Chapter 12
Implementation of Coding and Robotics in South African Public Schools, Fostering Teachers' Self-Directed Learning: A Scoping Review

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ABSTRACT

This study utilizes a scoping review of literature to explore the implementation of coding and robotics and its potential to foster and enhance teachers' self- directed learning skills through the implementation of coding and robotics within the South African educational context. This chapter presents a comprehensive synthesis of scholarly articles, reports, and studies published from 2013 to 2023. The study further aims to provide an extensive examination of the current status quo of coding and robotics implementation, as well as the possibilities that arise for professional development as well as the development of self-directed learning skills, also identifying gaps that will guide further studies in this field and later produce a systematic literature review. This scoping review utilizes a methodical and rigorous methodology to identify the current body of literature, discern significant themes, and provide a concise summary of the results.

INTRODUCTION

Information Technology (IT) and Computer Applications Technology (CAT) initially comprised the South African public-school Computer Science Education (CSE) curriculum. These two subjects were implemented in the South African public school system for Grade 10 in 2006 (Chiles, 2013) and the Grade

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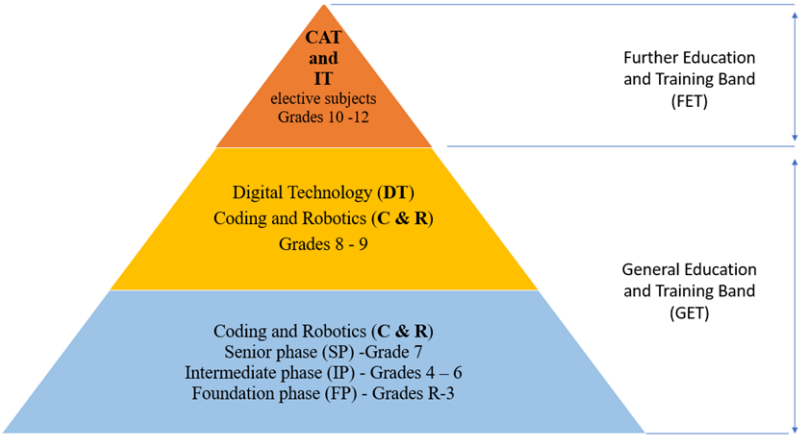
12`s sat for the inaugural paper in November 2008 (Havenga and Mentz, 2009). The CSE curriculum was expanded when two new CSE subjects, Digital Technology (DT) (Botha, 2020) and Coding and Robotics (C & R) (Department of Basic Education, 2021a), were introduced as part of the Curriculum and Assessment Policy Statement (CAPS). CAT and IT are presented as elective subjects in the Further Education and Training band (FET) for grades 10-12 while DT was introduced in the Senior Phase (SP) for grades 8 and 9. However, C & R has been introduced in the General Education and Training band (GET), which includes the Foundation Phase (FP) for grades R-3, the Intermediate Phase (IP) for grades 4-6, and the SP for grades 7-9 (Figure 1).

This curriculum change marks a dynamic paradigm shift in the teaching and learning of CSE subjects, where the elective CSE subjects, CAT and IT, taught mostly by a small percentage of subject specialists (Van Wyk, 2012) to a small percentage of grade 10-12 learners (Gustafsson, 2014), pivot to what will become a mandatory subject, C & R, taught to every learner entering the South African public school system in the FP (Department of Basic Education, 2023). This move of the Department of Basic Education (DBE) essentially establishes the base of the CSE pyramid (BoCSEP) and the foundation of the South African CSE (Figure 1), where the fundamentals of information and communication technology (ICT) and digital skills (DS) will be introduced and subsequently form the foundation for future teaching and learning of the DT, CAT, and IT subjects in the upper education levels (Figure 1). Furthermore, this curriculum change infers that the onus of teaching the foundations of CSE also shifts to the BoCSEP and becomes the responsibility of all FP teachers.

Figure 1. Base of the Computer Science Education Pyramid (BoCSEP)
(Author)



Computer Science Education in the South African Public School system

FP teachers encounter challenges when introducing new subjects and educational programs. Makeleni & Sethusha (2014) identified several challenges faced by teachers during curriculum implementation while Geldenhuys & Fatar (2021) identified factors crucial for an efficient introduction of the C & R curriculum in South African schools, obstacles encountered by educators, and aspects requiring attention

to ensure successful implementation. These challenges encompass the requirement for ongoing training, assistance, and access to necessary materials.

