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Synergy of Research Paradigms and Critical Theory in an Action Research Study

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ABSTRACT

The study explores the synergy of research paradigms comprising the living education paradigm, action learning paradigm, action science paradigm, and cooperative paradigm with critical theory in an action research study. This is supported by the explanation in Figure 4. Action research changes situations that people encounter in their everyday activities. Purposive sampling was used to select Grade 8 Technology Education (TE) teachers. Thirteen TE teachers from seven public schools participated in the study through the emancipation action research approach. Data were generated through observations and interviews. In collaboration, TE teachers were engaged in Progressive Environmental Action Research (PEAR) activities. The study found that TE teachers experience challenges in schools, including the integration of environmental matters into their subject. The implementation of PEAR activities addressed teachers' challenges in their schools and shared insights on the synergy of research paradigms and critical theory. There is a synergy between research paradigms and critical theory, where identified problems are turned into workable solutions. Applying the research paradigms and the critical theory in TE has implications for teaching and learning in schools. The study's findings are useful for TE teachers and other stakeholders when planning activities that promote collaborative learning, as advocated by research paradigms and critical theory.

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INTRODUCTION

Environmental Education (EE), sometimes labelled as Education for Sustainable Development (ESD), is integrated across school subjects as stipulated by the Department of Basic Education in the Curriculum and Assessment Policy Statement (CAPS) document in South Africa. The integration of Environmental Education (EE) across different school subjects helps learners develop a holistic understanding of environmental issues and encourages them to become environmentally responsible individuals (Ismail, Luqman & Budiati, 2023). However, few TE teachers have integrated EE into the curriculum (Wang, Loh & Sera, 2023). This low-scale integration can be attributed to the fact that many teachers do not know how EE can be integrated into the TE curriculum (Yatagawa & Kurishima, 2022). Moreover, the curriculum does not command a uniform teaching technique to incorporate EE into classroom teaching and learning. The selection of EE content to teach in class is based on the teachers' personal experience and the learners' interests (Damoah, Khalo & Adu, 2024). TE is an environmentally oriented subject, and failure to acknowledge the integration of EE across TE learning content (Processing, Systems and Control, Structures, Society and Environment) could contribute to environmental problems

owing to the availability of materials. Environmental problems are problems that continue to be experienced repeatedly (Ismail et al., 2023).

In today's world, raw and processed materials are used in everyday life activities, and their use has increased significantly over time, resulting in environmental issues such as littering in our living spaces. Plastics serve a purpose in our daily lives; however, improper disposal of plastic pollutes the environment. To reduce the ever-increasing use of materials that result in litter, integrating design for sustainability in TE could serve the purpose because TE has design elements embedded in its curricula. Design was identified as a critical component in the transition to more responsible and sustainable production and consumption models (Bhamra & Hernandez, 2021). The ability to self-maintain over time is called sustainability (Penty, 2019). Thus, meeting current needs without jeopardizing future generations' needs (World Commission on the Environment and Development, 1987). People are encouraged to reuse and reduce rather than recycle when designing for sustainability. For example, as argued elsewhere in this document, plastics could be used to crochet doormats, reducing the production of plastic bags reused for a specific task. Design education prioritizes creativity and innovation; activities in design education aim to develop technological capability and innovative problem solvers through design (Conway, Leahy & McMahon, 2021). Design for sustainability fits well into the study because designers consider the environment when designing products that will reduce environmental issues. Considering the three key factors of sustainability, which are human (people), economic (profit), and environmental (planet) (Penty, 2019).

Foregoing argument, TE encourages collaborative learning, allowing learners to seek solutions to real-world problems by examining materials, using tools and equipment, designing and building, developing procedures, and conveying the value of their work (British Columbia Ministry of Education, 2016). Accordingly, TE shares a similar approach with the research paradigms and critical theory, as both advocate collaborative problem-solving to address identified problems in the study. Therefore, teaching learners how to solve problems is an important purpose of education (DeLuca, 1991). However, TE teachers confront challenges in implementing EE design activities due to a lack of understanding of EE and design, a lack of motivation to conduct EE design activities, insufficient teaching resources, and restricted teaching time (Wang, Loh, & Sera, 2023). Damoah et al. (2024) found that teachers' and learners' perspectives and knowledge of integrating EE into teaching and learning are limited and uninteresting. Teachers had no experience with EE, which impeded their efforts to incorporate EE into their classroom practices as mandated by the CAPS. In the study, Progressive Environmental Action Research (PEAR) activities presented in Table 3 were implemented to address some of the barriers, including insufficient teaching materials, by utilizing waste materials to carry out teaching and learning activities.

