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Integration of Coding and Robotics in the South African Curriculum: A Pathway to Teacher Reskilling and Professional Diversification

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Method Article

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Abstract

South Africa's introduction of Coding and Robotics has largely been viewed and discussed as a curriculum innovation problem, with most debate centring on teacher preparedness, infrastructure deficits and implementation risk. Less attention has been given to a second and important policy question: whether the reform also creates a structured reskilling pathway for teachers whose subject specialisations have become vulnerable within particular school contexts, and for those who are interested in trying new things. This study addresses the teacher re-skilling and professional diversification literature gap by conducting an exploratory qualitative study based on individual interviews with 05 purposively selected teachers from Umlazi, KwaZulu-Natal, South Africa. An integrated framework approach combining Technological Pedagogical Content Knowledge (TPACK) and Human Capital Theory (HCT), embedded in a pragmatist paradigm, guided the study. The study found that the interviewed teachers lacked substantive knowledge of Coding and Robotics, yet those in earlier career stages recognised the subject as a possible route to renewed relevance and to attaining SDG 04 (Quality Education) and employability. Older participants were markedly more hesitant and preferred redeployment or retirement to reskilling in coding and robotics. The study argues that Coding and Robotics should not be treated only as a curriculum burden. It should also be approached as a labour-market and professional development intervention through which the state simultaneously responds to teacher underutilization, subject contraction, and digital curriculum reform. The paper concludes that teacher reskilling and diversification strategy will only succeed if it is systematised, funded, practice-based, and sensitive to school inequalities.

1. INTRODUCTION

The move by South Africa to integrate Coding and Robotics into its curriculum contributes to achieving Sustainable Development Goal 4 (SDG) (Quality Education). This inevitable reform is driven by the complex landscape of digital transformation, the growing need to teach computational thinking, and the pressure on schools to equip learners for more technology-intensive labour markets. However, the national discourse has been largely shaped by compelling issues of teacher preparedness, infrastructural deficits, and the feasibility of implementing this educational reform in under-resourced settings. Studies indicate that the school system is already defined by technological disparity, inconsistent digital competence, and unequal institutional provision, thereby creating a sharp disjuncture between policy ambitions and classroom preparedness (Hart, 2023; Mhlanga & Moloi, 2020; Zivanayi & Malinga, 2025).

However, this inevitable curriculum reform provides a professional pathway for teachers interested in venturing into the new subject discipline, particularly those whose current subject specialisations have become peripheral in certain school environments and those at risk of redeployment. This topic has received less scholarly attention, particularly in the South African context. According to data underlying this paper, some teachers reported self-interest in reskilling to teach Coding and Robotics. Teachers also reported the shrinkage or elimination of subjects such as Accounting, Afrikaans, Biblical Studies,

Business Studies, Economics, Mathematics, and Physical Science in some schools, as well as the risk of redeployment. These service teacher experiences and documented realities have consequential effects on workload distribution, professional identity, and future employability. In line with this, the paper redefines the debate not only on whether schools are ready for Coding and Robotics but also extends it to whether the curriculum can serve as an institutional process for reskilling and diversifying teachers.

Guided by Technological, Pedagogical, and Content Knowledge, embedded in a pragmatist paradigm, this qualitative paper utilised semi-structured individual interviews to generate and collect data from 5 senior-phase teachers at 4 Coding and Robotics pilot schools in Umlazi. The research paper makes three contributions to the South African literature: it goes beyond deficit narratives that make teachers obstacles to reform, it situates curriculum change within the labour realities of schools, where the demand for subjects can vary while the supply of teachers remains constant and it uses interview data to show that reskilling potential is unevenly distributed across career stages and is highly mediated by knowledge, confidence, and perceptions of professional risk. The main thesis is that Coding and Robotics should be viewed not only as a new area of learning for students but also as a professional development frontier.

