Broadening Participation in Adult Education: A Literature Review of Computer Science Education

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ABSTRACT

Extending computer science (CS) education to address inclusion, diversity, and equity in all settings can broaden the participation of underrepresented groups including the adult education. Recently, studies have examined CS education at elementary and college levels, however, little is known in the context of adult education. This study systematically investigates past studies on computing education research in adult education (formal or informal) through the lenses of a literature review. The study sought to understand: (i) how research in this domain has evolved over the years; and (ii) what impact - in terms of learning outcomes - has been reported in the literature. Data were collected from three databases including the ACM digital library, Scopus, and Web of Science. Findings from this study show that despite CS in adult education had started since the 1980s, there is little scholarly progress and advancement witnessed in this domain. In addition, indicators measuring the impact of broadening participation in CS education among adults appear insignificant. Further, the learning outcomes reported in CS education research for adults includes motivation, increased interest, self-confidence, and computing knowledge. This study revealed several gaps and draws scholar's attention to broadening participation in Adults' CS education, highlighted study implications and future research agenda.

CCS CONCEPTS

• **Social and professional topics** → **Adult education**.

KEYWORDS

broadening participation, computing education, adult education, literature review

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1 INTRODUCTION

Advances in Science, Technology, Engineering, and Mathematics (STEM) education to provide twenty-first-century skills are ongoing. In the recent past, several practices and concepts have been introduced by scholars to foster this agenda. For example, broadening participation in STEM, inclusion, equality, and diversity in STEM, are among the concepts introduced in literature. Indicators to measure the success of these practices over a given period exists [50]. For example, one indicator of this success is the increase in the number of underrepresented groups who have access to and benefits from STEM knowledge, studying STEM, or even working in STEM areas.

There have been excellent efforts in broadening participation in CS by democratizing computing education [2] to cater for the inclusion of underrepresented groups [6]. Yet, many of the existing research focuses on K-12 [43] or college students [26, 37]. While there is a growing studies in advancing computing education and broadening participation in STEM in different contexts including K-12 [8, 43], little attention is given to broadening participation in the context of adult education [17, 28]. In this study, 'adult education' refers to both formal and non-formal modes of learning and education to encourage personal and professional development by promoting and integrating active citizenship in the twenty-first-century [12]. Hence, until computing education in the adult education context receives serious research attention, we may be failing to realize the goal of inclusion and broadening participation from the notion of CS4all [8].

According to Rutherfoord [40], it is important to understand adults' learning process, especially in this digital age, and because adults learn differently compared to young children, there is a need to examine studies that provide indicators on how broadening participation in STEM for adult education are growing. Hence, this study aims to investigate the democratization of computing education through the lens of a literature review of articles that focus on broadening participation in CS in the context of adult education. A literature review is a useful approach in exploration study that aims to investigate the evolution of a research idea or field [49]. Therefore, this study is guided by two research questions (RQ):

RQ1. How has computing education in the context of adult education evolved? This research question provides insights into how studies that demonstrate computing education in the context of adult education emerged and progressed over the years, and what we might learn from the recent status that could shape future research in this field.

RQ2. What outcomes are reported in studies on CS for adult education? This research question seeks to unravel successes or failures

reported by studies focused on computing education in the context of adult education and to investigate the indicators of such outcomes in relation to broadening participation.