Much research has shown that environmental-based learning improves learning quality greatly, yet many teachers have struggled to incorporate it into their teaching methods (Baan, 2023). Such research includes the following: In the United States, DeLuca (1991) carried out research to identify and explain problem-solving processes, thinking abilities, teaching approaches, and teaching styles often used by TE teachers recognized for their teaching excellence. Ndlovu and Gumbo (2018) conducted a descriptive case study to investigate how TE teachers in South Africa incorporate the Technology-Society-Environment strand into their teaching and learning activities. Another study in Malaysia by Rosman, Omar, and Zahari (2019) investigated teachers' pedagogical approach to incorporating ESD into the topic of design and technology (TE). Wang et al. (2023) conducted a study in Japan to better understand the problems that TE teachers face while incorporating EE design activities into the TE curriculum. These studies have the limitation of not investigating the implementation of PEAR activities to address the issues that TE teachers experience in their schools.

This study integrates research paradigms, including the living education paradigm, action learning paradigm, action science paradigm, cooperative paradigm, and critical theory in an action research (AR) study. These paradigms are integrated with critical theory in the study to

establish the synergy and its influence in the study. The paradigms and critical theory advocate empowerment through collaboration. In exploring the synergy, the study used PEAR activities, which refer to participatory hands-on activities to turn identified problems into practicable solutions. The application of PEAR activities is to provide stimulus and awareness to learners on a regular basis to keep caring for and maintaining the environment to always be clean, which, if done continuously, will indirectly make a habit in learners who have a caring spirit for the environment (Ismail et al., 2023). The current study addressed challenges encountered in TE by integrating environmental matters. However, the study focuses on the synergy of the paradigms and critical theory to explore if there is a synergy between research paradigms and critical theory applied in the AR study. Hence, the study differs from the mentioned studies of locating research paradigms within a theory, subsequently addressing TE challenges.

The study focuses on the synergy of the paradigms and critical theory, which responds to the question: *Is there a synergy between research paradigms and critical theory applied in the action research study*?

People change over the years, and the environment in which they live has a constant influence. In this regard, little is known about the synergy of paradigms and critical theory in an action research study. The practical application of the study's theoretical framework and research paradigms is described in Table 1.

Table 1. Research paradigms

	How are they integrated?	How are they used in the study?
Living education paradigm	TE teachers examined and reflected on their teaching practices to conscientise learners on litter issues. Through teachers' reflections, the elements, including routine and habits, were evaluated.	The study took TE teachers out of their comfort zone by challenging the status quo of teaching TE like any other school subject. It disrupted teachers' norms of thinking and doing things. Teachers' practices were altered from a teacher-centred approach to cooperative learning.
Action learning paradigm	TE teachers were asked questions related to the problem, which revealed challenges they encounter in raising learners' awareness of littering and coming up with a solution. Solutions are translated into TE teachers' actions through collaboration.	Teachers worked together in their respective schools to plan lessons and integrate environmental content into TE lessons to raise learners' awareness of litter. The PEAR intervention programme was designed and implemented through AR cycles: plan, observe, act, and reflect.
Action science paradigm	Data generated informed actions that were taken. The paradigm formed the basis of Cycle 1 of pre-analysis to understand problems that TE teachers encounter in schools and to propose solutions.	The PEAR programme was implemented to address litter issues at school, utilising AR cycles to plan, observe, act and reflect.
Cooperative paradigm	TE teachers took part in the designing of a PEAR programme discussed in Cycle 2 (Section 4.1) and worked together in their respective schools to conscientise learners on litter issues.	The paradigm is applied in Cycle 2 of drafting the PEAR programme based on identified challenges and throughout the study as TE teachers implement activities to solve identified problems, as reported in Cycles 3 and 4 in Section 4.
Critical theory	Challenges identified were turned into workable solutions	AR cycles plan, observe, act and reflect were implemented to empower teachers.