2. LITERATURE REVIEW AND ANALYTICAL FRAMING

South Africa is experiencing a rapid growth in the body of Coding and Robotics literature. However, this literature leans more towards preparedness, curriculum interpretation, play-based learning, and broader questions about the digital transition. A smaller corpus focuses more directly on teacher preparation in computational thinking and robotics. This section summarises these strands to place teacher reskilling and diversification in teaching Coding and Robotics as a valid analytical prism, rather than an accidental policy byproduct.

2.1 Coding and Robotics as Curriculum Reform in South Africa

Recent South African scholarship contextualises the introduction of Coding and Robotics as a major curriculum change, but one that occurs within a system already overwhelmed by unequal access to technology, inconsistent digital literacy, and limited teacher support. Geldenhuys and Fataar (2021) found that, even in the early stages of implementation, teachers in the Foundation Phase felt uncertain about the subject's requirements and the methods of teaching it. Hart (2023) synthesised South African educational technology research and subsequently identified five common determinants of uptake: access to technical resources, pedagogical fit, skills and training, efficacy beliefs, and supportive leadership. These aspects are directly applicable to Coding and Robotics, as the topic depends not only on the devices but also on teachers' confidence and instructional legitimacy (Geldenhuys & Fataar, 2021; Hart, 2023).

Recent studies affirm that teacher preparedness is the critical bottleneck. In a systematic review of Educational Coding and Robotics curricula, Zivanayi and Malinga (2025) found that resources, pedagogical computer skills, and institutional support directly influence teachers' willingness and

confidence. Similar results were found by Selepe (2025), who noted that teachers of the Foundation Phase tend to use unplugged or low-technology methods due to the lack or limited availability of technological tools. Mashite and Dewa (2024) suggest that the South African debate has now swung between hope and danger, and teacher preparation is at the heart of the conflict.

2.2 Teacher Preparedness and Professional Learning

The global study of coding, robotics, and computer science teacher learning leads to a solid conclusion: teacher learning in this field cannot be improvised. In a review of teacher training programmes in educational robotics, Schina, Esteve Gonzalez, and Usart (2021) identified that effective programmes include technical content, pedagogical modelling, design tasks, and practice opportunities. Ni, Bausch, and Benjamin (2023) also found that professional learning communities help overcome teacher isolation and improve continuity in computer science teacher development. More recently, Ma et al. (2025) found a significant overall effect of in-service computer science teacher professional development, especially when programmes focused on knowledge, practice, and teaching competence together and not independently.

This general professional learning literature guides the current study by transforming the reskilling question as a rhetorical desire into a tangible design problem. To move teachers into Coding and Robotics out of other subject areas, they need more than enthusiasm; they need organised, sequenced learning, curriculum-based examples, long-term support, and time to teach, reflect, and reteach. If these important aspects are taken seriously, teachers will be more likely to be interested in reskilling. Already, Ogegbo and Ramnarain (2022) reported that teachers expressed a desire to use computational thinking across other subject areas but required contextualised strategies.

2.3. Reskilling as Professional Repositioning

Reskilling involves acquiring new competencies to meet evolving professional demands, particularly in response to technological and institutional change (Bhoi *et al.*, 2026). Therefore, the study defines reskilling as the intentional learning of new curricular, pedagogical, and technological skills that enable teachers to realign themselves in response to institutional change. This definition is consistent with the recent research on digital transformation in education, which highlights that the future relevance of teachers is increasingly determined by their ability to learn new technologies, translate them into pedagogy, and redefine professional identity under the conditions of uncertainty (Maqoqa, 2024; Mhlanga & Moloi, 2020; Reimers, 2021).

Coding and Robotics reskilling is especially important because the discipline combines technical skills with broader pedagogical importance. Studies associate educational robotics and block-based coding with problem-solving, creativity, critical thinking, collaborative learning, and enhanced learner engagement (Moraiti, Fotoglou, & Drigas, 2022; van Zyl et al, 2025). Govender and Govender (2021) also explain that physical computing has the potential to make programming more tangible and approachable for beginners, which is essential when teachers lack a background in computer science.

