Professional development of teachers in science, Technology, Engineering, and Mathematics: A bibliometric analysis

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Selection and peer-review under the responsibility of Assoc.Prof. Dr. Deniz Ozcan, Ondokuz Mayis University, Turkey. ©2022 Birlesik Dunya Yenilik Arastirma ve Yayincilik Merkezi, Lefkosa, Cyprus.

Abstract

The quality of the teaching and learning process in the 21st century encourages teachers to innovate learning integrated into all subjects of science, technology, engineering, and mathematics (STEM) to produce students who are critical, creative, and communicative. However, the majority of teachers in developing countries still have difficulty implementing the learning process integrated with STEM due to the lack of training in professional teacher development in STEM. This study aims to identify what teacher professional development (TPD) is currently targeted, instructional strategies are most used, and the topic is most prominent in five-year-olds (2016-2020) using the SCOPUS database. The design of this study is a systematic review. Data analysis on the first and second objectives is to use a qualitative, deductive, and thematic approach. The objectives of the third study were analyzed using VOSviewer software version 1.6.15.0. The identification results from 30 articles show that teacher professional development targets five-year-olds is the focus on practical application skills on STEM and teacher attitudes and beliefs towards learning that integrates STEM.

Keywords: Instructional strategy; professional development; STEM; Teacher.
1. Introduction

One of the teaching and learning (T&L) processes that can prepare students to suit the 12th century is integrated learning of science, technology, engineering, and mathematics (STEM). Because the STEM learning process can develop students' creativity, critical thinking, collaboration, and communication skills for the better. Thus, one of the reasons for optimism by leaders and decision-makers is to enhance and apply the STEM learning process in schools (Hill, Lynch, Gonzalez & Pollard, 2020). The importance of an effective T&L process is highly emphasized to be created by teachers for the success of students and the wider community.

In the current era of globalization, teachers are encouraged to have interdisciplinary knowledge and improve their ability to teach. However, the maximum preparation made by teachers in the T&L process is still overwhelmed, frustrated, and failing with the current TPD on STEM demands. Therefore, if the teacher still wants increased professional development then the teacher needs specialized training to provide pedagogical model experience appropriate to the context, in-depth skills in aspects of STEM, and sustainable programs (Keiler, Diotti, Hudon & Ransom, 2020). Besides, teachers also need to have good experience in how to deliver STEM learning interestingly and manage T&L integrated with STEM subjects in the classroom. The need for teacher experience is supported by programs from TPD in the field of STEM.

The TPD program is designed to engage teachers directly in peer-to-peer learning activities of science, technology, engineering, and mathematics (Nesmith & Cooper, 2019). TPD aims to improve student learning outcomes in STEM subjects. Also, TPD can bridge the gap between traditional STEM subject teaching strategies and current teaching strategies (National Academies of Sciences, 2016). Maass and Engeln (2019) show that the success of the implementation of TPD programs at the international level in 13 countries depends on the confidence and views of teachers supported by the policy of administrators and the organization of the time and classroom space T&L process.

During the professional development (PD) process, teachers need a lot of time to learn aspects of the STEM curriculum, improve learning materials, deepen learning content, and assessment techniques and adapt learning strategies to student characteristics (Banilower et al., 2018). However, the facts in the field found that many teachers are still not ready to teach based on STEM due to a lack of ability and knowledge in integrating STEM subjects in the T&L process (Nesmith & Cooper, 2019). A recent study by Vossen, Henze, De Vries, and Van Driel (2020) found that very few teachers' knowledge of how STEM integration is carried out in the learning process and the design of the relationship between TPD on STEM in realistic and holistic steps is found to date. Teachers also have constraints from lack of training, frequent intimidation, and lack of self-efficacy (Jamil, Linder & Stegelin, 2018).

1.1. Purpose of study

Students' mastery of STEM subject skills can support the preparation of 21st-century skills, especially for the survival and career of students. Especially the combination of both science and mathematics subjects that are indispensable in the career world now and in the future. Therefore, this study attempts to identify aspects of teacher professional development in STEM and instructional strategies that are often used by teachers during the last five years in improving student learning outcomes in the field of STEM. The research questions in this study are:

(a) What TPD is currently targeted for five-year-olds?

(b) What the instructional strategy STEM is most used by teachers on five-year-olds?