Teachers, however, need the resources and a solid knowledge base of ICT and the relevant skills to facilitate theoretical and practical content to teach CSE subjects (Breed, 2015). According to Gorrah (2022), teachers, as custodians of the curriculum, have a crucial responsibility in implementing the South African C & R curriculum; therefore, it is critical that they possess adequate expertise and knowledge to facilitate C & R. Numerous educators currently tasked with teaching C & R lack the basic digital knowledge (DK) and DS that they would have acquired through the completion of a three to four-year specialized course. Jantjies (2019) therefore acknowledge that many teachers in the education system received few or no ICT-infused learning experiences while also studying. This impediment could be addressed through PD programs and activities, however teachers in schools are not efficiently trained for the pilot C & R implementation plan (Mokonyane-Motha & De Jager, 2023; Gorrah, 2022). Dlamini and Mbatha (2018) maintain that the requirements for teachers to enhance their ICT skills and competencies are not adequately met through a substantial and organized approach to their Professional development (PD) in ICT.

Therefore, teachers would need to engage in acquiring DS and DK regularly even after PD programs. Moreover, teachers should reinforce the essential knowledge and skills required to teach C & R attained through multifaceted PD programs by becoming self-directed learners who recognize their learning requirements, establish objectives, find resources, choose learning strategies, and evaluate their learning (Knowles 1975).

As C & R is an emerging component of CSE, literature pertaining to the introduction and implementation of C & R suggests that CSE teachers encountered challenges (Khanlari, 2016) with PD and training programs, DK and DS and face challenges with curriculum implementation (Stokes et al., 2022). It is therefore imperative to understand how the implementation of C & R at the BoCSEP, in South African public schools, will foster the SDL of teachers who will be responsible for facilitating C & R. Subsequently, this chapter presents a theoretical framework aimed primarily at serving as a comprehensive guide for researchers interested in exploring the initial introduction and future implementation of C & R in South African public schools.

The Background section of this study focuses on C & R, SDL, and other Literature Reviews pertaining to the introduction and future implementation of C & R directed at SDL. The Methodology section explains the methodology used in this article, specifically describing the protocol followed in conducting the scoping review. Furthermore, this research effort aims to provide a comprehensive scoping review that focusses on the introduction and future implementation of C & R in public schools within the South African context and how this will foster self-directed learning of teachers identified to teach C & R in the GET band. The review draws upon the limited array of existing national and a broad array of international literature sources to ensure a diverse and comprehensive literature mapping, as well as to identify gaps that will guide further studies in this field.

BACKGROUND

What Are Coding and Robotics?

C & R emerged as a critical subject introduced or implemented in the changing international educational landscape in recent years. Using robots in the classroom is often referred to as educational robotics (ER)

as many studies (Tang et al., 2020; Theodoropoulos et al., 2017) explored ER and the connection between programming, C & R, and its application in the classroom. Hence, Sapounidis and Alimisis (2021) state that ER is a teaching tool that affords students to use an easy-to-understand coding language to build and program a robot. In the South African context, the subject has been introduced as C & R that aligns with the view of Sapounidis and Alimisis (2021) as the DBE (2023) envisions that including C & R in the curriculum will equip learners with the necessary skills and knowledge to succeed in the workplace. Subsequently, the DBE noted the value of introducing learners to C & R from grade R-9 that covers interrelated IT (coding) and engineering (robotics) topics. The subject examines logical and computational problem-solving focusing on algorithms and coding, robotic skills, application skills and internet and e-communication skills pattern recognition and problem solving being added in the FP (Department of Basic Education, 2023). Consequently, computer science lessons, such as programming and robotics skills, would progressively increase in difficulty as learners progress through each grade level. Learners in grades R-3 would engage in analog and unplugged activities that impart fundamental concepts of coding and algorithms. Learners in grades 4 through 6 would utilize block-based programming tools. During grades 7 to 9, students would utilize coding platforms (Fares et al., 2021).

Coding and Robotics Skills and Knowledge

As it will be the responsibility of teachers to implement and teach the C & R subject (Gorrah, 2022), teachers should acquire the essential DK and DS required to teach C & R. As teachers need specific knowledge and skill sets to prepare today's learners for the world of work, one should acknowledge that teachers should rely on these professional aptitudes, upskill, and stay current with present teaching and learning demands. The C & R proficiency, one of these skills, is becoming more imperative for individuals to secure employment opportunities in the current and future job market (Xia, Wan, Kochhar & Lo, 2019). Consequently, computational, and critical thinking, problem solving, and digital literacy are poised to be crucial in future job markets. Moreover, integrating C & R offers a favorable solution to address and promote these skills of the 21st century. Additionally, basic coding skills facilitate a more effective orientation between educational qualifications and labour market demands (Demertzi et al., 2018). However, such a dynamic shift in curriculum requires a new way of thinking about education in general. Therefore, one would argue that exposure to new skills and knowledge would encourage and require teachers to view themselves as self-directed lifelong learners.

Teachers must develop competence in and master C & R to teach effectively and facilitate the C & R subject. Internationally, it is now best practice for educators to further improve their C & R skills and knowledge through participation in workshops, online courses, and communities of practice (Pankratova et al., 2021; Scaradozzi et al., 2019). Morze and Strutynska (2023) focus on providing future teachers with the essential competencies to successfully teach educational robotics. These experiences do more than improve teachers' abilities; they also foster a mindset that values and allows for SDL.

