Work in Progress: Impact of Non-Degree Credentials on STEM Workforce Development-A Systematic Literature Review

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Abstract

While non-degree credentials hold the potential to revolutionize access to the STEM workforce by providing more opportunities and pathways to gain relevant knowledge, skills, and abilities [1], a critical challenge to their use lies in the ways learners, academic institutions, and employers understand and value non-degree credentialing programs. This work-in-progress paper aims to synthesize the empirical published literature on the impact of non-degree credentials related to STEM workforce development. This review aims to synthesize relevant information and develop guidelines for future research and two-year college education practice related to non-degreed workforce training credentialing and work-based learning programs for STEM degree and non-degree holders. Working with a research librarian, we developed keywords and database-specific search terms for three robust databases, Education Source, ERIC, and Scopus, to locate education-related literature within the area of STEM workforce development. To reduce self-selection bias, which is the primary threat to the validity of secondary research, the selection of articles for inclusion in the study was guided by a set of inclusion and exclusion criteria. During data extraction, we gathered and categorized information on study design, participant demographics, and outcomes. During synthesis, we will employ qualitative content analysis to assess research quality and thematically analyze study results [2]. The preliminary findings provide a comprehensive characterization of the emergent empirical literature related to non-degree credentialing programs in STEM fields. Results indicate that NDCs emerged as an area of STEM education and workforce research interest during the past ten years. Specifically, practical training, hands-on experiences, career preparation, and short-term certificate programs comprise current STEM NDC program initiatives. Moreover, the results provide guides for researchers, educators, industry leaders, and policymakers in shaping the future landscape of STEM education and workforce development.

Introduction

Known for demanding, technically focused preparatory approaches, science, technology, engineering, and mathematics (STEM) career fields have traditionally emphasized completion of a formalized, post-secondary degree program as the primary indication of workforce readiness [3], [4], [5]. However, considering today's global labor market dynamics and the increasing pace of technological advancement, scholars now suggest that a broader, more accessible array of STEM workforce qualifications and pathways is needed [6], [7], [8], [9], [10], [11]. Resultantly, non-degree credential (NDC) programs are drawing interest due to their broad accessibility, lower cost, shorter duration, and ability to be quickly tuned and adjusted to meet evolving industry needs. In this work-in-progress research paper, we report on the preliminary findings of a systematic review of empirical literature related to the implementation and impact of NDC programs for the U.S. skilled STEM workforce. Overall, our systematic literature review broadly aims to address three research questions (RQs):

RQ1. How are non-degree credentialing programs being implemented for STEM workforce development in the United States?

RQ2. How (e.g., academically, economically, societally, etc.) does the implementation of non-degree credentialing programs impact the U.S. STEM workforce?

RQ3. What types of workforce readiness knowledge, skills, and abilities are integrated within STEM non-degree credentialing programs, and how do they align with the industry's needs?

Our preliminary findings characterize the existing literature in terms of publication timeline and trends, workforce populations studied, types of non-degree credential(s) implemented, industry sectors targeted, and NDC challenges and gaps identified. These preliminary findings provide broader insights for educators, industry leaders, and policymakers currently engaged in shaping the future landscape of STEM workforce development and for identifying directions for future research in this emerging area of importance to the STEM workforce.

Background

Higher education degree programs have historically played a critical role in workforce development in the United States by providing a mechanism for knowledge and skill acquisition that is purported to lead to meaningful employment and higher salaries. NDCs play a valuable role in STEM workforce development, though it is different from traditional engineering degree programs. Today, traditional and non-traditional students are expected to benefit from NDCs that provide supplemental training toward jobs or education [1]. Though fundamentally different from post-secondary science and engineering degree programs, NDC programs are expected to play a valuable role in STEM workforce development.

NDCs include licenses, certificates, certifications, badges, and micro-credentials designed to fulfill different student, employer, and community training needed. NDCs can be stacked, embedded, or matched with degrees, thereby improving professional flexibility and progress. Certifications and certificates demonstrate specific competencies or acknowledge training, meeting job market and technology demands. Badges and micro-credentials provide digital proof of acquired credentials or skill acknowledgments that recognize learning achievements that are narrower more comprehensive credentials [1].