Synergy is "the value that comes when the whole adds up to more than the sum of its parts" (Kanter, 1990, p. 58), as shown in Figure 1. Theories are among the most important tools of science (Maier, van Dongen & Borsboom, 2024). Despite theories in AR being explanatory, they are also exploratory and descriptive. Theories describe the conditions and processes through which

learning occurs (Saunders & Wong, 2020), leading to action learning. The explanatory, exploratory, and descriptive power of the theories leads to a deeper understanding of the phenomenon under study. Given that EE/ESD and TE are all hands-on disciplines, it is crucial to understand how TE teachers integrate environmental themes into their classrooms to provide learners with environmental knowledge and awareness. As Lucas (1972) has argued, it is meaningful to speak of environmental research taking place *in* the environment and of education *about* the environment aimed at preserving the environment. It is also important to mention education *about* the environment that takes place *in* the environment, for the learner to try to preserve the environment. As an example, TE teaches learners about design artefact solutions to their immediate problems and processing materials to come up with a new product.

The researcher worked with TE teachers to improve their practice by utilizing research paradigms, emancipatory action research, and critical theory. This process revealed ways to solve problems. According to Zuber-Skerritt (2001), learning is lifelong and ongoing (problem-solving) in cycles of action and reflection in response to new questions that are unfamiliar to us and that we try to answer using research paradigms, emancipatory action research, and critical theory. Figure 1 depicts this. Taking action and learning from experience or concrete experiences results in meaningful learning. In emancipatory action research, inside practitioners take responsibility, or ownership, for the research process to change practices (Nehez, 2024). It is critical to underscore that the concepts of living education, action learning, action science, the cooperative paradigm, critical theory, and emancipatory action research are conceived as a dialectical relationship between 'action'—activities, concrete experiences, practical trials, explorations, or applications—and 'learning' or 'research'—understanding, creating, and advancing knowledge through reflection, inquiry, and critical evaluation (Zuber-Skerritt, 2001).

Figure 1 indicates how research paradigms are interconnected to develop a close relationship between EE and TE. For instance, teachers allow learners to learn in their immediate environment and to be aware of littering by working together to keep the environment clean. This allows teachers and learners to explore their living conditions. In simple terms, the activity allows learners to learn individually and/or in groups to take action to solve environmental problems in their local environment. It has been demonstrated that anyone can act as a scientist and produce contextual knowledge (grounded theory) within an organization or among any group of people by participating in emancipatory action research projects. This type of problem-solving inquiry works best in a supportive, non-hierarchical environment (Figure 1). For personal and organizational change to be truly transformative, all group members should adopt a critical and self-critical mindset (Zuber-Skerritt, 2001). The critical theory advocates for self-determination, participation, and justice in democracy and seeks to awaken the world to its possibilities. Critical theory is a social theory that aims to critique and change society as a whole (Nickerson, 2022).

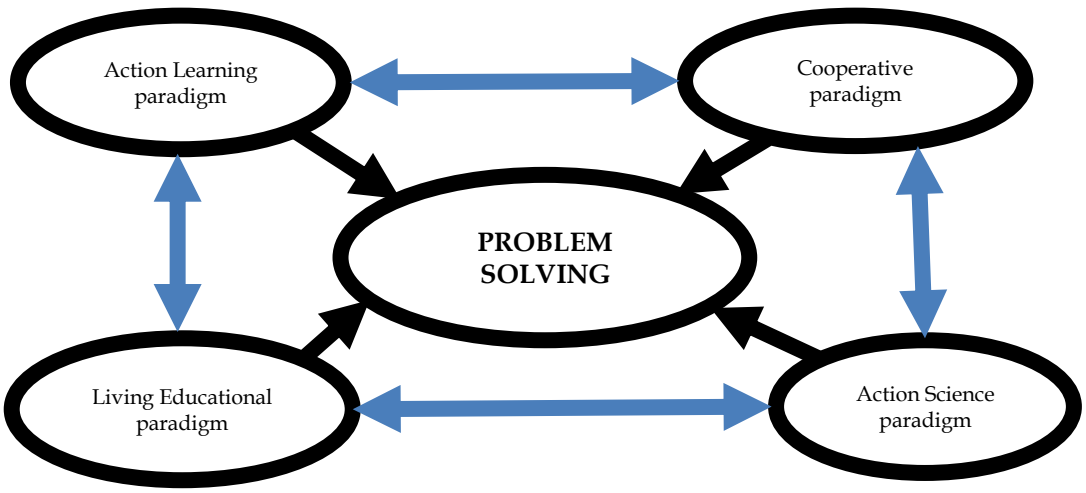

Figure 1. Blending research paradigms (Matsekoleng, 2023).