Coding and Robotics Training and Professional Development

Wu et al. (2020), emphasized that many schools now teach coding and other 21st-century skills. However, there is a noticeable gap in official and sufficient training for teachers in effectively

incorporating C & R activities into their teaching practices at the school level as studies in broader literature have identified challenges that must be addressed to achieve complete integration and implementation of the C & R curriculum (Greyling,2022; Stokes et al., 2022). Giannandrea, Gratani, and Renieri (2020) noted that teachers' knowledge and abilities improved by participating in teacher training in design, C & R. As a result, these changes created increased self-assurance regarding their professional aptitudes. Camilleri (2017) proposed a framework for teacher learning and training to facilitate the integration of robotics in primary school. Therefore, Hill, Kim, and Yuan (2019), recommended the integration of C & R into the primary school curriculum, with a particular emphasis on the importance of adequate teacher preparation, further underscoring the potential influence of incorporating C & R into primary education. The role of teachers in integrating C & R into the curriculum is crucial. Teachers are the ones to lead learners in educational programs and projects that provide opportunities to discover, experiment, and develop computational and 21st century skills (Ogegbo & Aina, 2022). Most teacher training courses focus on teaching basic skills and knowledge, and the training content is mostly planned and organised by outside providers, leaving teachers' roles as subjects (Giannandrea et al., 2020).

The DBE and their training partners initiated diverse C & R training initiatives (Department of Basic Education, 2021b), but despite participating in PD programs the problem is that teachers often revert to their old and familiar teaching methods (de Beer 2019). However, Fares et al. (2021) indicated that the South African government's efforts to incorporate Computer Science (CS) into the curriculum have not been complemented by effective PD programs to adequately train teachers for CSE. Mokonyane-Motha and De Jager (2023), demonstrated the importance of DK and DS acquisition and transferring these knowledge and skill sets to students and learners. The newly suggested C & R curriculum would significantly reinforce the demand for teachers with expertise in CSE and computational thinking (CT) (Fares et al., 2021). Enhancing teacher preparedness for the subject is thus the utmost priority for the government and nonprofit partners to provide quality CSE to more learners. However, Stokes et al. (2022) recognized a shortage of resources, inadequate curriculum integration, and limited opportunities for PD as obstacles that impede the broader implementation of robotics education. This is also evident in the South African context as Greyling (2022) highlights challenges to be overcome with implementing C & R including the lack of resources and lack of trained teachers.

Research emphasizes the importance of C & R teacher education and continuous learning of C&R teachers (Boz & Allexsaht-Snider, 2022). However, resources confined to and beyond PD courses, teacher collaboration, C & R platforms, and teaching approaches can either facilitate or impede teachers' learning of C & R. According to Avalos (2011), PD involves acquiring knowledge from teachers, developing their learning skills, and applying this knowledge to their instructional practices to facilitate the growth and development of their learners.

The process of teacher professional learning is multifaceted, as it necessitates the active engagement of teachers both individually and collectively, the ability and willingness to critically assess one's convictions and beliefs, and the exploration and implementation of suitable alternatives for enhancing or modifying current practices. The onus is therefore on teachers to navigate the challenges and craft a professional path for their own C & R education and SDL.

CODING AND ROBOTICS AND SELF-DIRECTED LEARNING

Conceptualizing self-directed learning

Self-directed learning (SDL) is one of the most researched topics due to its impact on education (Doo et al., 2023) observing that SDL is becoming an increasingly important concept in education (Van der Westhuizen and Bailey, 2022). SDL is best defined by Knowles (1975) and Boyer et al. (2014) as the student taking initiative, diagnosing learners' needs, formulating learners' goals, identifying resources for learning, appropriate learning, and evaluating learning outcomes.

SDL is an important goal to improve the quality of preparation of students for the future (Sumuer, 2018) and it is essential that the learner's SDL skills be developed to release students' full potential (Williamson 2007) as learners are growing up to be more independent to allow for SDL development (Kruger et al., 2022). Morris & Rohs (2023) maintain that SDL is a fundamental competence to live and work in the modern world, especially in the digital age. Candy (2004) pronounces that in the rapid times we are living, considering the constant new development of technology, learners should become aware of the benefits of SDL. Van Zyl & Mentz (2019) reports that promoting SDL in education will prepare students for a changing world. SDL competencies benefit someone who wants to pursue a rapidly changing career, such as information technology. SDL is important to improve the quality of student learning and prepare students for the future. SDL is vital for 21st-century education (Mentz & Bailey, 2019).