NDC Trends in the U.S. Workforce. Through the provision of two-year associate degrees and NDC programs, two-year community and technical colleges are increasingly viewed as alternative pathways to four-year academic degree programs and gateways to the science and engineering workforce [1], [12]. Moreover, there is a rising number of NDCs, such as certificates, offered independently as well as integrated within degree programs. For example, according to the National Science Board [13], over 200,000 science and engineering certificates were awarded by community colleges in 2021. Industries and professional development organizations are also using NDCs to supplement the training and learning outcomes for individuals who already hold four-year post-secondary degrees [14].

Since 2000, the postsecondary certificate has been the fastest-growing credential in the United States [15]. The study by Weeden and colleagues [16] highlighted that approximately 1,908 existing certificate programs are in the United States. By 2021–2022, over 1 million certificates below the baccalaureate level had been conferred by postsecondary institutions, with approximately 58% of these certificates awarded to women [15]. While it can be argued that credentialization is increasing rapidly in the United States, it remains a challenge to identify individuals who have NDCs and use them to obtain employment [17].

NDC Trends in the U.S. STEM Workforce. According to Chen and colleagues [1] over 36 million U.S. workers were employed in STEM-related occupations in 2019. Because STEM-related jobs often require specific expertise, STEM workers commonly receive specific forms of education and training to equip them with the necessary skills, knowledge, and abilities to perform effectively within STEM industries [18]. It is projected that, from 2020 to 2033, employment in architecture and engineering occupations will grow faster than the average, with an average of 195,000 job openings each year due to the employment growth and the need for replacement of retirees [19]. To fill these gaps, workforce development programs that offer job readiness through skills development are essential.

According to Okrent and Burke [20], slightly more than half of STEM workers do not have a bachelor's degree. Approximately 19% of these workers are employed in healthcare; 20% in construction trades; 21% in installation, maintenance, and repair; and 14% in production-related occupations. NDC programs that demonstrate and certify skills needed in these industries are particularly valuable for these workers. The U.S. Bureau of Statistics' career outlook on education level has projected that, between 2023-2033, fifty-one occupations will require certificates or other NDCs to fill available openings [21]. While many of these fifty-one occupations are non-STEM related occupations, there is strong evidence of positive earnings outcomes for those earning certificates in various STEM occupational areas (i.e., computer and information sciences, nursing, and construction) [21].

Methodology

In this Systematic Literature Review [22], we identified, selected, and examined peer-reviewed empirical research related to the implementation of NDC programs for STEM workforce development in the United States. Our research design coheres with formal frameworks [23],

[24] for conducting systematic literature reviews. Specifically, we followed the seven-step process recommended by Borrego et al. [23] for conducting a systematic review in engineering education and other interdisciplinary fields:

Step 1: Deciding to do a Systematic Review
Step 2: Formulating the Research Questions
Step 3 Defining Inclusion Criteria,
Step 4: Finding and Cataloging Research Articles
Step 5: Critique and Appraisal Research Articles
Step 6: Synthesizing the data
Step 7: Addressing Limitations.

Deciding to do A Systematic Literature Review (Step 1): Our primary reasons for conducting this SLR were to synthesize empirical information, identify research gaps, and develop guidelines for future research and educational practice related to non-degree workforce training credentialing and work-based learning programs that are accessible to all learners [24].

Formulating the Research Questions (Step 2): Following published recommendations for designing research questions [25], the lead author drafted a list of possible RQs. Subsequently, the research team continued to collaboratively refine the RQs as the study evolved.

Defining Inclusion Criteria (Step 3): The research team defined seven article inclusion criteria based on the purpose of the review and our research questions. These inclusion criteria require that selected articles:

i. Are empirical in nature to enable the authors to synthesize available research and provide directions for future research and educational practice;
ii. Are published in archival journals or peer-reviewed conference proceedings to ensure that all articles have undergone a rigorous review and meet scholarly standards;
iii. Are published between 2000-2024 to capture recent research advancements, methodologies, and trends while excluding potentially outdated findings;
iv. Are published in English because it is the single common language among the research team members;
v. Represent research conducted in the United States to focus the review geographically and within a common economic and workforce context;
vi. Are focused on STEM workforce development to gather evidence of emerging impacts of NDC programs in STEM-related occupations; and
vii. Describe an implementation of NDCs (i.e. certificates, certifications, skill training documentation) to ground the synthesis in emerging NDC workforce practices.