2 BACKGROUND AND RELATED WORK

Broadening participation in CS education has taken diverse approaches over the years [42]. One of the recent practices introduced by scholars is the principle of Culturally Responsible Computing (CRC), which aims to increase interest in computing among various groups who are underrepresented [10]. The CRC which stems from the theory of Culturally Responsible Teaching (CRT) introduced by Gay [13], has been discussed as a pragmatic principle for addressing digital disparity, considering the diverse community of learners [42]. According to Stevens et al. [48], CRT allows instructors to incorporate learners' identities and backgrounds into the classroom by designing a curriculum that fits learners of diverse cultural backgrounds. This practice brings a sense of inclusion into the learning environment and creates opportunities for more engagement and participation. Indeed, CRC has been used to increase participation in STEM among young K-12 learners [35], and adults in STEM education [47]. If we are to teach CS to adults with the aim of motivating their interest and increasing their participation in computing, a CRC approach is necessary. Moreover, developing a curriculum for teaching CS in the context of adult education can be daunting. For adults, the principle of self-directed and independent learning, which is an element of andragogy – the study on how adults learn — is a usual practice [40]. Andragogy was promoted by Knowles [23], an author who provided theory and assumptions that characterized adult education. Particularly in the context of computing education, andragogy has been found useful for adult education [38]. Therefore, exploring andragogy as a pedagogical approach and CRC principle could foster meaningful strategies for broadening participation for CS in adult education [3].

To understand the research landscape of CS in the context of adult education, scanty studies were found. For example, Kim [21] conducted a review of computer learning and usage among older adults by analyzing data collected from ERIC, Academic Search Premier, and PsycINFO to unravel insights into adult learners' motivation, learning barriers, age disparity among them, instructional materials, and change in their attitudes. The study noted the insufficient research that addresses older adults' computing education, the lack of scholarly attention given to diversity and inclusion in computing education for adults, limited understanding of the older adult's computing learning process, and learning theories' achievements. Furthermore, a recent study by Colbourne et al. [9] reviewed articles on adults' computer skills and proficiency, as reported in ACM Digital Library. They found that there are no standard metrics for reporting adults' computer skills in the literature, however, users' interaction with technology, attitude, and experience were the common characteristics reported.

Similarly, Laupichler et al. [25] conducted a review on artificial intelligence (AI) literacy in higher and adult education contexts. This study reviewed 30 articles to understand how the targeted audience defined and understood AI, what pedagogical approach and instructional contents have been developed to teach AI to the targeted group, and how they made sense of the knowledge. Laupichler et al.'s findings suggest that AI literacy is still emerging and research in that area is gradually increasing. Thus, teaching AI in adult education contexts remains still-witted. Unlike previous studies, this study focuses on investigating the field of computing in adult education with the aim to unravel how broadening participation in this context has fared over the years. Because little is known about this field due to scanty research available [21], this current study seeks to fill this gap. Indeed, a recent study examined broadening participation in K-12 CS education [43]. However, this previous study is not focused on adult education context. Thus, there is still a research gap regarding study that investigate broadening participation in CS for adult education.

3 METHODOLOGY

This study maps key concepts and knowledge existing in studies focusing on CS for adult education. The aim is to uncover the emergence and progression of this area of study and to provide insight into how indicators that measure broadening participation from the perspective of CS in adult education have grown over the years. Therefore, this study followed the guidelines for conducting a systematic literature review [36], being the methodology. According to Peters and colleagues [36], systematic review is a suitable way to examine a research field where studies that provides a comprehensive understanding of several phenomena is scarce.

3.1 Search strategy

In this study, the author followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) framework [34] as depicted in Figure 1. The search strategy was systematic rather than exhaustive, and was developed to include only keyword of studies that focuses on areas related to this study research questions. The keywords were chosen based on sets of keywords that are commonly used in related published articles. For example, a combination of keywords in one instances of the search include *TITLE-ABS-KEY ((("computing" OR "Broadening participation" OR "computer science" OR "CS" OR "programming" OR "coding") AND ("education")) AND (("adult education" OR "life long learning" OR "Life-long learning" OR "older adult education" OR "aged adult education")))*. Three databases were identified and selected as the main data collection points. The databases consist of the Association for Computing Machinery (ACM) digital library, the Scopus database, and the Web of Science. The rationale for opting for these three databases is to reduce the chances of leaving out any relevant article since they warehouse multidisciplinary studies including computing education [1]. In the search strategy, the author was interested in collecting articles that were published in either journal or conference proceedings.

3.2 Data Screening

The data collection process did not place any limit on the publication date. All dates were deliberately allowed to ensure that comprehensive data were collected for analysis.