Reskilling seems to have positive implications for both curious and obsolete teachers. Coding and Robotics need not be a niche for preexisting experts, making it a convenient route to diversify teachers' professional foundations through well-designed professional pathways (Govender & Govender, 2021; Moraiti et al., 2022; van Zyl et al., 2025).

3. THEORETICAL FRAMEWORK

This study utilised an integrated theoretical framework that combined Mishra & Koehler's Technological Pedagogical Content Knowledge (TPACK) and Schultz & Becker's Theory (HCT) to guide the analysis and interpretation of findings on teacher reskilling. The TPACK framework was employed to examine how teachers' levels of Coding and Robotics content, pedagogy, and technological knowledge are linked to subject acceptance (Mishra & Koehler, 2006). Human Capital Theory views reskilling as an investment in individuals' knowledge and skills that enhances their productivity, adaptability, and future professional value (Becker, 1993; Schultz, 1961), making it highly applicable in guiding the study of teacher reskilling in emerging areas such as Coding and Robotics.

Pragmatism guided the study in integrating findings and practical interpretations by focusing on how teachers' experiences, perceptions, and reskilling outcomes can inform real-world improvements in the adoption of robotics in education.

4. METHODOLOGY

This qualitative study explores how teachers view Coding and Robotics as a potential path to reskilling and diversification. The research takes a pragmatic stance, appropriate to both interpretive and practical aspects, to shed light on how a curricular change can address complex, concrete staffing and professional development issues in schools.

4.1 Research Design and Context

The study followed an exploratory qualitative design with the aim of eliciting perceptions, hopes, interests, desperations, anxieties, and possibilities that could not be easily measured with standardised measures.

4.2 Sampling, Participants and Data Generation

The data were generated and collected from a purposively selected sample of 5 senior-phase teachers from 4 Coding and Robotics pilot schools in the Umlazi District. The senior phase was the last phase to implement the Coding and Robotics pilot programme in 2024. The implementation was fairly new and challenging for teachers and school management. The sample from this phase was most relevant for the study. The use of purposive sampling was justified by the study's focus, particularly the schools where Coding and Robotics are already taught. The sample was limited to 5 due to either the delayed implementation of the pilot programme in their schools or the pilot programme being halted. The sample

was not representative of the entire nation, but this weakness is consistent with the exploratory nature of the study.

The profile of the participants showed that they focused on younger and mid-career age groups, with two participants aged 18-28, one aged 29-38, one aged 39-48, and one aged 49 and above.

The individual interviews focused on four areas: teachers' current specialisations, their experiences with subject contraction, their perceptions and knowledge of Coding and Robotics, and their willingness to reskill teaching Coding and Robotics. The analytic emphasis was not on exhaustive life histories but on the determination of patterned dispositions to the reform. Table 1 summarises participants' profiles and the extent of subject displacement reported in the sample.

Table 1. Participant profile and reported subject displacement by age cohort

Indicator	18 to 28 years	29 to 38 years	39 to 48 years	49 years and above	Total
Participants	02	01	01	01	05
Participants reporting one or more specialisations contracted	00	01	01	01	03
Participants reporting consultation before contraction decisions	00	00	00	01	01
Participants expecting redeployment	00	00	01	01	02
Participants teaching some/mainly non-specialisation subjects	02	01	01	01	05

Table 1 shows that the experience of subject contraction reported was largely among senior participants, and consultation with affected teachers was uncommon. The table also shows that subject instability was already driving staffing changes, in particular, the relocation of teachers to non-specialised subjects. These trends are important as they outline the pragmatic circumstances within which reskilling is a viable option.

4.3 Data Analysis

The interview data were analysed using reflexive thematic analysis, as per the modern framework of Braun and Clarke. The analytical procedure involved repeated readings of the interview transcripts, the creation of preliminary codes, the grouping of similar codes, and the development of broad themes that summarised patterned meanings across the dataset (Braun & Clarke, 2021). Due to the study's limited scope, the analysis was tightly constrained by the data while seeking interpretive depth. The goal was not simply to list responses, though the numerical counts were helpful for depicting the distribution of attitudes by age groups; rather, it was to describe how teachers explained the relationships among subject instability, knowledge gaps, and professional futures.