The above paradigms are the branches of AR in which emancipatory action research falls. Living education, action learning, action science, and cooperative paradigms embrace experiential knowing and are participative. Paradigms rely on verbal and non-verbal recorded conversational data, which promotes transformational learning and may lead to the empowerment of TE teachers in their daily struggles to integrate environmental themes into TE. As literature has emphasized, knowledge arises in and for action (Reason, 1994). Critical theory's approach to the social construction of experience led them to view their disciplines as manifestations of the discourse and power relations of the social and historical contexts that produced them (Steinberg & Kincheloe, 2010). The applied paradigms in Figure 1 helped provide contextual knowledge while solving the problem. Critical theory, according to the scholars Steffy and Grimes (1986), claims to be an empirical and practical philosophy that incorporates epistemological concerns such as the relationship between method and theory and the social consequences of theory validated through particular modes of research into the methodology. The study's research paradigms, critical theory, and data collection methods revealed challenges that TE teachers encounter in schools to raise learners' awareness of litter. Critical theory presupposes that theories, systems of knowledge, and facts are ingrained in and reflect relativistic worldviews, according to Steffy and Grimes (1986). Using an analysis of the ontological, epistemological, and methodological presuppositions underlying research, critical theory promotes organizational science. Such an analysis forces discussion on the applicability of theory and paradigms and challenges dominant forms of reason. In addition to examining the ontological, epistemological, and methodological foundations of organizational science, critical theory also examines the practical connections between theory, technology, practice, and ideology (Steffy & Grimes, 1986).

RESEARCH METHOD

Figure 2 depicts a research flow diagram. The study used qualitative emancipatory action research to mitigate barriers experienced in schools. Because AR differs from other research methodologies in that it combines research and action. Action research provides a structured process for customizing research findings, enabling teachers to address specific questions, concerns, or problems within their own classrooms or schools (Mertler, 2021). Action research intends to understand a problem in a particular area and devise strategies to improve the situation collaboratively. In this context, I refer to the problems experienced by Grade 8 TE teachers, but the focus is on the synergy of the research paradigms and critical theory in responding to the question: *Is there a synergy between research paradigms and critical theory applied in the AR study*?

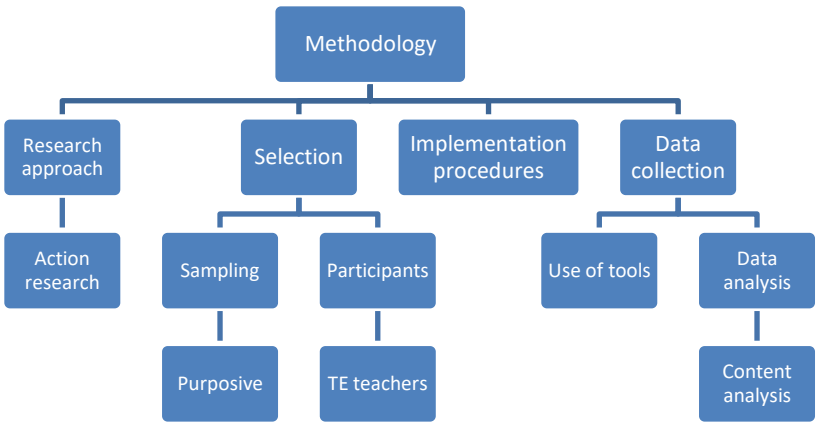

Figure 2. Research flow diagram

The researcher used purposive sampling to select 18 Grade 8 TE teachers from 10 schools in Gauteng Province in the Gauteng East district. Since TE can offer hands-on activities through a design process and is considered an environmentally oriented subject. The application of purposive sampling allows data collection focusing on specific people with rare knowledge or experiences (Ahmed, 2024).

Five TE teachers in three schools withdrew their participation owing to different reasons, such as workload. The study, however, continued with seven schools and 13 TE teachers. Participants were informed that participation was voluntary and that they could withdraw their participation at any time without consequences. Table 2 presents the number of TE teachers who participated in the study categories according to their age. The age categorization aimed to show the persistence of challenges that TE teachers have encountered over the years. However, the study aimed to explore whether there is a synergy between research paradigms and critical theory applied in the AR study.