(c) What topics are most prominent in the research on TPD on five-year-olds?
2. Methodology

2.1. Database

The database used in the study was only sourced from the SCOPUS database with subject areas specific to social sciences. The limitation of using this database was that the data analysis process was based on simultaneous analysis of VOSviewer software in the form of "ris" files.

2.2. Procedure

The methodology applied in the study is to use a systematic review. Justification for the selection of this method was due to a strict, explicit, and responsible review system (Gough, Oliver & Thomas, 2017). Besides, this method could also synthesize based on the findings of previous articles that are more informative to other readers (Boland, Cherry & Dickson, 2014). The review process that was developed by inclusion and exclusion was carried out based on the research question in the study. The next step was to search the database, the suitability of the article is determined based on the title and abstract. Analysis of the aspects of TPD currently targeted on five-year-olds was to use a systematic review. While the analysis for the first and second research questions (RQ-1 and RQ-2) was used VOSviewer software version 1.6.15.0.

2.2.1. Key search

There are five keywords used in the article search process in the SCOPUS database:

(1) Key-1: (teacher and professional and development and on and stem) and (limit-to (pubyear, 2020) or limit-to (pubyear, 2019) or limit-to (pubyear, 2018) or limit-to (pubyear, 2017) or limit-to (pubyear, 2016)) and (limit-to (doctype, "ar")) and (limit-to (subjarea, "soci")) and (limit-to (exactkeyword, "professional development")) and (limit-to (language, "english")) and (limit-to (srctype, "j"))

(2) Key-2: (teacher and professional and development and on and science and education) and (limit-to (pubyear, 2020) or limit-to (pubyear, 2019) or limit-to (pubyear, 2018) or limit-to (pubyear, 2017) or limit-to (pubyear, 2016)) and (limit-to (doctype, "ar")) and (limit-to (subjarea, "soci")) and (limit-to (exactkeyword, "professional development")) and (limit-to (language, "english")) and (limit-to (srctype, "j"))

(3) Key-3: (teacher and professional and development and on and technology and education) and (limit-to (pubyear, 2020) or limit-to (pubyear, 2019) or limit-to (pubyear, 2018) or limit-to (pubyear, 2017) or limit-to (pubyear, 2016)) and (limit-to (doctype, "ar")) and (limit-to (subjarea, "soci")) and (limit-to (exactkeyword, "professional development")) and (limit-to (language, "english")) and (limit-to (srctype, "j"))

(4) Key-4: (teacher and professional and development and on and engineering and education) and (limit-to (pubyear, 2020) or limit-to (pubyear, 2019) or limit-to (pubyear, 2018) or limit-to (pubyear, 2017) or limit-to (pubyear, 2016)) and (limit-to (doctype, "ar")) and (limit-to (subjarea, "soci")) and (limit-to (exactkeyword, "professional development")) and (limit-to (language, "english")) and (limit-to (srctype, "j"))

(5) Key-5: (teacher and professional and development and on and mathematic and education) and (limit-to (pubyear, 2020) or limit-to (pubyear, 2019) or limit-to (pubyear, 2018) or limit-to (pubyear, 2017) or limit-to (pubyear, 2016)) and (limit-to (doctype, "ar")) and (limit-to (subjarea, "soci")) and (limit-to (exactkeyword, "professional development")) and (limit-to (language, "english")) and (limit-to (srctype, "j"))
2.2.1. Selection criteria

There are two levels of criteria in the article selection process in this study, namely inclusion and exclusion. Articles could be included when meeting the inclusion and inclusion criteria. Aspects observed in the process of inclusive criteria are.

(1) was published 2020-2016,
(2) has an explicit focus on access type in open access,
(3) has an explicit focus on document type in the article,
(4) has an explicit focus on the subject area in social science,
(5) has an explicit focus on exact keywords in professional development,
(6) was published in the English language, and
(7) has an explicit focus on a source type in the journal.

While the process of exclusive criteria is conducted in this study in Figure 1. The inclusive process implemented is based on two aspects (1) has an explicit focus on TPD STEM and (2) has an explicit focus on quantitative and qualitative methods.