Finding and Cataloging Research Articles (Step 4): We completed three steps for finding and cataloging the research articles: (a) choosing the databases to use to find articles; (a) defining search terms and logical operators (i.e., AND, OR) for each database; and (c) selecting articles for inclusion [23]. At this stage, the lead author met with a research librarian at his institution; the librarian helped identify available engineering education databases, organized the SLR search terms that the team had brainstormed, and created a structure for the Boolean operators to aid our search [23]. Based on database availability at our institution and our librarian's recommendations, we selected three databases to use to generate articles for this review: Education Source, Scopus, and ERIC. To define our database search terms, we conducted a preliminary Google Scholar search to identify key terms and then used these terms to develop preliminary search keywords: non-degree credentials, alternative certificates, certifications, training programs, industry credentials, micro-credentials, credentialing, stackable, bootcamps, apprenticeships, MOOCs, upskill, and engineering workforce development. After a second discussion with our research librarian about our preliminary search keywords, we categorized them into three groups (S):

S1: Credentials, certificates, certifications, training programs, upskilling.
S2: non-degree, alternative, industry, micro, stackable; and
S3: Bootcamp, apprenticeship, MOOCs.

The librarian helped us develop the following search strings based on the groups to satisfy the unique specifications of each database. We then ran our first database search using the search strings as shown in Table 1.

Table 1: Databases for literature search string #1

Database	Syntax	Results
Education Source	(credentials OR certificates OR certifications OR training OR upskilling) AND (non-degree OR alternative OR industry OR micro OR stackable) AND (engineering workforce development)	30
Eric	(credentials OR certificate OR certification OR training OR (upskilling and reskilling)) AND (non-degree OR alternative OR 2-year college OR industry OR micro-credentials OR stackable) AND (engineering workforce development)	24
Scopus	(TITLE-ABS-KEY (credentialing) OR TITLE-ABS-KEY (credential) OR TITLE-ABS-KEY (certification) OR TITLE-ABS-KEY (certificate) OR TITLE-ABS-KEY (training) OR TITLE-ABS-KEY (upskilling) OR TITLE-ABS-KEY (reskilling) OR TITLE-ABS-KEY (non-degree) OR TITLE-ABS-KEY (alternative) OR TITLE-ABS-KEY (2 year AND college) OR TITLE-ABS-KEY (micro-credentials) OR TITLE-ABS-KEY (stackable AND credentials) AND TITLE-ABS-KEY (engineering) AND TITLE-ABS-KEY (workforce AND development) AND TITLE-ABS-KEY (stem) AND TITLE-ABS-KEY (industry)) AND (LIMIT-TO (SUBJAREA , "ENGI")) AND (LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English"))	55

After conferring among the team, we revised the search strings by adding "STEM" in the syntax and "AND" as a new operator. We then ran our second database search using the search strings as shown in Table 2.

Table 2: Databases for literature search string #2

Database	Syntax	Results
Education Source	(credentials OR certification OR certificates OR training program AND Engineer* AND stem) OR (non-degree OR alternative OR industry OR micro OR stackable AND engineer* AND STEM) OR ((bootcamp OR apprenticeship OR 2 year college OR (moocs or massive open online courses) AND Engineer* AND STEM)) AND (engineer* workforce development)	67