4.4 Reliability and Ethical Issues

Reliability was strengthened by a strong correspondence between the research question, the interview schedule, and the themes expressed in the findings. The paper also uses tables to maintain the descriptive integrity of the source dataset and to reduce interpretive overreach. Since the sample size is small, the results are described as exploratory and may not be necessarily generalizable.

5. FINDINGS

The results showed a pattern throughout the interviews. Coding and Robotics was rarely perceived through the prism of substantive curricular language, but it gained new significance when participants were asked to consider it in the context of subject contraction, redeployment risk, and future employability. The findings are organised into the following four themes: subject contraction and new teacher precarity; near-universal knowledge gaps in Coding and Robotics; reskilling orientation influenced by career stage; and teaching outside specialisation as an interim survival strategy.

5.1 Subject contraction and new teacher precarity

Participants described the subject contraction as an administrative ruling with direct consequences for professional security. Four out of the five teachers in the sampled schools stated that one or more of their specialisations had been contracted or destabilised, but only stated that she had been consulted. P2 said,

Well, I had fears for my future; I really don't know what will happen. I only learnt at the end of last year that I will be teaching Coding and Robotics this year. No reasons were provided at that time, except for a change in the school curriculum. I was so shocked, but at least I survived redeployment

In this regard, interview accounts did not describe subject contraction as an abstract curriculum management process but as a lived experience of uncertainty. To most participants, the main impact was increased fear of redeployment, loss of teaching identity, or progressive professional obsolescence.

This theme is analytically important as it demonstrates that the perceived value of Coding and Robotics did not appear in a vacuum. It became a reality in a local labour environment, where some teachers wanted to try new things, while others faced displacement and were at risk of redeployment. As a result, the reform was seen not only as a new topic for learners to study but also as a potential means of professional development, particularly by younger teachers.

5.2 Near-universal knowledge gaps in Coding and Robotics

The depth of the knowledge gap was the most salient finding. None of the 5 participants reported a clear operational understanding of the Coding and Robotics content, methodology or technology. All participants reported having little or no knowledge of the subject's substantive requirements. However,

three participants were aware of the lack of teachers in this field. This is a serious contradiction: the opportunity structure was partly apparent, but the knowledge needed to act on it was lacking. P1 explained,

I had heard about the subject and its future significance, but I didn't know much about it. I didn't think the subject would be taught even in our schools, so I didn't think much about it until I had to teach it.

That paradox is representative of South African literature. Teachers can be aware of the symbolic significance of Coding and Robotics but lack pedagogical knowledge for classroom implementation. Recent South African research indicates similar trends of poor preparedness, dependence on low-tech solutions, and demands for more contextualised teacher support (Selepe, 2025; Zivanayi & Malinga, 2025). The data align with the current literature, indicating that teacher mobility in the subject is also inhibited by a deficit in Coding and Robotics knowledge. The table shows Coding and Robotics knowledge and reskilling by cohort.

Table 2. Knowledge of Coding and Robotics and reskilling orientation by age cohort

Indicator	18 to 28 years	29 to 38 years	39 to 48 years	49 years and above	Total
Participants reporting clear knowledge of Coding and Robotics	00	00	00	00	00
Participants reporting little knowledge of Coding and Robotics	02	01	00	00	03
Participants viewing the subject as a reskilling opportunity	02	01	01	01	03
Participants willing to reskill	02	01	00	00	03
Participants preferring redeployment to reskilling	00	00	01	00	01
Participants preferring resignation or retirement to reskilling	00	00	00	01	01

Table 2 illustrates that the reported minimal subject knowledge did not provoke a unanimous rejection of the initiative. Instead, the willingness differed significantly across age groups: younger participants were more likely to view the lack of knowledge as an overcomeable deficit, whereas older participants were much more likely to see the same deficit as an insurmountable barrier they were unwilling to face.