Figure 1

Inclusion and exclusion criteria process

2.3. Data analysis

The process of data analysis in 30 articles according to the research question of the study. RQ-1 and RQ-2 were analyzed by systematic review analysis with a qualitative, deductive, and thematic approach (Schreier, 2013). There were 10 aspects analyzed in each article (1) Author, (2) Sample, (3) Teach-in level, (4) Setting, (5) Range of teaching profession, (6) PD items, (7) Instructional strategy on STEM, (8) Design,
(9) Duration, and (10) Assessment. These ten aspects were analyzed to identify emerging themes and patterns. While RQ-3 was analyzed using VOSviewer software version 1.6.15.0.

3. Result

The importance of TPD in the STEM learning process has a very significant impact on the quality of learning in the classroom. Therefore, many researchers study the TPD article that has been implemented through the teacher training process. Good professional development is one of the main keys to helping teachers to implement STEM in the T&L process. Professional development aims to train teachers on how to engage students to be active in the T&L process (Dailey & Robinson, 2016). The PD process provides a direct opportunity for teachers to learn the application of STEM subjects and present them in the T&L process. To produce good PD quality, a continuous development process is needed for teachers and support from administrators, collaboration with other teachers, and shared responsibility.

Based on Appendix A TPD is currently targeting five-year-olds is the focus on practical application skills in STEM (n = 19, e.g. Baker & Galanti, 2017; Barnard et al., 2020; Brand, 2020; Brenneman, Lange & Nayfeld, 2019; Brown & Bogiages, 2019; Dailey & Robinson, 2017; Dailey, Jackson, Cotabish & Trumble, 2018; Erdogan, Navruz, Younes & Capraro, 2016; Estapa & Tank, 2017; Havice, Havice, Waugaman & Walker, 2018; Keiler, Diotti, Hudon & Ransom, 2020; Maass & Engeln, 2019; Pleasants, Olson & De La Cruz, 2020; Pollard, Hains-Wesson & Young, 2017; Quigley Herro, Shekell, Cian & Jacques, 2019; Ring, Dare, Crotty & Roehrig, 2017; Siegel & Giamellaro, 2019; Smith & Nadelson 2016; Williams, Singer, Krikorian, Rakes & Ross, 2019). Practical application skill competency refers to the combination of teacher knowledge and practice in a coherent T&L process (Barnard et al., 2020). Besides, aspects studied by the researcher on five-year-olds are teacher attitudes and beliefs toward teaching integrated STEM (n = 4, e.g. Barnard et al., 2020; Brenneman, Lange & Nayfeld, 2019; Jamil, Linder & Stegelin, 2018; Thibaut, Knipprath, Dehaene & Depaepe, 2018). Teachers’ attitudes and beliefs have a positive effect on the process of professional development in STEM subjects (Chen, Huang & Wu, 2021). Therefore, teachers are encouraged to have a positive attitude and good confidence in applying STEM learning in the classroom through training programs.

The TPD implementation process is carried out by selecting the appropriate instructional strategy. Based on Appendix A instructional strategy most commonly used by teachers on five-year-olds is STEM-Problem based learning (n = 5, e.g. Capraro et al., 2016; Dailey & Robinson, 2017; Jamil, Linder & Stegelin, 2018; Navruz, Younes & Capraro, 2016; Pollard, Hains-Wesson & Young, 2017). Followed by inquiry-based learning (n = 3, e.g. Brand, 2020; Maass & Engeln, 2019; Smith & Nadelson, 2016). The advantages of the T&L process with inquiry involve five processes (1) engage, (2) explore, (3) explain, (4) elaborate, and (5) evaluate. The first level is the involvement of students who play an active role in asking questions so that it can stimulate their interest. On the second level, students are allowed to explore the subjects they are studying. This level provides an opportunity for students to find appropriate ideas and concepts. The third level is an explanation. This level provides an opportunity for students to convey to teachers and other peers how the exploration process they have done. The elaborate level is that students are given questions appropriate to the subject to expand the exploratory process implemented. Finally, it is the level of teacher evaluation of student findings. This level of assessment is useful for assessing students’ level of understanding of concepts and knowledge.

While the topics that are most prominent in the research on TPD on five-year-olds are shown in figures 3 and 4. That figures show that the network visualization of 30 articles was analyzed based on title, abstract, and keyword. The found four large groups frequently studied by researchers during the year...
2020-2016 in TPD on STEM are (1) teachers, (2) students, (3) science, and (4) STEM. Besides, these four large groups were studied in 2018 only (see Figure 4).