Eric	(credentials OR certification OR certificates OR training program AND engineer* AND STEM) OR (non-degree OR alternative OR industry OR micro OR stackable) OR ((bootcamp OR (apprenticeships or apprenticeship programs or apprenticeship training) OR 2 year college OR (moocs or massive open online courses)) AND ((engineer* AND STEM AND (workforce or workplace or labor or employee)))	89
Scopus	(TITLE-ABS-KEY (credentials) OR TITLE-ABS-KEY (certification) OR TITLE-ABS-KEY (certificate) OR TITLE-ABS-KEY (training AND program) OR TITLE-ABS-KEY (non-degree) OR TITLE-ABS-KEY (alternative) OR TITLE-ABS-KEY (industry) OR TITLE-ABS-KEY (micro) OR TITLE-ABS-KEY (stackable) OR TITLE-ABS-KEY (bootcamp) OR TITLE-ABS-KEY (apprenticeship) OR TITLE-ABS-KEY (moocs) AND TITLE-ABS-KEY (engineer*) AND TITLE-ABS-KEY (stem) AND TITLE-ABS-KEY ("workforce development")) AND PUBYEAR > 2003 AND PUBYEAR < 2025 AND (LIMIT-TO (SUBJAREA , "ENGI")) AND (LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re") OR LIMIT-TO (DOCTYPE , "cr")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (EXACTKEYWORD , "Engineering Education") OR LIMIT-TO (EXACTKEYWORD , "STEM (science, Technology, Engineering And Mathematics)") OR LIMIT-TO (EXACTKEYWORD , "Students") OR LIMIT-TO (EXACTKEYWORD , "Workforce Development"))	35

In running searches with this revised set of search strings, we noticed that our second search set did not fully encapsulate the findings of our first search, most likely due to the addition of the “STEM” identifier. Therefore, we combined the results from both database searches to ensure our search was as exhaustive as possible.

Title and Abstract Screening: Results from the two searches yielded a total of 303 papers (300 identified through database searches and 3 identified through citation searches from the references of a paper that the lead author used for an article critique assignment in a gr). We used the PRISMA flowchart [26] as a guideline for describing the results of the screening process (Figure 1). The 303 generated articles were uploaded into Mendeley 2.124.0. by the first author, where 49 duplicate articles were removed because they appeared more than once with the same title, same author's name, and same published year.

After removing duplicates, we retrieved and evaluated the titles and abstracts of 254 articles based on the defined inclusion criteria mentioned above. The first and third authors independently assessed each article by exporting all 254 articles as RIS files into Microsoft Excel. Following the screening, 82% agreement was met from the authors' reviews. The authors engaged in a Zoom conference call and reached a consensus on 54 papers to be moved on to the full-text review. As shown in the PRISMA flow diagram (Figure 1) seventy-five articles were removed because they reported on informal, rather than on formalized, training. Forty-five articles were removed because they focused on curricular and pedagogical interventions rather than formalized NDC programs. Nineteen articles were removed because the targeted studies were done outside the United States, and 61 were removed because they focused on policy and were not related to NDC implementation focus.

Full-text Appraisal (Step 5): The first and third authors then independently assessed the full texts of the 54 articles that passed the title and abstract screening for agreement with the inclusion criteria. As the authors read the articles, they took notes on the purpose of the study, the STEM field, participants, main findings, and limitations. Subsequently, another Zoom conference call was initiated to reach a consensus on articles that should be included in the final review synthesis. After the full-text review, we found that 16 articles met all inclusion criteria**.**