5.3 Reskilling orientation is influenced by career stage.

The interviews showed a big difference between the participants aged 18 to 38 and those aged 39 and above. The younger cohort indicated a willingness to reskill, whereas the older cohort showed none. One

older person from the older age groups preferred redeployment over reskilling, and one other senior preferred to resign or retire rather than take up Coding and Robotics.

This trend cannot be explained by mere age. In this regard, age is used as a proxy for career stage, technological change confidence, and perceived payoff of additional learning. Age, career stage, prior experience, and perceived relevance shape intrinsic motivation and adult learning engagement (Knowles, 1984). There is sufficient evidence that practical familiarity with robotics and computational thinking among teachers predicts the degree to which they perceive the potential of Coding and Robotics in the classroom (Hijón-Neira et al., 2024; Papadakis et al., 2021), and that seniority is possibly linked to a less conceptualised view of Coding and Robotics and more sceptical views of educational robotics (Papadakis et al., 2021). The statistics used in this paper align well with that trend (Vinnervik, 2022).

This discovery thus makes it difficult to make simplistic policy assumptions. The Department of Basic Education cannot simply declare reskilling opportunities. Teachers compare reskilling against various factors, such as time horizon, professional identity, workload, confidence, and perceived difficulty. Teachers in this sample with early-career and lower-middle-career experience were more likely to consider Coding and Robotics as an investment, and late-career participants were more likely to consider it disruptive.

5.4 Teaching outside specialisation as an interim survival strategy

The prevalence of non-specialised teaching was also reported. All participants reported that they were already temporarily or permanently assigned to teach subjects outside their area of expertise. This practice was a temporary measure to counter subject contraction, but it also revealed a systemic contradiction. Schools address short-term staffing emergencies by reallocating teachers, but this response risks perpetuating poor curriculum implementation when teachers have limited content and pedagogical understanding.

These data results have a two-fold implication in the context of Coding and Robotics. On the one hand, it shows that schools are already accustomed to reallocating staff when the curriculum demand changes. It also warns against conflating simple reassignment with reskilling. Reskilling in coding and Robotics should not be a tick-box or an administrative replacement, but an intentional shift in mindset.

6. DISCUSSION

Coding and Robotics is a curriculum innovation that involves a professional labour issue, which raises two important issues for discussion in this paper. The literature available in South Africa has focused more on implementation readiness. Readiness questions cannot be discussed outside the context of teachers' perceptions of their future roles in the school system.

6.1 Curriculum reform to labour market opportunity

The most powerful revelation of the research is that Coding and Robotics can be a significant reskilling opportunity when teachers are subjected to curriculum change rather than a remote policy discussion. To those whose specialisations were strained, the new subject may be a potential path back to relevance. This does not imply that the reform is a panacea for teacher underutilization. It implies that the reform opens up a policy space for teacher reskilling.

That argument is consistent with the modern research on digital educational change. Both Maqoqa (2024) and Reimers (2021) stress that educational change is increasingly reliant on teachers' willingness to renew their practice and expand their professional competence. If this digital curriculum change were clearly and positively linked to employability, redeployment avoidance, and career continuity, teachers might be more receptive to it than when it is framed solely as national innovation rhetoric.

6.2 Requirements of successful teacher reskilling

The results also show that reskilling cannot be left to personal improvisation. All participants indicated limited knowledge of Coding and Robotics, so a self-directed transition is unlikely to occur at scale. Therefore, well-planned, hands-on, and continuous teacher development programmes are suggested to transform practice, build collaborations, and build confidence, thereby capacitating teachers in content, relevant subject pedagogy, and technological expertise (Ma et al., 2025; Ni et al., 2023; Schina et al., 2021). Ogegbo and Ramnarain (2022) demonstrate that, in South Africa, teachers require contextualised and practical assistance if computational thinking were to become part of daily classroom activities.