Inclusion and exclusion criteria: Several inclusion and exclusion criteria were applied during the data screening. First, the study considered only articles published in the English language. Second, the study included only articles that are published in journals and conferences and excluded other venues. The rationale for considering only journal and conference papers is to ensure that the study

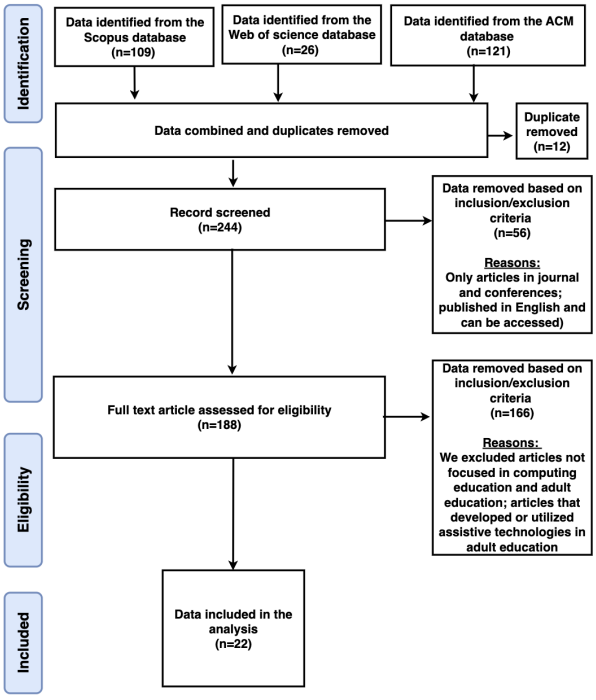

Figure 1: Study selection flow diagram following PRISMA framework.

was peer-reviewed. Next, the author only included articles that are focused on computing or CS education and not the use of computers for education. For example, The study excluded all articles that developed or utilized assistive technologies in adult education or developed computer-based applications to aid adults' education. Additionally, this study included only articles that addressed computing or CS education in the context of adult education and not any other context such as K-12 or higher education. It is worth noting that this study is not focused on using computers as technology to foster adult education or so-called 'Computer-aided learning' but on teaching and learning computer science or computing among adults.

Data extraction and synthesis

To provide insights into the research questions, the author developed a data extraction strategy by using a Microsoft Excel application to formulate key data categories, each having a separate column. This approach is useful in the analysis because it helps to further reinforce the inclusion criteria by helping the author to judge whether an article is relevant to the study or not. The categorized headings include article title, author(s), publication year, publication source, country of study, aim and purpose of the study, study sample, sample age, study methodology, and main findings. As depicted in Table 1, an overview of the data synthesized and included in the analysis is provided.

4 RESULTS AND DISCUSSION

The findings from this study are conceptually categorized following Peters et al. [36] but with certain nuances to address the formulated research questions.

RQ1. How has computing education in the context of adult education evolved?

In order to understand how the research landscape of CS in adult education has progressed, the finding presented in Table 2 shows that the first paper that demonstrated computing education in the context of adult education was published in 1980. This study entitled 'An adult education course in personal computing' reinforces the basics of computing among adults. Surprisingly, the analysis shows that this earliest paper did not receive any citation (at least in Google Scholar) since the year it was published (see Table 1). As the year progresses, it can be noticed that there are several years where no article focusing on CS in adult education was published. For example, 1982-1984, 1986-1990, 1993-1997, 1999-2007, 2012-2014, 2016, 2018-2019, and 2021 witnessed no paper. The years with the maximum number of paper publications were 2010 and 2022 (n=3) followed by 2009 and 2020 (n=2). The rest of the years received one article published.

Regarding the publication venues, Table 3 shows that computing education research in adults has been published mostly in the proceedings of the SIGCSE technical symposium on Computer science education (n=4), followed by the proceedings of the CHI Conference on Human Factors in Computing Systems (n=2). In general, more than half of the articles analyzed were published in the conference proceeding, suggesting that studies in this area form interesting discussion topics among scholars attending conference sessions yearly [15].