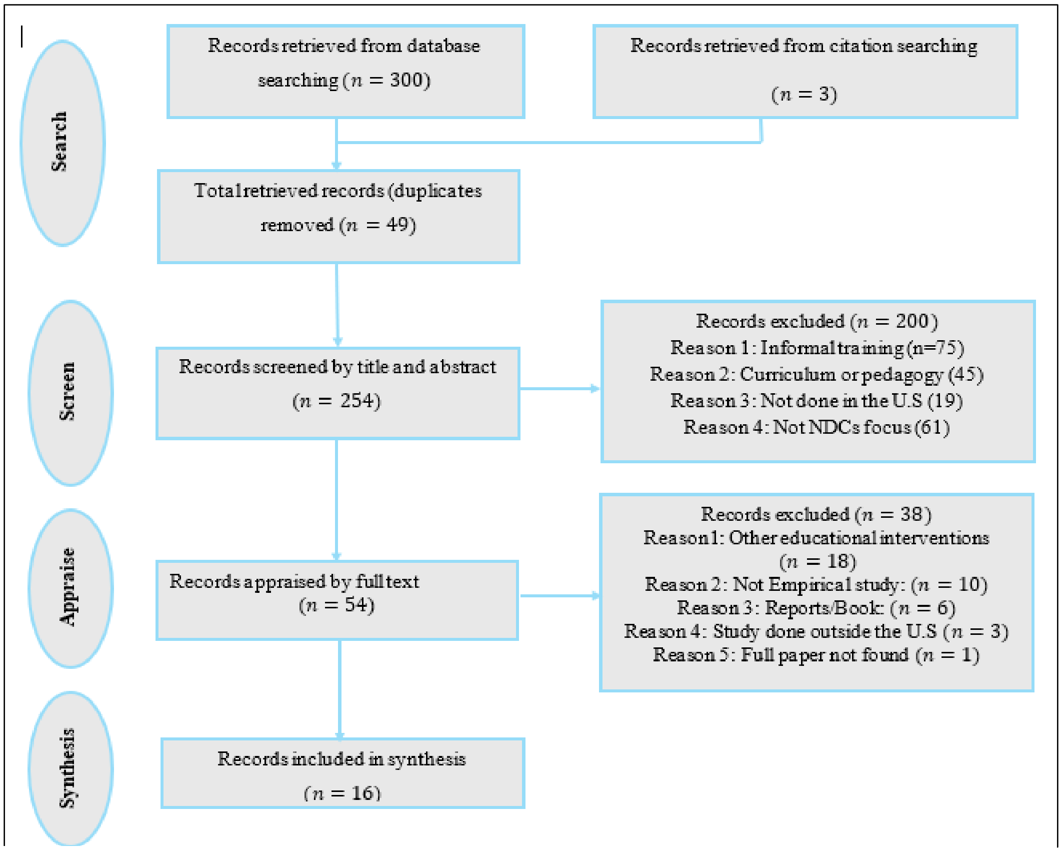

Figure 1: PRISMA flowchart for the systematic review of STEM workforce development in engineering education [26]

Data Synthesis (Step 6): The final step of the systematic literature review process is to conduct a content analysis of the data across the 16 included articles. Content analysis is a synthesis method using qualitative and/or quantitative data to extract key themes, differences, and patterns that could address our RQs [27]. In future work, we will independently code each article and then convene virtually to harmonize findings and apply thematic analysis to synthesize results [2], [28]. Finalized synthesis results will be presented in a follow-on publication. Results will synthesize competencies based on well-defined readiness skill frameworks, provide an assessment of article quality, and describe overall results to answer the RQs.

In this work-in-progress paper, we report on preliminary findings that we developed using a coding frame to categorize data, including publication timeline and trends, research methods, participant population engaged, types of non-degree credential(s) awarded, industry sectors targeted, and challenges and gaps identified, if any, across articles. The completed coding frame is provided in the Appendix.

Results

Preliminary Findings. Publication timeline and trends. Our resultant set of included articles comprised 16 papers. As shown in Figure 2, there were no articles published between 2000 to 2013, five articles were published between 2014 and 2019, and 11 articles were published between 2020 to 2024. This finding suggests that interest in STEM-related NDC programs and/or the urgency of STEM workforce hiring are emerging and potentially increasing. There were 12 articles published between 2014 to 2024 in archival journals [29], [30], [31], [32], [33], [34], [35], [36], [37], [38], [39], [40]. After 2020, articles were published in archival journals and peer-reviewed conference proceedings. Also, there were four conference proceedings [34], [41], [42], [43], [44].