Self-Directed Learning Skills

Van der Westhuizen and Kemp (2022), du Toit Brits (2019); Van Zyl &Mentz (2019) justifies that SDL skills are an important skill to survive in the 21st century. Bailey & Breed (2022) challenges that the South African curriculum should introduces subjects such as coding, robotics, and digital technology in all schools. SDL skills are crucial for success in the rapidly changing social and economic areas concerning education we acquire lifelong and SDL learners (Kruger et al., 2022). The SDL developments are one strategy that could be implemented in teaching and learning to promote skills of the 21st century. There is a need to provide teaching and learning experiences that help learners learn to use SDL skills (Bosch et al. (2019). There is a concern that education lacks the development of skills of the 21st century (Van Zyl & Mentz, 2019).

Self-Directed Learning and Technology

With the demanding world, it is noticed that the advancement of technology requires the education sector to become more adopting in how we engage in teaching and learning for the future (Kruger et al., 2022). A study by Sumuer (2018) points out that SDL with technology warrants further investigation because SDL, as a process, is particularly enhanced with the convenience of ICTs. Geng (2019) asserts that a learning environment integrated with technology can provide students with ample opportunities and capabilities to develop self-directed learning skills. With the introduction of the C & R in schools, many teachers were required to independently acquire proficiency in various programs. Geng (2019) asserts that a high management level is crucial for SDL, and teachers should employ diverse strategies to acquire these skills. Geng (2019) found that research on self-directed learning with technology (SDLT) indicates that the perception of collaborative learning promotes SDL.

Van der Westhuizen and Bailey (2022) mentioned that the education landscape has not kept up with the rapid changes and the demands to equip our students for the fourth industrial revolution. More exposure to SDL and technology increases students' technological development and directly influences SDL. Doo et al. (2023) emphasized that self-directed learning needs to reflect whether they have learnt the skills and competencies. Schools should prepare learners with the skills needed for a successful life and employment in the 21st century (du Toit, 2019).

RESEARCH METHODOLOGY

The outline section illustrates the study design, data collection procedure, and data analysis procedures adopted for this study.

Study Design

The research process was based on suggestions from (Arksey and O'Malley, 2009; Levac et al., 2010; Pharm et al., 2014; Peters et al., 2020) in consultation with the Proposed Methodology of the Scoping Reviews based on the Joanna Briggs Institute (JBI) Framework of Evidence Synthesis. A scoping review methodology was used for this study. This paper aims to furnish a scoping literature review on how implementing C & R fosters educators' SDL skills.

Munn et al. (2018) maintain that scoping reviews are a novel approach and ever increasingly popular in synthesizing evidence. (Pharm et al., 2014; Tricco et al., 2018). Khalil et al. (2016) validate that scoping reviews will ensure further research and identify gaps that will contribute to the body of knowledge. Scoping reviews present a large, diverse body of literature on a specific research question (Pharm et al., 2014). Sannicandro et al. (2022) supports that scoping reviews can provide researchers with insights into the characteristics of a body of evidence, concepts of terms used, and topics reported on. Subsequently the aim of this scoping review is to look at existing knowledge, significant trends, and research gaps concerning the incorporation of C & R into the South African public-school curricula and how this move will be cultivating SDL in teachers' task to teach the new subject. Consequently, with these aims in mind, we embarked on this scoping review study to address the following research question:

1. How does the implementation of Coding and Robotics foster and enhance teachers' self-directed learning within the South African public educational context?
2. How can Coding and Robotics implementation influence self-directed learning skills of teachers?

Data Search Strategy

Researchers used a database covering education to ensure the relevant literature search to the research questions. Boolean operators (AND, OR) were used to refine the search. The search terms included: Coding AND Robotics, Coding AND Robotics AND South AND Africa, Computer AND Science, Robotics AND Education, Robotics AND Education AND South AND Africa, Self AND Directed AND Learning, Fostering AND Self AND directed AND Learning AND Skills and ("coding and robotics") AND "South Africa" AND "self-directed learning" AND "robotics education".

On 18th October 2023, the initial search yielded 2 430 articles related to Coding and Robotics, Coding and Robotics in South Africa, Robotics Education, Computer Science, Self-directed learning, and Fostering Self-directed learning skills.