4. Conclusion

All The ongoing TPD processes can help teachers to implement the STEM learning process in the classroom. Quality learning does not escape the appropriateness of the strategy methods used by teachers. Based on the results of the analysis in this study shows that teachers need to care about the
practical application skills of STEM and teachers' attitudes and beliefs towards learning that integrates STEM.

While the instructional strategy used by teachers is STEM-Problem-based learning and inquiry-based learning. The advantage of this strategy is the active involvement of students in the T&L process so that it can encourage students to think directly about how to solve problems faced.

References


Appendix A. The details of the 30 studies included in the systematic literature review

<table>
<thead>
<tr>
<th>No</th>
<th>Author</th>
<th>Sample (n)</th>
<th>Teach in Level</th>
<th>Setting</th>
<th>Range of Teaching Profession</th>
<th>PD items</th>
<th>Instructional Strategy on STEM</th>
<th>Design</th>
<th>Duration</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Baker &amp; Galanti (2017)</td>
<td>6</td>
<td>Elementary and Middle School</td>
<td>United State</td>
<td>Varying teaching experiences</td>
<td>Focus on: (1) participants’ perceptions and understandings of STEM; (2) connections of participants’ specific contexts and roles to STEM integration; (3) the affordances and challenges MEAs offered to mathematics teaching and coaching; and (4) development of reasonable and realistic goals for the upcoming school year that involved the integration of MEAs</td>
<td>Mathematics tasks with MEA</td>
<td>Qualitative</td>
<td>3 weeks summer</td>
<td>Teacher Efficacy and Attitudes Toward STEM Survey</td>
</tr>
<tr>
<td>2</td>
<td>Barnard et al. (2020)</td>
<td>6</td>
<td>High School</td>
<td>Mississipi</td>
<td>24-35 year</td>
<td>Focus on: (1) Attitudes toward flipped learning &amp; teaching in STEM; (2) Knowledge application; (3) Instructional professionalism; (4) Learning environment management; (5) Technology skills; and Content knowledge-health</td>
<td>Flipped learning approach</td>
<td>Documenting method</td>
<td>One year</td>
<td>(1) Science Teaching Efficacy Belief; (2) Teaching Practices Inventory; (3) Teacher Self-Efficacy Scale; (4) Health Literacy Skills; (5) Knowledge assessments; (6) Document reviews; and (7) Structured observations and self-assessments</td>
</tr>
<tr>
<td></td>
<td>Program</td>
<td>School</td>
<td>United</td>
<td>Duration</td>
<td>Focus</td>
<td>Methodology</td>
<td>Qualification</td>
<td>Additional Details</td>
<td></td>
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<tr>
<td>3</td>
<td>Brand (2020)</td>
<td>Middle</td>
<td>United</td>
<td>6 to 30 years</td>
<td>Focused on time for practical application, reflection, and revision</td>
<td>Qualitative</td>
<td>A 3-day workshop in the summer</td>
<td>Interviews</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Brenneman, Lange &amp; Nayfeld (2019)</td>
<td>Preschool</td>
<td>United</td>
<td>2 years</td>
<td>Focus on: (1) Educator-driven design; (2) Supporting coaches; (3) Builds teachers’ content knowledge; (4) Attends to teachers’ attitudes and beliefs; (5) Engages with teachers at multiple levels (large group, small group, and one-on-one); (6) Connected to classroom practice; (7) Educators reflecting on practice, with feedback; (8) Creates a community of practice</td>
<td>Qualitative and quantitative</td>
<td>1-4 year</td>
<td>Questions/Survey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Brown &amp; Bogiages (2019)</td>
<td>Secondary</td>
<td>United</td>
<td>1-2 years</td>
<td>Focus on: (1) Mathematical and scientific content knowledge of teachers (integrated nature of knowledge and practice within and among the disciplines of science and mathematics) and connections between the MP and SEP</td>
<td>Qualitative</td>
<td>One in the summer and one in the fall</td>