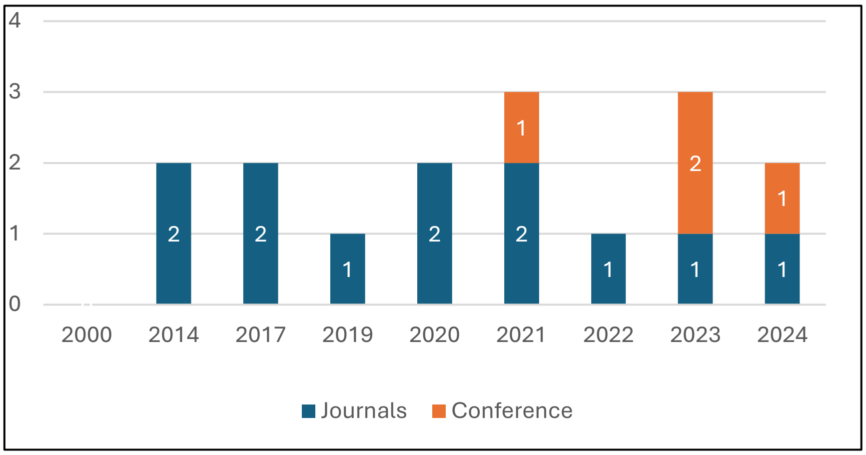

Figure 2: Number of included articles by year and type of publication

Research methods. As demonstrated in Figure 3, most of the included articles (10 /16) employed mixed methods approaches [29], [30], [31], [34], [35], [36], [40], [41], [43], [44]. The remaining six studies employed either quantitative [32], [37], [38], [39] or qualitative [33], [42]. We also observed that more of the journal articles (7/10) used mixed methods approaches [29], [30], [31], [34], [35], [36], [40], with fewer mixed methods studies published in conference proceedings (3/10) [41], [43], [44]. The use of mixed methods approaches for research in this area may be driven by a desire to holistically understand the educational impacts of NDC programs. By employing mixed methods approaches, researchers quantified program effectiveness, explored participants' experiences, and considered contextual factors that might influence the outcomes [29], [30], [40]

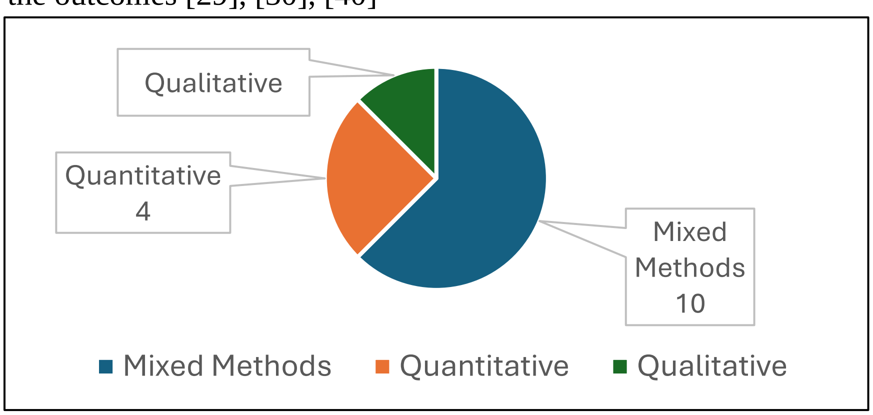

Figure 3: Number of included articles by research

Participant Populations. As displayed in Table 3, the included studies engaged with diverse participant groups from within the STEM workforce, including undergraduate and graduate STEM and engineering students [30], [41], [42], [43]; industry leaders, employees, and entry-level workers [33], [35], [38], [39], high school students from underserved communities [29], adult learners (i.e., non-traditional students) and underrepresented students at community colleges (i.e., women, veterans, disabled persons) [30]; and apprentices from historically underrepresented groups [31].

Table 3: Content analysis of NDCs synthesis literature

Authors	Participants
[29]	100 participants of high school students from underserved communities
[30]	343 participants of adult learners and underrepresented students including non-traditional students, women, veterans, and disabled persons in STEM at community colleges.
[31]	Targeted apprentices from historically underrepresented groups in Oregon
[41]	68 undergraduate students from diverse backgrounds including underrepresented groups
[42]	Engineering students seeking internships and work experience in industry
[32]	students who enrolled in postsecondary education from 2003-2004
[33]	Production workers in two manufacturing firms
[34]	69 alumni Underrepresented minority students
[35]	55 industry leaders from various agricultural sectors
[36]	Working engineers
[37]	Women STEM PhD holders
[43]	Puerto Rican engineering students and graduates who faced challenges in passing the PE exams
[44]	University STEM students including women and first-generation students
[38]	Employees and stakeholders
[39]	Those entering the skilled technical workforce
[40]	Students in STEM-related online courses designed to provide professional development

NDC approach. As shown in Figure 4, NDC approaches varied across the included studies. Six studies focused on programs that provided professional and/or practical skills training and hands-on experiences to bridge the gap between theoretical knowledge and real-world application to enhance career readiness [29], [33], [34], [37], [41], [44]. While these programs did not provide physical credentials, completion of the training can be used for job signaling in participant resumes and job applications. Another eight studies explored programs that provided short programs and awarded certificates or badges to their participants [30], [32], [35], [38], [39], [40], [43], [36]. Finally, Arnold and Kelly [31], and Xie [29], [31] examined apprenticeships and internship training workforce development. These studies considered the completion of an apprenticeship program that combined classroom learning with on-the-job training.