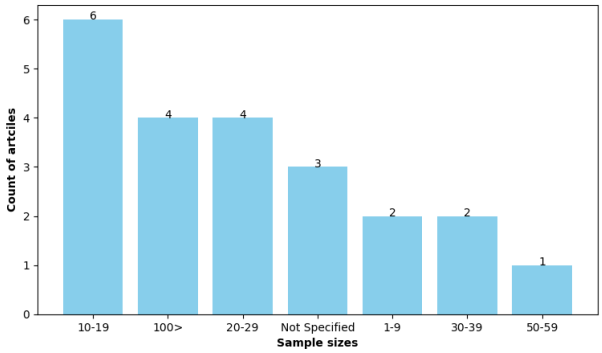

Figure 2: Sample sizes of subjects in studies focusing on computing in adult education.

Figure 2 shows that only 32% of studies on computing in adult education had recruited samples between between 10-19 as their participants. Similarly, 21% of these articles recorded a sample size greater than 60; another 21% reported a sample size between 20-29; while 15% of the articles did not specify their sample size. Indeed, 5% of the articles reported a sample size between 50-59 while 10% recruited less than 10 participants. These dynamics in the sample size show that adult education lacks a sufficient sample size that could provide an in-depth understanding of different phenomena on CS in adult education. Therefore, it is difficult to generalize the findings from these articles.

Table 1: Data included and analyzed in this study

Pub. Year	Authors	Article title	Citation	Study focus
2017	Guo [15]	Older adults learning computer programming: Motivations, frustrations, and design opportunities.	67	To teach older adults basics of programming languages that enable them to directly control computers.
1998	Sikorski [44]	Teaching computers the young and the adults: observations on learning style differences.	9	To foster young adults' computing competence, engagement, and creativity.
2007	Ng [30]	Motivation among older adults in learning computing technologies: A grounded model.	103	To motivate older adults in learning computing, create lasting interest in computing, and confidence to showcase their skills to the public.
2010	Kim & Merriam [22]	Situated learning and identity development in a Korean older adults' computer classroom.	87	Examine how learning of computing influences older adults' identities.
2011	Wexler [52]	Service-learning computing courses assist with technology needs in community-based organizations serving older adults.	8	To integrate relevant computing courses into adult education and gain communication literacy and active cognition.
2010	Nycyk & Redsell [31]	Making computer learning easier for older adults: a community study of tuition practices.	5	Provide evidence to support the effect of community tutoring practices to overcome the digital divide in older adults and to continue in computer learning.
2010	Antonis [5]	Evaluation of the effectiveness of a web-based learning design for adult computer science courses.	59	To investigate how a learning environment designed by the author facilitates computing education among young adults.
2022	Reyes [39]	Negotiating digital marginalization: Immigrants, computers, and the adult learning classroom.	0	To investigate immigrants and marginalized groups' behavior after being exposed to digital devices and training through the lenses of pedagogical ethnography and Internet Communication Technologies.
2009	Hollinworth & Hwang [16]	Learning how older adults undertake computer tasks.	5	This study was designed to examine how older adults execute computing tasks and to unravel some of the difficulties they face when operating computer applications.
2009	Salminen-Karlsson [41]	Women who learn computing like men: Different gender positions on basic computer courses in adult education.	12	This study presents an approach to examine the notion about gender different learning patterns among adult computing education courses.
2015	González et al. [14]	WICT learning by older adults and their attitudes toward computer use.	103	To examine older adults' attitudes towards computer technology during courses to facilitate basic skills.
1991	Kieran-Greenbush [20]	Reaching the adult learner: Adult learning and computer training.	8	To train older adults who are professionals the basics of computing to allow them to master and apply the knowledge in their careers.
1981	Jacobs [18]	Teaching software engineering in the adult education environment.	1	A teaching tips and syllabus to address how to teach software engineering in the adult education context.
2008	Eugene & Gilbert [11]	C-PAL: cultural-based programming for adult learners.	11	To discuss the design of a research agenda that creates opportunities for long-term adult learning and bridge the barriers that may prevent them from participation in computing education.
1980	Solntseff [46]	An adult education course in personal computing.	0	The aim of this study is to reinforce the fundamentals of computer science in adult education.
1985	Weinstock [51]	Adult computer competence.	1	To allow adults to gain self-confidence in computing and a basic understanding of how computers execute instructions for problem-solving.
1992	Morris [29]	The effects of an introductory computer course on the attitudes of older adults towards computers.	48	To examine attitude and other concerns of adults in an introductory computer course.
2020	Krafft et al. [24]	Motivating adult learners by introducing programming concepts from scratch.	3	To examine the efficacy of the Scratch exercise on adults' programming education compared to other exercises.
2022	Ortiz et al. [33]	Computational Thinking and Mental Models: Promoting Digital Culture in the Youth and Adult Education.	1	To reduce the digital divide by integrating computational thinking with digital culture in adult education.
2023	Lusa Krug et al. [27]	Attracting Adults to Computer Programming via Hip Hop.	0	To attract adults learners who do not have programming background to computing education, build their confidence in programming and enhance their skills for career opportunities.
2020	Ohashi et al. [32]	Development of a programming course for senior citizens taught by senior citizens.	3	The study developed a curriculum for programming course to teach senior citizens who will impact the knowledge on students in the local elementary schools.
2022	Mirecki et al. [28]	"My Brain Does Not Function That Way": Comparing Quilters' Perceptions and Motivations Towards Computing and Quilting.	2	The aim of this study is to examine how to explore metaphore in computing education among adult women.