To achieve the best outcomes, the DBE needs a reskilling model grounded in progressive development. That programme would start with conceptual orientation and unplugged computational thinking, followed by low-cost physical computing and block-based environments, and then move on to subject-specific pedagogy, lesson planning, and mentored classroom practice. Reskilling should thus be technologically ambitious but contextually modest. It must not train teachers in an idealised environment, but in real schools (Govender & Govender, 2021; Selepe, 2025). Therefore, low-tech pedagogies cannot be excluded from the programme, as they remain necessary in under-resourced schools (Selepe, 2025).

6.3 Opportunity without romanticism

Munje and Jita (2020) demonstrate that the integration of Coding and Robotics in South Africa is constrained by insufficient infrastructure, unequal access, insufficient training, and institutional inequality. The opportunity identified by this study would be analytically careless to romanticise. Reskilling is necessary, but given the challenges associated with Coding and Robotics, it is a difficult decision. Hart (2023) and Mhlanga and Moloi (2020) state that the digital transition in South Africa is fast-tracked under pressure, not with equal preparedness. Although the integration of Coding and Robotics opens opportunities for teachers who want to try new things, those whose subjects are constrained, and those facing redeployment, it is important to understand that it is not a magic bullet for addressing teacher unemployment or subject redundancy. However, it significantly contributes to

teacher redundancy and redeployment challenges. The reskilling pathway will be symbolic and not practical without funding, time, devices, leadership support, and continuous pedagogical mentoring.

7. STUDY LIMITATIONS

The sample is narrow, limited to one province, KwaZulu-Natal, and self-reported rather than observed in classrooms or training interventions. The results thus do not warrant national generalisation. However, they legitimise a more acute research and policy agenda. Future research must explore pilot reskilling programmes, compare results by age and subject group, and monitor whether reskilled teachers are indeed confident and competent in entering Coding and Robotics classrooms.

8. CONCLUSION

This paper argues that the introduction of Coding and Robotics into the South African curriculum must be interpreted in two complementary ways. It is a curriculum reform that requires greater implementation capacity. It is also a professional development opportunity, enabling some teachers to reskill and diversify as their current subject pathways become constrained. The interview data indicate that this opportunity is factual but disproportionate. The willingness to reskill was significantly higher among younger participants, and the willingness to redeploy or leave was higher among older participants. Across the entire sample, knowledge of Coding and Robotics was low, suggesting that willingness alone will never be enough. The provincial departments and the DBE should consider integrating Coding and Robotics as a strategic component of reskilling the broader teacher workforce. Reskilling should be planned, budgeted, and designed accordingly. Universities, teacher development centres, subject advisors, and school-based mentors should be mobilised to develop and facilitate accredited short-term programmes that integrate computational thinking, low-cost robotics, pedagogy, and supervised practice. That way, Coding and Robotics may become a plausible pathway, particularly for under-utilised teachers to become relevant again, for schools to increase staffing capacity, and for curriculum reform to gain a more robust human infrastructure.

Declarations

STATEMENT OF PARTICIPANTS' CONSENT

Ethics Approval and Consent to Participate

Ethical clearance for this study was obtained from the relevant institutional ethics review committee prior to data collection. Permission to conduct the research was also granted by the South African Department of Basic Education and the respective school authorities. (see documents attached).

All participants were fully informed about the study's purpose, the procedures involved, and their rights as participants. Participation was voluntary, and teachers were assured that they could withdraw from the study at any time without penalty. Written informed consent was obtained from all participants

before data collection commenced. To ensure confidentiality, pseudonyms were used, and all identifying information was removed from the data. Data were securely stored and accessed only by the researcher (see documents attached).

Consent to Participate

All participants provided written informed consent to participate in this study. They were informed about the nature and purpose of the research, the methods of data collection (including interviews, classroom observations, and document analysis), and how the data would be used. Participants were assured of confidentiality, anonymity, and their right to withdraw at any stage without negative consequences (see attached documents).

Consent to Publish

Participants provided informed consent for the anonymised data collected during the study to be used in academic publications and presentations. No identifying information is included in this publication, and all efforts have been made to ensure that participants and their respective schools cannot be recognised.

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