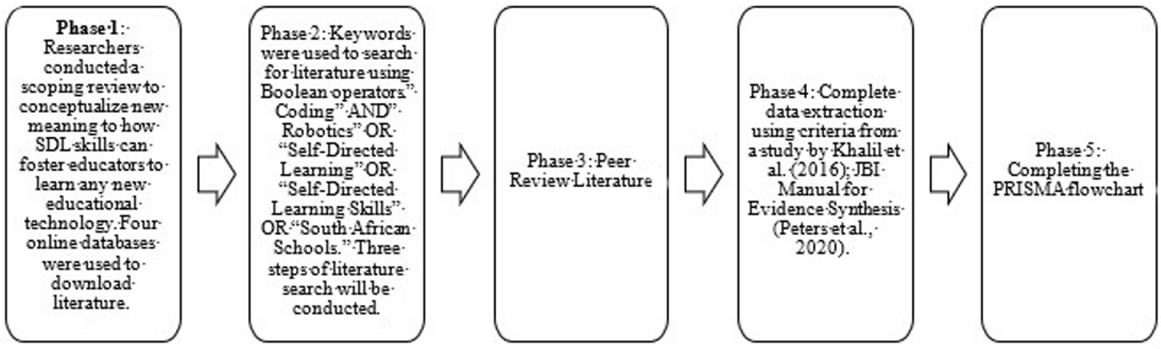
Inclusion and Exclusion Criteria

During our literature search, researchers included teachers involved in teaching C & R at the school's national and international levels. C & R form under the different strands of CSE. The main concept for this study is the implementation of C & R and its effect on fostering SDL skills. Literature evidence clearly describes teaching C & R, which usually takes place in the classroom/computer laboratory. The only language selected for the literature search was English. Empirical research published between 2013–2023 must be peer–reviewed. The exclusion criteria thus include studies that fall outside the identified period, publications in languages other than English, and studies that do not directly focus on the implementation of C & R in the South African context.

Data Collection

Mensah-Williams and Derera (2023) suggest steps are needed for a scoping literature review. The study thus incorporated a series of steps, including the identification of research questions, identification of relevant studies, selection of studies, organization and analysis of data, and summarization and reporting of the results. (Figure 2).

Figure 2. Phases the researchers followed towards completing the article



This study used online databases *Scopus, African Journal, EBSCOhost, and Google Scholar* (Table 1). Separate phases were performed for the Scoping review. The researchers identified the following keywords: Self-directed learning, Self-directed learning skills, Self-directed technology, Computer Science Education, Coding and Robotics, and Robotics Education. The search was conducted from October to December 2023. The extensive search ended in December 2023. Table 1 displays the analysis of results when researchers conducted a literature search.

Table 1. Data collected

Key Words	**African Journal**	**Scopus**	**EBSCOhost**	**Google Scholar**
Coding AND Robotics	4767	1178	73	19 100
Coding AND Robotics AND South AND Africa	35 503	35 503	0	19 400
Computer AND Science	77 297	119 943	6083	53 700
Robotics AND Education	9324	7882	2627	37 400
Robotics AND Education AND South AND Africa	8084	27	6	17 600
Self AND Directed AND Learning	27 946	11 162	1557	17 800
Fostering AND Self AND directed AND Learning AND Skills	7900	86	2	17 800
(“coding and robotics”) AND “South Africa” AND “self-directed learning”	0	1	60	42

Data Extraction

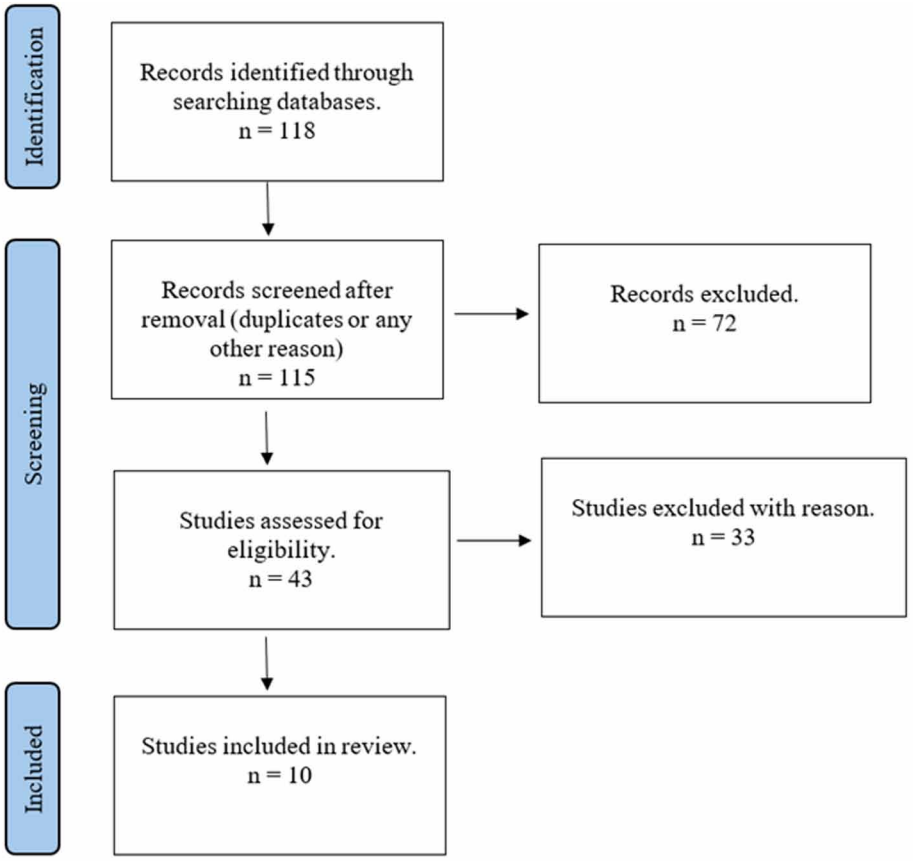
The PRISMA 2020 checklist, depicted in Figure 3, employed in this scoping review, presents a systematic and lucid approach for extracting and reporting data. By following the PRISMA guidelines, researchers aimed to achieve higher levels of reliability and reproducibility in their results, which aims to improve the understanding of the implementation of C & R in South African schools. The utilization of the PRISMA 2020 checklist aids in the systematic arrangement of collected data. The objective is to identify trends, patterns, and gaps in the current literature. This enables a thorough analysis of the incorporation of C & R in South African schools and the affordance of fostering SDL and SDL skills in the teachers’ task with introducing, implementing and subsequently teaching the C & R curriculum at the BoCSE in the GET in South African public schools.