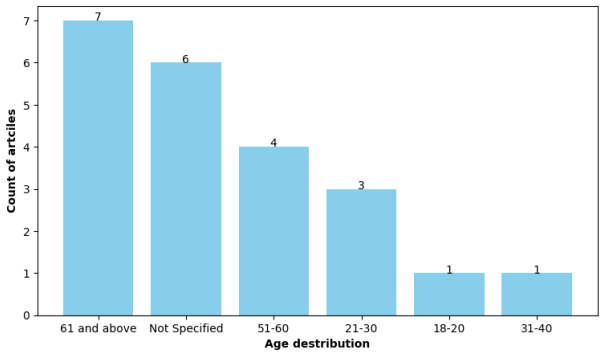

Figure 3: Age distribution of subjects in studies focusing on computing in adult education.

Additionally, it is revealed in Figure 3 that the age bracket of the participants in studies focusing on CS in adult education remains on average between 61 to 79 years old. Meanwhile, the majority of the studies (47%) did not specify the ages of their participants. Only 5% were between the ages of 21 to 30, whereas one study was found to contain participants between the age bracket of 18-20.

Furthermore, the author analyzed the countries where each study was conducted and found that the United States of America (USA) dominates the list while many other countries presented in Table 4, including Australia, Germany, Hong Kong, and Canada showcased only one article each. While at least a country was found to represent regions such as South America, North America, Asia, Europe, and Australia, it is worthy of note that no study was found from the region of Africa. Regarding the methodology demonstrated in the literature focusing on computing in adult education, the result presented in Table 5 shows a combination of various methods. However, 'course design' dominates the pedagogical approach while surveys and questionnaires were found to be concurrently used

Table 2: Publication year

Year	Frequency
1980	1
1981	1
1985	1
1991	1
1992	1
1998	1
2007	1
2008	1
2009	2
2010	3
2011	1
2015	1
2017	1
2020	2
2022	3
2023	1