<td>Instrumental case study</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Authors</td>
<td>Year</td>
<td>Grade(s)</td>
<td>Location</td>
<td>Length</td>
<td>Focus</td>
<td>Strategic Design</td>
<td>Quantitative and Qualitative</td>
<td>Two-day Training Experience</td>
<td>Notes</td>
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<tr>
<td>6</td>
<td>Bryans-Bongey &amp; Rosen (2019)</td>
<td>21</td>
<td>Middle and High School</td>
<td>Nevada</td>
<td>Four years or more</td>
<td>Focus on: Provided to master essential safety information, connect, explore flight simulation activities, fly drones, plan lessons, and deliver the new curriculum</td>
<td>Strategic design elements that ranged from an online course site with FAA/safety content and quiz</td>
<td>Quantitative and qualitative</td>
<td>Two-day training experience</td>
<td>Two-day training experience is included in the online course site with FAA/safety content and quiz.</td>
</tr>
<tr>
<td>7</td>
<td>Capraro et al. (2016)</td>
<td>56</td>
<td>Elementary, Middle, and High Schools</td>
<td>Urban area United States</td>
<td>0-7 years</td>
<td>Focus on: Professional learning communities</td>
<td>STEM PBL project-based learning</td>
<td>Qualitative and Quantitative</td>
<td>3-year longitudinal observational</td>
<td>3-year longitudinal observational is included in the study.</td>
</tr>
<tr>
<td>8</td>
<td>Czajka &amp; McConnell (2019)</td>
<td>11</td>
<td>Postsecondary</td>
<td>United States</td>
<td>Less than five years to over 20</td>
<td>Focus on: RTOP captures aspects of student-centered instruction (e.g. whether a lesson was directed by student ideas, the nature of teacher-student relationships)</td>
<td>InTeGrate teaching resources and the characteristics</td>
<td>Qualitative</td>
<td>Three semesters 2015</td>
<td>Three semesters 2015 is included in the study.</td>
</tr>
<tr>
<td>9</td>
<td>Dailey &amp; Robinson (2017)</td>
<td>60</td>
<td>Primary Schools</td>
<td>United States</td>
<td>One year</td>
<td>Focus on: (1) provided training on problem-based science curriculum units, inquiry-based instruction, classroom management, and technology use in the classroom; and (2) Establishing an investigative classroom</td>
<td>Problem-based curriculum unit</td>
<td>Experimential or experimental study</td>
<td>2-year The PASTeL and Diet Cola Test</td>
<td>The PASTeL and Diet Cola Test is included in the study.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project</th>
<th>Context</th>
<th>Duration</th>
<th>Focus</th>
<th>Method</th>
<th>Data Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Dailey, Jackson, Cotabish &amp; Trumble (2018)</td>
<td>19 Primary Schools, United States</td>
<td>Varying teaching experiences</td>
<td>Focus on: (1) How to increase student engagement with the addition of artistic components and technology tools; (2) The hands-on experiences to learn engineering practices, and (3) the ability to transfer the skills to the classroom</td>
<td>STEMulate Engineering Academy Students</td>
</tr>
<tr>
<td>11</td>
<td>Erdmann, Miller &amp; Stains (2020)</td>
<td>42 Postsecondary, Midwest United States</td>
<td>0 to 6 7 plus</td>
<td>Focused on: (1) Exam; (2) Clicker questions; (3) Homework; (4) Activities/assessment; (5) Quiz; (6) Student questions or comments; (7) formative assessment method is just-in-time teaching (JiTT)</td>
<td>Instructional planning and revisions</td>
</tr>
<tr>
<td>12</td>
<td>Erdogan, Navruz, Younes &amp; Capraro (2016)</td>
<td>48 High Schools, Southwest United States</td>
<td>3 years</td>
<td>Focus on: Innovative instructional practices</td>
<td>STEM PBL instruction</td>
</tr>
<tr>
<td>13</td>
<td>Estapa &amp; Tank (2017)</td>
<td>10 Elementary School, Midwest</td>
<td>Varying teaching experiences</td>
<td>Focus on: Engage with engineering design-based learning of science and mathematics</td>
<td>STEM integration and engineering design</td>
</tr>
<tr>
<td>14</td>
<td>Goodnough (2018)</td>