This review included an extensive search across prominent academic databases (Table 1), which resulted in an initial set of records. A comprehensive full-text review as illustrated in Figure 3 was performed which resulted in the inclusion of studies that satisfied our predetermined inclusion and exclusion criteria. This was accomplished after the elimination of duplicates and the completion of an initial screening. Records were disregarded prior to screening because they did not have any relevance to introduction, implementation, integration, and SDL. When these findings were synthesized, a nuanced understanding of the South African landscape of C & R introduction, implementation or integration was provided. This understanding revealed a concept of self-directed learning fostering based on the introduction and implementation of C & R. The purpose of this scoping review is to serve as a foundational resource for future research endeavors, and it does so by contributing valuable insights into current trends and focal points within the C & R field.

Data Analysis

The study comprised of 10 articles published from qualitative, quantitative, and mixed-method studies in different educational journals with reference to the introduction, implementation, integration, or SDL of C & R. The articles were reviewed and scanned by the researchers with the research librarian’s

Figure 3. PRISMA flow diagram of article inclusion and exclusion
Note: Adapted from: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71



assistance; during this process, duplicate articles were removed. Table 2 shows the data extracted into a tabular form focusing on how the implementation of C & R foster and enhance teachers' SDL within the South African public educational context, whilst Table 3 presents data pertaining to how C & R implementation influence SDL skills in teachers.

SOLUTIONS AND RECOMMENDATIONS

The implementation of C & R in South African public schools faces numerous challenges (Fares, 2021; Greyling, 2022), including but not limited to teacher training and PD, as well as curriculum integration. The lack of skilled teachers with specialized DK and DS presents a significant challenge, requiring the implementation of thorough and continuous PD initiatives to empower teachers to enhance their understanding of the incorporation of C & R, as well as their proficiency in utilizing these tools to supplement their teaching (Willemse, 2023). Heyns (2023) expresses concern about the limited availability of teachers in the South African context who possess the required enthusiasm and digital skills. They argued that the

Table 2. Coding and robotics introduction, implementation or intergration (n=4)

First Author and Year	Title	Implementation of Coding and Robotics	Fostering Self-directed learning
Fares, K, (2021)	How South Africa implemented its computer science education program	The paper addresses CSE challenges and opportunities in South Africa in a comprehensive manner. It prioritizes teacher training, infrastructure, curriculum, and public-private partnerships.	Prioritizing teacher training is crucial when introducing CSE, according to the study. It stresses the importance of qualified teachers in computer science education. It also emphasizes the need for extensive professional development to equip educators with computer science skills.
Greyling, J. (2023)	Coding Unplugged—A Guide to Introducing Coding and Robotics to South African Schools	The study aims to aid in the introduction of C & R into South African Schools by offering a comprehensive guide for introducing the subject in an unplugged way. The authors argue that the unplugged approach can serve to bridge the digital divide and offer C & R `s to learners who lack access to technology. The study also emphasizes the significance of early implementation of C & R in schools to equip learners for the future labour market.	This study underscores the significance of teacher training in context of implementing C & R in South African schools and the necessity to equip educators with the requisite DS and DK to proficiently instruct coding principles through unplugged activities. This highlights the importance of investing in teachers' professional development to guarantee the effective implementation of C & R in schools.
Havenga, M. (2013)	Metacognitive and Problem-Solving Skills to Promote Self-Directed Learning in Computer Programming: Teachers' Experiences	The study proposes that instructing students in metacognitive and problem-solving skills could enhance their ability to manage their own learning. Additionally, teaching students' management processes and activities may contribute to their academic success and performance improvement. Moreover, combining instruction in both metacognitive and problem-solving skills could potentially enhance students' programming performance and their capacity to exert cognitive control.	Students who develop metacognitive and problem-solving skills become more responsible for their own learning, taking ownership of their progress and development.
Havenga, M. (2023)	Introducing Coding and Robotics: Prospective Mathematics Teachers' Metacognitive Thinking in Scratch	The study emphasized the significance of students' metacognitive abilities in facilitating their thinking during coding tasks. It underscored the importance of metacognitive knowledge and thinking in effectively tackling challenges and resolving complex problems, especially in C & R. The results also indicated that students possessed metacognitive awareness and utilized metacognitive strategies when engaging in coding tasks. This involved planning their actions, monitoring their progress, reflecting on their thought processes, and assessing the quality of their work.	The inclusion of higher cognitive skills such as problem solving, decision making, critical and creative thinking, innovation, and computational thinking, along with metacognitive skills, is crucial for C & R. Students demonstrated metacognitive thinking and their own metacognitive knowledge awareness or lack thereof.