Credentials Provided. *Certificates* were provided by community colleges or universities and were designed to document the completion of short-term training in specialized skills in areas such as manufacturing, construction, or technical roles within STEM fields. *Badges* were most often a digital form of certification that validated smaller sets of, or specific, skills or competencies. *Certifications* were awarded in the form of professional qualifications, such as those required for passing the professional engineering (PE) exams. For example, Nutwell and colleagues [36] examined the effectiveness of non-credit online courses to help professional engineers bridge the gap between theory and practice. Also, Rivera and colleagues [43] identified challenges that professional engineers face while attempting to pass the PE examination. Therefore, certifications documented the technical proficiency of participants, ensuring they met industry standards necessary for certain engineering roles [43]

Figure 4: Number of studies by NDC approach

Industry sectors. As shown in Figure 5, we found that eight studies were conducted with participants from STEM and engineering fields [32], [34], [36], [37], [39], [40], [42], [43]. Of the 16 reviewed studies, four studies focused on workforce development in the manufacturing and construction industries [30], [31], [33], [44]. Also, three studies were implemented in some combination of information technology, GIS, electrical and computer engineering [29], [38], [41], and one study was conducted in agricultural engineering [35].

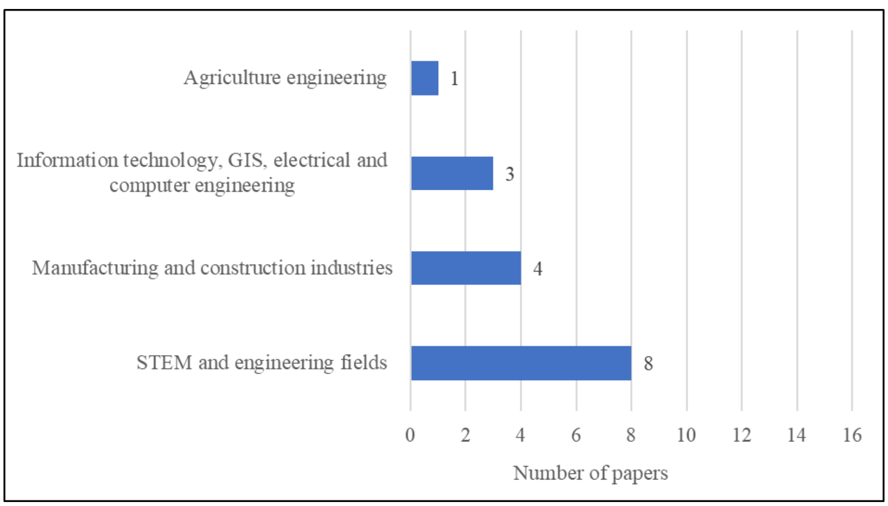

Figure 5: Numbers of papers by field

Discussion

Our preliminary results show that NDCs as a mechanism for STEM workforce development have emerged as an area of research over the past ten years. As shown in Figure 2, there has been a gradual increase in publication over recent years. Also, the distribution of publications over the years demonstrates that, while the field is gaining attention, the pace is modest, and substantial opportunities are emerging for future research.

As shown in Figure 2, most researchers disseminated their findings in journal articles. This preference might reflect the depth of research and comprehensive methodologies these studies employed, which are always more suited for journal formats. Notably, most published papers concentrate on training and certificate programs (Fig.4). These data demonstrate that practical training, hands-on experiences, career preparation, and short learning leading to certificates comprise current NDC workforce development initiatives in STEM.