Table 2. Number of TE teachers who participated in the study

Age category	Number of TE teachers	Percentage
20-30	6	33%
31-40	5	28%
41-50	4	22%
51-60	2	11%
61-70	1	6%
Total	**18**	**100%**

Data were collected through observations and semi-structured interviews. The interview questions asked of participants in the study were piloted first. Piloting helps to ensure that the questions are clear and easy to understand but also enables the researcher to raise the quality and reduce the vagueness of the collected data (Al-Sinani, 2020). This was done, among other things, to close the ambiguities of the questions. For instance, one question read as follows: *How do you rate the cleanliness of your school and classroom?* Selected participants, who did not form part of the study, struggled to answer some of the questions owing to language technicalities. Upon piloting the instrument, this question, among others, was refined as follows: *How do you rate the cleanliness of your school and classroom on a scale of 1-5?* One means poor, two fair, three average, four good, and five excellent.

The observation schedule was used to observe TE teachers in their classrooms and the school surroundings. The interviews were used to provide a fresh perspective on the challenges faced by TE teachers in raising learners' awareness of littering. The application of the research tools aimed to generate data that could lead to new knowledge.

The researcher used a digital audio recorder to record interviews with TE teachers, and the recordings were transcribed. Data from observations and interviews were also transcribed, and tables were utilized to organize the data. This process was carried out in accordance with the research question of the study. A verbatim coding method was employed to capture the essence of the TE teachers' responses. The study employed content/textual analysis as a systematic and objective method of interpreting verbal, visual, or written data to characterize and quantify certain events (Wolhuter & Seroto, 2020). This helped identify textual cues that facilitated understanding of the issues and interpretation of the data. Trustworthiness measures, including credibility, transferability, dependability, and confirmability, were applied in the study. I spent over six months in the field observing TE teachers and conducting interviews, which lasted between thirty minutes and an hour. The combination of research instruments, approach, theoretical framework, and research paradigms supported the validity of the study's findings. Paradigms are a vital part of research for generating new knowledge.

The study adhered to the research ethics set by the University of South Africa. The University of South Africa College of Education ethics review committee approved the study with ethics number 2020/06/10/48502928/28/AM. Informed consent was sought from the in-service teachers who were over the age of 18 years. The intention of the study was explained to the participants. Teachers' participation in the study was conducted in line with the University of South Africa's 2016 research ethics.

RESULTS AND DISCUSSION

This section presents research results. The researcher used tables and coding processes to analyze the generated data. The table application helped the researcher analyze observed events and simplify data analysis. Observed events are presented in Table 3, and various PEAR activities were conducted to address problems identified in collaboration with TE teachers.

Table 3. PEAR activities

PEAR activities	Observed	Task conducted	Researcher's view
Environmental policy	It was observed that schools did not have an environmental policy.	TE teachers in their respective schools designed the environmental policy in collaboration.	The environmental policy was implemented in some schools, but was not as effective as expected.
TE policy document	Some teachers did not have a policy document of their own but shared one.	TE teachers were given copies of the TE policy document to ensure that they have their own copies in their positions.	The policy reinforced the application of the policy when teachers planned their lessons.
Compilation of Teachers' Files	Some teachers did not have a ledger file to put their documents in.	A file was compiled to ensure important documents, such as lesson plans, are put in the file.	The file is vital for classroom management to ensure effective teaching and learning.
Design litterbin	There was a shortage of bins in school, especially inside the classroom, which led to the visibility of litter on the floor.	Teachers tasked learners to design a bin for their class, and a 25-litre plastic polycan container was used to design a bin. The container was washed and painted.	A permanent bin structure was designed to address a shortage of bins in the classroom, and they learnt about different types of structures, besides being conscious of littering.
Constructing dustpan	Schools had a shortage of cleaning materials, so learners used paper or any flat object to remove garbage on the floor. At times, garbage was pushed onto the ground outside the class.	Learners cleaned the beverage containers. Then, the containers and wire were used to make the dustpan.	The task afforded teachers an opportunity to link EE and TE content. Availability of dustpans in the classroom is minimised, and conscientious learners on litter issues.
Making brooms	There was a shortage of brooms, and teachers had to buy brooms for their classes.	Learners were tasked to use veld grass within the schoolyard to make a broom for their class. Learners cut long strands of the grass and tied the tops together with a string to make brooms.	Classroom dirtiness has improved owing to the availability of the broom. But also, a task-integrated EE in TE lessons for conscientising learners on litter issues.
Exercise: Plastic Bags	Exercises given to learners were not	Learners were given a written exercise to	Practical activities and theory-based learning improved