overall level of teacher proficiency in SA is not reassuring when it comes to the capacity of in-service teachers to acquire the skills needed to teach a new subject. It is necessary to modify both pre-service and in-service training to ensure that future teachers are prepared to teach C & R. Additionally, current teachers should be empowered and trained to handle this new subject. Khanlari (2016) found that teachers perceived C & R to have positive effects on students' lifelong learning skills and indicated barriers to integrating robotics into their teaching activities.

Table 3. Fostering self-directed learning skills (n=6)

First Author and Year	Title	Conceptualization of Self-Directed Learning	Fostering Self-directed learning Skills
Stefanie L. Boyer, Diane R. Edmondson, Andrew B. Artis, and David Fleming,2013	Self-Directed Learning: A Tool for Lifelong Learning	Since its 1967 introduction by Tough within the adult learning literature, SDL has been shown to be a highly effective method to engage and train adult learners (Ellinger, 2004). In SDL is a process by which learners manage their own learning process from beginning to end (Knowles, 1975). Research has shown that SDL is positively related to many education-related constructs: academic performance, aspiration, creativity, curiosity, and life satisfaction (Edmondson, Boyer, & Artis, 2012); however, limited research exists on how SDL is related to workplace-learning constructs.	College students who are taught how to be proactive and self-directed learners will be better prepared as employees to anticipate their organization's needs, tailor their learning to meet their own unique learning styles, and acquire the necessary skills, knowledge, and abilities to create value for their customers, employers, and organizations (Artis & Harris, 2007; Cron, Marshall, Singh, Spiro, & Sujan, 2005).
Charlotte Silén & Lars Uhlin.2008.	Self-directed learning – a learning issue for students and faculty!	The importance of becoming a self-directed learner is a learning process, and the need for teachers to take part in the learning is crucial. students' development as self-directed learners have been neglected.	The students need challenges, support, and feedback in their struggle to become self-directed learners and thus require ongoing attention. If the intention is to enhance the students' ability to become self-directed learners, and prepare for lifelong learning in their professions, it is essential to recognise that students becoming responsible and independent is a learning process.
KAILASH CHAROKAR1, MS, FAIMER Fellow; PUJA DULLOO2, MD, MHPE (UK), FAIMER Fellow.2022	Self-directed Learning Theory to Practice: A Footstep towards the Path of being a Life-long Learner	Self-directed learning cuts across all domains of learning and have a significant potential in shaping transformational learning experiences. The concepts of SDL are based on adult learning principles and experiential learning fostering skills for lifelong learning.	SDL through an explicit approach and dedicated teaching hours in the disciplines which gives the opportunity to develop skills for developing lifelong learners. The The prime goal of the SDL is to make students lifelong learners and gain subject topic knowledge as an immediate outcome.
Thomas Howard Morris, Nicholas Bremner & Nozomi Sakata.2023	Self-directed learning and student-centered learning: a conceptual comparison	Both SDL and SCL are poorly understood among many stakeholders (e.g., Neumann 2013; Gandomkar and Sandars 2018)	Rogers (1969) advocated that SDL is the most important competence in formal education to prepare young people to cope effectively with rapidly changing societies, stating that 'no knowledge is secure' and 'only the process of seeking knowledge gives a basis for security' Scholars of SDL view formal education settings as a primary opportunity to practice and foster competence for SDL: to form a foundation for successful lifelong learning (Bagnall and Hodge 2022).
Faiyaz Ahammad.2023.	SELF-DIRECTED LEARNING: A CORE CONCEPT IN ADULT EDUCATION	The idea of self-directed learning is significant in the context of adult education. Self-directed learning, often referred to as learning by oneself, encompasses a broad spectrum of skills and attributes within individuals. It involves the proactive identification of one's learning needs, the establishment of personal learning objectives, the selection of appropriate learning resources, the utilization of effective learning strategies, and the assessment of learning outcomes, either independently or with external support (Knowles, 1975).	Importance of 21st century skills in today's knowledge-based societies is on the rise, and lifelong education encompasses a wide range of topics
Thomas Howard Morris & Matthias Rohs.2023	The potential for digital technology to support self-directed learning in formal education of children: a scoping review	SDL has been recognized as a fundamental competence for living and working in the modern world, which enables persons to adapt to changing conditions (e.g., Boyer et al., 2014; Kranzow & Hyland, 2016).	Self-directed learning is a critical competence for living and working in an increasingly complex and unpredictable world. Understanding how SDL can be fostered through formal schooling in childhood is particularly important because studies have historically and consistently identified that many people do not fully foster SDL competence during their childhood (e.g., Bonk et al., 2018; Canty et al., 2019; Gatewood, 2019). Bonk and Lee (2017) note that this is surprising given that the importance of SDL has been noted by scholars for decades.