As shown in Table 3, the articles emphasized the transformative potential that NDCs have for improving access to STEM workforce development opportunities for all. Interestingly, NDCs are considered to have the capacity to bridge the educational and workforce gaps faced by underrepresented groups in STEM education, including minorities, women, and non-traditional students. For instance, Arnold and Kelly [32] highlight how NDCs can provide practical pathways to skilled professions, particularly for groups traditionally excluded from these fields. Mohammadi and colleagues [31] illustrate how online educational platforms and flexible learning models can extend opportunities to a wider audience, including those who may experience barriers to engagement in traditional educational settings. These studies suggest ways in which NDCs can become instrumental in making STEM careers more accessible and equitable.

Challenges and gaps

The reviewed papers identified a broad spectrum of challenges and gaps in STEM workforce development through NDC programs with a strong emphasis on diversity, accessibility, and educational alignment with industry needs. For instance, the studies done by Arnold and Kelly [31] and Mohammadi and colleagues [30] demonstrated barriers to entry for underrepresented groups in apprenticeships and technical fields, highlighting the need for more inclusive training programs. In the study by Xie [29] highlighted the necessity to engage underrepresented communities through meaningful internships and real-world projects that could sustain interest in STEM fields. Additionally, some of the studies emphasized the need for educational reforms that could integrate practical skills with theoretical knowledge, as seen in works focusing on two-year college pathways and the role of online experiential learning in improving STEM readiness [30], [32]. The papers that were reviewed collectively underline the critical need for systemic educational and workplace reforms to address the ongoing challenges that could equip a diverse workforce with relevant skills in an advancing technological landscape.

Limitations

Limitations for this SLR reflect those reported by Victoria and colleagues [45]. Because our literature search was completed using three databases available at our institution, our searches of the empirical literature may not have included all work performed and published on the topic. Because we focused this study on formalized NDC programs related to STEM workforce readiness, there may be informal or emerging industry training that is not reported or available in the extant empirical literature. In-house training programs conducted by industries, for example, are not likely to be published as peer-reviewed studies, and findings related to massive open online courses (MOOCs) outcomes may not be published in peer-reviewed studies because of the large levels of participation.

Despite these limitations, we ensured the systematicity and quality of this review in several ways. We worked with a research librarian to ensure our searches strategies were effective and our chosen databases had strong coverage of the topic. We conducted all article selection and assessment steps with at least two research team members working together collaboratively. Every decision related to the design and conduct of this review was conscious, documented, and determined via consensus. In this way, the research team mitigated self-selection bias, the primary threat to the validity of research using secondary data sources.

Conclusion and implication

In conclusion, this SLR not only maps the current landscape of STEM workforce development through NDCs but also sets the stage for future research to provide more dynamic, responsive educational studies within this field. Therefore, by widening the scope of future studies and employing a well-structured quality assessment tool, our future synthesis analysis will enhance the validity and applicability of research outcomes that could further contribute to the existing body of knowledge on how NDCs impact workforce readiness in STEM fields in the U.S. The included studies identified the need for educational reforms in engineering education by creating and improving the educational system to meet not only student's needs but also industry and the utility of NDCs in two-year colleges.

Major findings suggest a need for two-year colleges to consider integrating more hands-on, practical training within their existing STEM programs and to provide equal access for all, especially underrepresented groups (i.e., women, non-traditional students) [29], [31] by updating curricula to include more real-world applications, and case studies that reflect current industry practices and challenges and by introducing a flexible, safe learning environment that everyone. There is also a need for technical and community colleges to create strong partnerships with local industries to facilitate work-based learning opportunities (i.e., Internships and apprenticeships). Establishing alliances will enhance the practical training component and increase students' jobs upon completion of their NDC programs. Furthermore, two-year colleges should work closely with industry leaders to ensure that the credentials their programs offer are recognized and valued by employers. This could ensure that there are regular reviews and updates to the credentialing process to keep pace with industry changes.

To support underrepresented groups, two-year colleges should provide flexible learning options (i.e., weekend classes, online courses, and hybrid courses) and support services (i.e., tutoring, mentoring, and career counseling) to help ensure that all students have the necessary resources to succeed. Future research should explore innovative pedagogies, work-based learning, and industry collaborations that could enhance real-world skills application. Lastly, examining the role of NDCs in engineering education and their recognition by employers could further validate their importance in enhancing employability and meeting industry demands, ensuring educational systems adapt effectively to workforce needs.

Acknowledgment

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* Indicates article included in the work-in-progress systematic literature review

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