PEAR activities	Observed	Task conducted	Researcher's view
	linked with practical activities, but were theory-based learning and lacked integration of EE.	investigate the impact of plastic shopping bags on the environment.	learners' learning and environmental awareness. The task was linked with the doormat and flower as discussed below.
Crocheting Doormat	Lawns are not planted in schools, but some are paved. The dust causes dirt in the classroom.	Learners used plastic bags dumped on the school grounds to make a doormat for their class.	The doormat reduced dust in the classroom and raised learners' awareness of litter issues. Teachers managed to integrate EE with TE content.
Crafting an artificial flower	Practical activities are only conducted for Practical Assessment Tasks (PAT) and are not linked with informal tasks.	Learners used a cardboard box; flower petals and plastic bags were used to make an artificial flower to decorate the classroom.	Teachers with this activity explored learners' creativity and enhanced their critical and problem-solving skills. Teachers achieved the goal of integrating content.
Design Snail Cam/Drop Cam	The exercises given to learners were not linked with practical activities, but were theory-based learning.	Learners used discarded timber to make a snail cam.	Teachers used the snail cam exercise to teach learners about the mechanisms involved in mechanical toys and explore their prior knowledge about toys.
Exercise on Structures	The exercises given to learners were not linked with practical activities, but were theory-based learning.	Learners were given a written exercise and a task to make them understand man-made and natural structures. A class exercise was developed based on different types of modern and indigenous structures.	Learners learnt about types of modern and indigenous buildings, animals, among other things. Some of the structures incorporated the topic of systems and control, and the tasks integrated EE in TE.
Lesson on the wheelbarrow	The exercises given to learners were not linked with practical activities, but were theory-based learning.	Learners used a wire to design the structure of the wheelbarrow, and a tin of Zambuk served as a wheel for the wheelbarrow.	Teachers, with the exercise, managed to show learners that any waste material can be used to create something useful. The wheelbarrow model served as a learning resource for teachers and learners.
Projector	The lack of teaching resources in some schools is a challenge which impedes teaching and learning.	A projector was provided to teachers to incorporate visual aids via slides, PowerPoint presentations or videos to teach learners.	Being equipped with the necessary teaching equipment helped the teacher deliver a lesson. As well, it has helped the learners to learn beyond the topic itself, as watching videos gave learners another dimension of learning where information was offered from a source other than their teacher.
Additional resource	Even though participating schools were using the prescribed textbooks, they lacked in certain topics.	An additional textbook was provided to teachers to supplement their teaching resources.	The addition of a textbook proved to be an additional resource and added another dimension to lessons.

The PEAR activities presented in the table aim to help teachers overcome challenges in incorporating environmental topics into their teaching, thereby increasing learners' environmental awareness. Currently, schools lack a learning model that uses the environment as a resource (Baan, 2023). An environmental policy was introduced to address this gap. Teachers participated in collaborative learning to use the school environment to solve specific problems. For example, Table 3 describes an activity where TE teachers guided learners to design classroom bins to address litter and raise awareness. This activity tied into the TE theme structures. Another activity involved learners making dustpans to address a shortage, prompted by litter both inside and outside the classroom. Learners often discard waste, such as beverage containers, which are later collected and burned after being transported to a school dumping site. Additionally, TE teachers encouraged learners to build brooms for the classroom to address broom shortages and raise awareness about litter. Learners gathered grass from the schoolyard, introducing them to local materials and teaching about processing and different structures. The issue of plastic bag pollution, a national problem, was also addressed through a practical activity where learners explored plastic's environmental impact. This included crocheting a doormat and crafting an artificial flower to connect theory with practice. The crocheted doormat activity aimed to show that plastic waste can be repurposed into useful items, helping learners understand processing and litter reduction. Teachers assigned this activity to promote awareness and placed the doormat at the classroom entrance to dust off their shoes. This hands-on approach helped learners understand litter issues while using waste as educational tools. The activity of making artificial flowers used discarded plastic and other materials to decorate the classroom, raising awareness of litter while integrating processing, structures, society, and environment themes. Another written activity discussed sought to connect theoretical learning with practical applications, emphasizing that TE inherently involves environmental issues and should reflect societal concerns. A wheelbarrow model was also designed to teach about reuse, forces, and structural types, bridging classroom learning with real-life experiences. Since wheelbarrows are common in daily life, this activity demonstrated how school lessons can relate to home practices and everyday activities.