<td>38 Middle School, United States</td>
<td>5-30 years</td>
<td>Focus on: Contextual factors</td>
<td>Cultural-Historical Activity Theory (CHAT)</td>
</tr>
<tr>
<td>No.</td>
<td>Authors and Year</td>
<td>Grade/Region</td>
<td>Experience</td>
<td>Focus</td>
<td>Teaching Techniques</td>
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<tr>
<td>15</td>
<td>Havice, Havice, Waugaman &amp; Walker (2018)</td>
<td>Primary, Elementary, Middle, and High School, South Carolina</td>
<td>0 to more than 10 years</td>
<td>Focus on: (1) Integrative STEM curriculum that solved real-world problems; (2) Application of technology and engineering design-based teaching and learning in real-world problem, project, and design-based tasks; (3) Incorporate problem-based and project-based learning that helps students work in groups to develop cross-curriculum skills.</td>
<td>Integrative STEM education teaching techniques</td>
</tr>
<tr>
<td>16</td>
<td>Jamil, Linder &amp; Stegelin (2018)</td>
<td>Preschool, United State</td>
<td>38 years</td>
<td>Focus on: Teacher Beliefs about STEAM Education</td>
<td>STEM problem-based learning</td>
</tr>
<tr>
<td>17</td>
<td>Keiler (2018)</td>
<td>High School, New York City</td>
<td>2-13 years</td>
<td>Focus on: (1) Peer Enabled Restructured Classroom (PERC) (asking scaffolding questions, conducting the formative assessment, and providing targeted support); (2) The PERC class structure</td>
<td>Qualitative</td>
</tr>
<tr>
<td>18</td>
<td>Keiler, Diotti, Hudon &amp; Ransom (2020)</td>
<td>22</td>
<td>High Schools</td>
<td>New York City</td>
<td>One year</td>
</tr>
<tr>
<td>19</td>
<td>Love &amp; Wells (2018)</td>
<td>8</td>
<td>High School</td>
<td>United States</td>
<td>13 years</td>
</tr>
<tr>
<td>20</td>
<td>Maass &amp; Engeln (2019)</td>
<td>1256</td>
<td>Primary and Secondary School</td>
<td>Europe</td>
<td>Varying teaching experiences</td>
</tr>
<tr>
<td>21</td>
<td>Nesmith &amp; Cooper (2019)</td>
<td>59</td>
<td>Elementary School</td>
<td>Central United States</td>
<td>7 teachers one year, 9 teachers more than 20, and majority 1-5 year</td>
</tr>
<tr>
<td>22</td>
<td>Pleasants, Olson &amp; De La Cruz (2020)</td>
<td>38</td>
<td>Elementary Schools</td>
<td>United State</td>
<td>Three or more years</td>
</tr>
<tr>
<td>#</td>
<td>Authors (Year)</td>
<td>Level</td>
<td>Country</td>
<td>Duration</td>
<td>Focus Areas</td>
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<tr>
<td>23</td>
<td>Pollard, Hains-Wesson &amp; Young (2017)</td>
<td>Secondary</td>
<td>Australia</td>
<td>3.5-20 year</td>
<td>Creative teaching practice</td>
</tr>
<tr>
<td>24</td>
<td>Quigley Herro, Shekell, Cian, &amp; Jacques (2019)</td>
<td>Middle School</td>
<td>Southeastern United States</td>
<td>0 to more than 20 year</td>
<td>Focus on: (1) Problem-based approach (PB); (2) Authentic tasks (AT); (3) Multiple solutions (MS); (4) Student choice (SC); (5) Technological integration (TI); (6) Teacher facilitation (TF); and (7) Discipline integration (DI)</td>
</tr>
<tr>
<td>25</td>
<td>Ring, Dare, Crotty &amp; Roehrig (2017)</td>
<td>Elementary &amp; High School</td>
<td>Midwest United States</td>
<td>At least 3 years</td>
<td>Focus on: (1) Introduction to Engineering Education Framework; (2) Process of Design Session; (3) Content Breakout Sessions; (4) Introduction to STEM Integration Framework; (5) STEM Integration Coaching Conversations; (6) Cooperative Learning Session; (7) Curriculum Writing; (8) Brainstorming Technique Session</td>
</tr>
<tr>
<td>26</td>
<td>Siegel &amp; Giamellaro (2019)</td>
<td>Elementary, Middle</td>
<td>Pacific Northwest</td>
<td>0-39 year</td>
<td>Focus on: (1) STEM is a curriculum: Project-based learning (PBL) and real-world application; (2) Sociocultural approach</td>
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<tr>
<td>No.</td>
<td>Authors</td>
<td>Participants</td>
<td>Setting</td>
<td>Duration</td>
<td>Focus Areas</td>
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