Table 3: Venues publishing CS education for adults

Publication Venues	Frequency
Proceedings of the SIGCSE technical symposium on Computer science education	4
Proceedings of CHI conference on human factors in computing systems	2
Educational Gerontology (Journal)	1
Proceedings of the International Conference on Information and Education Technology	1
Interacting with Computers	1
Proceedings of the 4th European Conference on Software Engineering Education	1
Proceedings of the 1985 ACM annual conference on The range of computing: mid-80's perspective	1
Proceedings of the 46th ACM Southeast Regional Conference on XX	1
Proceedings of the 19th annual ACM SIGUCCS conference on User services	1
Current gerontology and geriatrics research	1
Journal of Vocational Education and Training	1
Proceedings of the 11th international ACM SIGACCESS conference on Computers and accessibility	1
Atlantic Journal of Communication	1
IEEE Transactions on Education	1
IFIP International Conference on Key Competencies in the Knowledge Society	1
IEEE Long Island Systems, Applications and Technology Conference	1
Adult Education Quarterly	1
Designing Interactive Systems Conference	1

Table 4: Study country

Country	Frequency
Australia	1
Brazil	1
Canada	1
Germany	1
Hong Kong	1
Japan	1
Not specified	4
Multi-countries	1
Poland	1
South Korea	1
Spain	1
Sweden	1
USA	7

for conducting research. Other methodological approaches such as classroom formal teaching, community of practice, observation, participatory design, informal evening classes, and pre-post survey are utilized in the articles.

RQ2. What outcomes are reported in studies on CS for adult education?

The second research question investigates the learning outcomes reported in articles that showcase computing in adult education by classifying their main findings into the four broad theoretical perspectives on learning and achievements by Slavin [45]. In addition, the classification also followed the learning outcomes model demonstrated by Brinson [7]. Table 6 shows the themes that emerged from the learning outcomes reported in the articles. Using the conceptual categories, the author coded the themes. For example, study reported thus:

The older adults were motivated to learn to program, however, they suffered from frustration, lack of interaction with peers or instructors and they were perceived to have low cognitive abilities. The study proposed a learner-cantered approach when designing interventions for older adults to learn programming - [15].

From this example of study outcomes reported above, themes such as motivation, low cognition, frustration, and user-centered learning, were coded and this step was repeated for all articles. Based on these themes generated, the analysis visualized in Table 6 shows that the majority of the articles stimulate adults' motivation to gain computing skills. It is believed that an increase in learners' motivation (intrinsic or extrinsic) will reflect on their engagement and behaviors towards learning [4]. Aside from motivation gained by adults, the analysis revealed that computing instructional materials emerged from the course design. Similarly, it was reported that adults gained computing knowledge from some of the studies.

Additionally, some of the studies reported that adults gained collaboration skills, increased interest, social interaction, self-confidence, and positive attitude towards CS. A previous study has emphasized an increase in computing interest and attitude among adults [21], which align with this study findings. Thus, suggesting that computing education studies in formal or informal settings can promote adults' twenty-first-century skills and encourage broadening participation from that perspective. Another interesting finding is the use of culturally responsive computing (CRC) practices by studies that integrate computing education among adults. As reported in those studies, CRC practice impacts on the subjects' computing knowledge and provides an opportunity for advances among users. Nowadays, CRC practice has been proposed by scholars as one way to increase interest in computing and the STEM field among various groups, including adults who are underrepresented [10, 35, 47]. On the negative side, a few studies reported frustration among adults who were learning computer programming. In addition, there were

Table 5: Methods demonstrated in studies on CS in adult education.

Methods	Frequency
Course design and survey	5
Focused group interviews	2
Community tutoring, observation, and interviews	2
Class session and task-based approach	2
Questionnaires	2
Online learning and survey instrument	1
In-classs teaching and observation	1
Course development, survey, and pre-post test	1
Classroom sessions, observations, and interviews	1
Course design	1
Course development and evening classes	1
Qualitative, interview and participatory design	1
Course design and pre-post survey	1
Feedback, observation and unstructured interview	1

Table 6: Learning outcomes based on the theoretical perspectives on learning and achievements