Therefore, implementing targeted training programs and support systems for educators will not only improve their skills but also cultivate a favorable educational atmosphere, equipping learners to meet the challenges of the digital era (Department of Basic Education, 2023) within the limitations of the South African educational context. The current C & R implementation milieu can provide teachers with exceptional opportunities and capabilities to become self-directed as one can argue that the state of PD relating to C & R will not fully equip teachers with DS and DK. Many teachers therefore are required to independently acquire C & R proficiency.

SDL can therefore enhance performance, making it crucial for educators to explore effective ways of incorporating C & R into their classrooms. It is recommended as a frequent approach to cultivate lifelong learning skills. The SDL approach, viewed as a teaching method, aligns with certain competencies, and offers a dual component in the curriculum: one to achieve lifelong learning goals. Education plays a vital role in developing the skills necessary for SDL, further research is needed to deepen our understanding, emphasizing its importance in fostering SDL skills to comprehend recent technologies such as C & R. Due to constantly changing innovative technology, if an educator is equipped with SDL skills it would be easier for a teacher to understand and implement C & R at the BoCSE pyramid.

FUTURE RESEARCH DIRECTIONS

In this chapter, the challenges and obstacles that teachers face in introducing and implementing the C & R subjects are documented. C & R, as the newest addition to the CSE in the South African public-school context, has shifted the teaching of DS, DK, and ICT principles from a relative few (grades 10-12) as an elective component to a mandatory subject to be implemented from grade R-9 at a broader base in South African public schools, referred to in this chapter as the BoCSE.

As this novel subject was rolled out, introduced, and implemented, the current teacher in-service corps were trained to teach C & R. They were not afforded the benefit of a full three or four-year digital and ICT course; instead, training was presented in short intervals. The quality of the professional development (PD) and training initiatives was brought into question, and it is evident that these challenges are a matter of concern for many stakeholders regarding how this will affect the implementation of C & R.

Numerous existing international studies in the broader literature have examined the implementation of C & R and ER, as these were implemented well before it was the case in South Africa. The authors found that there is thus a limited number of studies available relating to the implementation of C & R in the South African public-school environment and even fewer pertaining to the fostering of SDL to supplement and enhance delivered PD and activities. Subsequently, fostering SDL skills are necessary for teachers to navigate their own 21st-century learning path in this ever-changing digital era.

The authors, therefore, suggest that research should explore the role of C & R in fostering SDL among South African teachers who are tasked to implement the C & R subject, as this area was identified as a knowledge gap. C & R is emerging as a new field of study and further studies in this field could present the possibility to produce a systematic literature review.

CONCLUSION

The DBE aims to implement the C & R subject as part of the broader CSE in South African public schools with the purpose of providing learners with the necessary skills for the 21st century. These skills will enable these learners to effectively adapt to the Fourth Industrial Revolution (4IR). Challenges exert an impact on the successful implementation of the subject in South African schools of which one is teacher training and PD. To successfully implement C & R, it is crucial to address these factors that could hamper the successful implementation of C & R. The teacher plays a crucial role as they are responsible for implementing the curriculum and providing South African learners with the essential knowledge and skills required to succeed in a technology-driven world and to prepare learners for the workforce. This task starts in the FP and for the purpose of CSE the C & R will be implemented at the BoCSE pyramid in the GET phase. It is evident that teachers teaching at this level do not have the necessary DK and DS. As teachers are expected to facilitate 21st century skills, they should possess them. Teacher training opportunities are necessary, especially when introducing a new concept. Training and PD programs and activities provided by the DBE and their training partners would undoubtedly provide the basic knowledge and skills to assist teachers to teach C & R. However, knowledge and skills gained through PD and training opportunities could be enhanced through the teachers own SDL. In the ever-changing digital age, the onus rests on the teacher to acknowledge their own learning needs, acquire SDL skills, become self-directed learners, and navigate their own CSE in this 21st century.

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