digital video to investigate phenomena in more detail. Engineering was underrepresented in the papers located for this review. However, when included, the examples of children's engagement with engineering demonstrate the rich opportunities afforded by informal spaces such as museums as well as through tinkering in makerspaces, highlighting exciting potential for future research.

Another key consideration that emerged from this review was the connection between STEM/STEAM and literacy, moving the discourse beyond STEM and STEAM elements. This included drawing on elements of storytelling and story creating [78,90,94] and presents opportunities to further explore and expand the arts and creativity in STEAM. For our youngest children, play and literacy experiences (such as storytelling) are fundamental for learning.

4.3. Equity of Opportunity with STEM and STEAM

The review shows a recognised value of STEM and STEAM in play-based experiences for young children as a way to address inequity, particularly when the diverse experience and knowledge that children bring from their home and community contexts are recognised and incorporated. Acknowledgement of the potential for early STEM/STEAM learning to interrupt long-standing social inequities is a key finding of this review, including inequities relating to poverty, disadvantage, lower socio-economic status, gender, race and culture, language, disability and giftedness [3,59,73]. The review presents the potential for STEAM experiences to provide important foundational knowledge and confidence that underpins later learning and academic achievement, as well as for later career opportunities and success [1]. It also highlights the value of working with families when engaging in STEM, STEAM and makerspace learning experiences [88,97].

A key finding of the review is the unrecognized knowledge and skills that many adults hold in STEM/STEAM domains. Collaborative STEM/STEAM experiences between children, educators and other community members provides opportunities to recognize and embrace these diverse skillsets, experiences and knowledge of wider communities. While articles focusing on STEM and STEAM learning in formal early learning or school settings were common, other articles demonstrated the advantages of providing informal opportunities and the value of including families.

There is a clear alignment with the hands-on nature of tinkering with concrete materials and themes such as playful learning and learning through movement [70,93]. Such an approach can be seen to level the playing field by reducing the academic perception of STEM that can make it prohibitive to some. Similarly, inclusion of the arts increases the accessibility of STEM by providing a wider range of ways to investigate, seek knowledge and communicate understanding [38].

Provision of experiences in community spaces such as libraries, museums and civic spaces can level the playing field by creating a space where everyone feels welcome and has a sense of belonging [53,69,70]. This scoping review identified that when included in non-academic settings and when effectively facilitated, STEAM and makerspace experiences provided opportunity for collaboration and could challenge inequity by enabling participants of different ages, abilities and experience to have equal voice [86,98]. The development of spaces for collaboration with families and community must consider how more-diverse groups of people can be made to feel welcome, with thoughtful consideration of potential social and cultural barriers. Such learning can extend to adopting a sociocultural framework where the roles of expert and novice are dynamic, and where children, educators, families and other community members can move in and out of the role as more-knowledgeable others through experiences [99].

Within makerspaces teachers take on the role of guide or collaborator [64,68]. However, effective facilitation must support equity of contribution and create a community/collaborative culture requiring leaders in makerspaces to provide support that is responsive and adaptable to different abilities, interests, experience and ways of thinking, and to provide the necessary resources and scaffolds to build people's expertise and conceptual knowledge. This highlights the need for professional development for those working in makerspace contexts.

4.4. Professional Develop and Support for Educators

One of the key findings from this review is the potential to challenge long-experienced inequities that relate to the fields of science, technology, engineering and mathematics—for both children and adults. While STEAM and makerspace experience reduce the need for the adult to be the expert and increase opportunities for children and adults to be co-learners, findings from this review highlight the need for increased professional development for educators and a more-tailored STEM/STEAM approach in preservice teacher training [76,83,84]. Professional learning needs to focus on domain-specific STEM knowledge, as well as an understanding of how to effectively integrate STEM/STEAM elements and effective pedagogical approaches. This can include taking a more-holistic approach while being mindful of not diluting the STEM/STEAM domain knowledge, especially as research indicates that educators and families often lack confidence, familiarity or strong knowledge base in these areas.

Effective pedagogy was noted as including well-thought-out experiences, contexts and pedagogical approaches as a way to build agency and self-confidence, as well as positive attitudes and dispositions towards STEM/STEAM for children, educators, families and other community members [32,80]. Pedagogical approaches should support children to show their expertise, while also enabling both children and adults to feel comfortable with what they do not know and be willing to listen to others and learn more. A key consideration is the value of playful learning in building STEM/STEAM skills and how makerspaces afford play-based learning and inquiry [70,88]. The value of play is commonly recognised in early childhood learning, though this is a pedagogical and philosophical belief that has value for all ages.

5. Conclusions

Findings from this scoping review present many exciting possibilities for further STEM/STEAM and makerspace experiences with young children, educators, families and communities. In moving forward, the authors suggest that STEAM rather than STEM holds more relevance to learning and experiences in the early childhood years, and perhaps beyond. In making this claim, we emphasize again the power of play and the arts (particularly literacy) in helping children understand, explore and represent their emerging understandings of the STEM domains. The literature archive recognizes that young children engage with STEAM experiences and learning through everyday experiences as well as through planned or intentional experiences. There is an identified need for adults to recognize these opportunities and to have the ability and inclination to look for, support and foster these emerging interests and understandings in young children. Additionally, the relevance of literacy in STEAM is also a key finding from this review and invites further consideration of how STEAM is defined and conceptualized.

Supporting STEAM learning in the early years has the potential to disrupt intergenerational disadvantages associated with aversion to the STEM domains and fields. Where communities can engage with STEAM-related opportunities as co-learners there is potential to not only build children's knowledge and confidence, but to also consolidate and extend self-efficacy in adults. The arts offer unique opportunities to explore STEM domains, particularly through literacy-focused activities. The possibilities for community-based resources (including people) are identified. This review emphasizes the relevance of STEAM and makerspaces in the lives of very young children too and highlights the need for resources that demonstrate the continuum of STEAM learning from infancy through to the school years.

Inequities can be further challenged when STEM, STEAM and makerspace experiences occur beyond academic settings, and where they reflect people's real-world experiences and understandings. Such contexts can enable both adults and children to move in and out of the roles of expert and novice—removing the pressure adults may feel to be the more-knowledgeable other, while also enabling all participants to recognize and confidently share the expertise they have developed through their own lived experiences. Professional learning opportunities for educators are pivotal to supporting new opportunities in STEM/STEAM and makerspace learning opportunities with young children. This includes conceptual understandings of STEM areas to be broadened and deepened to show connection with creativity and the arts, and the ability to include the wider community and to extend beyond the classroom into community spaces. The maker mindset presents a valuable pedagogical approach that supports interest and skill development in the areas of STEAM [100]. Our future research will explore the affordances of the STEM/STEAM/makerspace nexus in supporting the learning and development of young childrens.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su142013533/s1, Full archive of scoping review articles.

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