Perspectives of learning and achievements	Reported learning outcomes	Frequency
Motivational perspective	Motivation	7
	Positive attitude	2
Social cohesion perspective	Collaboration	1
	Confidence	3
	Culturally responsive computing practices	1
	Equity	1
	Frustration	1
	Social interactions	3
Cognitive elaboration perspective	Cognitive capabilities	1
	Increased computing knowledge	4
	Low cognition	2
	Basic programming knowledge	1
Other outcomes other than achievements	Advances in computing education	1
	Competence	2
	Positive self-perception about computing	2
	Increased interest	4
	Computing instructions	1
	Computing skills	1
	Experiential learning	1
	Increased autonomy	1
	Learning design model	1
	Literacy	1

indications of low or limited cognition among adults who participated in some of the studies. These findings are not surprising as it is generally known that CS education (particularly programming) can be very challenging even for young learners.

4.1 Study reflection and implication

Advances in computing and digital literacy remains an important approach for working groups to improve their twenty-first-century skills and integrate growing technology into their work life. One of the implications of this study is that professional development and training in the STEM field can leverage adult education which takes the formal or informal approach to provide opportunities for combining work and education. This study revealed a dearth in studies that integrate CS education among adults. While there are traces of studies that demonstrate computing education for adults from the last four decades, this research domain had remained inconsistent. Consequently, there is little evidence on the impact of broadening participation among adults, which may negatively affect their interest in lifelong learning of computing. Indeed, it is interesting to note that adults who are above 60 years were the most targeted participants of computing in adult education [14, 15, 29, 31]. The implication is that computing education can facilitate lifelong learning. As revealed in some of the studies analyzed, even old adults who are no longer actively working could learn computing skills to keep them cognitively active and build their self-confidence, which is one of the benefits of lifelong learning [19].

While conference venues such as SIGCSE and CHI were seen to promote broadening participation in the context of adult education, it could be more effective to see other venues of computing education such as the ITiCSE, Koli Calling, and ICER joining efforts to provide opportunities for showcasing computing within the context of adult education. This study revealed that there are no evidence of research on computing education for adults from many developing countries, particularly in Africa. While it is important to democratize computing education, one recognize that CS education among adults in the developing countries is highly significant and should be given adequate attention. Furthermore, current literature on computing in the adult education context does not demonstrate relevant theories in their research. In other words, no evidence of integrating relevant theories such as andragogy to fostering computing education among adults. This suggests that the approach and methods demonstrated in current research to fostering computing education among adults may lack useful elements of theories that are suitable, and can lead to meaningful outcomes. Therefore, it is recommended that scholars should consider grounding their research on relevant theories in future studies.

4.2 Limitations

This study suffers from limitations as common with review studies. First, this study considered articles published only in the English language and excluded any other language. Our experience during the data search indicates that some articles were published in other languages such as Chinese, which could be relevant to this study. Further, this study review collected articles from three databases which makes it susceptible to missing out on some relevant data. Exploring more databases such as IEEE Xplore and so on could be considered in future reviews. In addition, developing perfect search keywords for a review study could be challenging, therefore, the author acknowledges that the keywords used in this study may not be exhaustive. While there is no reason to believe that these limitations invalidate the findings in this study in a significant way, it is important to highlight them as they provide opportunities for further study and to advance research leading to more understanding in this area.

5 CONCLUSION

Broadening participation in CS education has received scholarly attention with increasing studies targeted at different learners [6]. However, findings from this review reveal that CS education for older adults has witnessed limited research with a few studies targeted at teachers' professional development. Interestingly, broadening participation in computing education for adults is not a new research area since earlier papers published in premier venue such as SIGSCE proceeding as revealed in this study were dated as far as 1980. However, the missing gap remains the lack of continuity and less support to advance research in this area. Meanwhile, democratizing computing education by fostering the inclusion of adult education may be one effective ways to broaden the participation of underrepresented groups in computing. Therefore, this study concludes by calling on educators and scholars in CS education to broaden participation in adult education, considering that CS education has a huge potential of developing older adults' self-confidence in this digital age and can stimulate their cognition for a lifelong learning experience.

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