The ensuing subsection discusses PEAR activities presented in Table 3, which were conducted with TE teachers using the cyclic process illustrated in Figure 3. The researcher explored the synergy of research paradigms and critical theory in an AR study.

Progressive Environmental Action Research Spiral Cycles

The researcher in this section discusses PEAR activities carried out in collaboration with TE teachers through the cyclic process displayed in Figure 3. In Cycle 1, the researcher conducted the reconnaissance study, which comprised generating data from TE teachers using observations and interviews. The intention of Cycle 2 was to design a PEAR program with TE teachers that served as a working plan for empowerment. These two cycles comprised Phase One of the study. Phase Two of the main study comprised Cycles 3, 4, and 5. Cycle 3 focused on working with the TE teachers in the interpretation of the curriculum. The aim of Cycle 3 was to ensure the issues of littering were integrated into lessons and assessments. Underutilization of waste materials in informal and formal assessments informed Cycle 4. This cycle made use of waste materials to serve as teaching and learning resources to raise learners' awareness of littering and to empower teachers with environmental pedagogies of integrating litter issues in their lessons. The final cycle, Cycle 5, provided teachers with resources. This was done to supplement teachers' teaching resources and address the lack of resources. The cycles are cyclical in their approach, as they were conducted progressively while planning, acting, observing, and reflecting in collaboration with teachers. Repeating phases and cycles, as well as movement between reflection and action phases, allowed for the development of deeper insights and refinement of solutions and thus enhanced credibility (Fredericks et al., 2024).

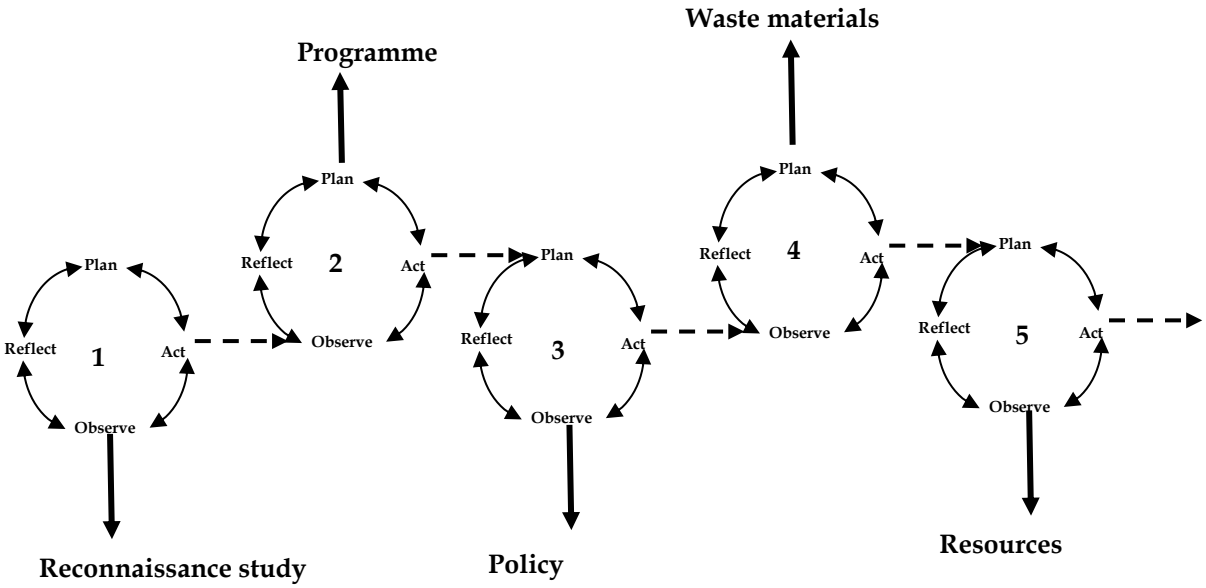

Figure 3. PEAR spiral cycles with TE teachers (Matsekoleng, 2023).

Teachers' Reflections on Lessons Learned

The section presents the perspectives of the TE teachers involved in the study, and trustworthiness was supported by the teachers' reflections (Fredericks et al., 2024). Critical theory provides a lived experience and a voice to those who are marginalized, thus providing the ability to change concepts and responses to populations (Parry, 2023). These perspectives demonstrate the success of PEAR activities conducted collaboratively, aimed at overcoming the challenges faced by TE teachers in raising learners' awareness of environmental issues, such as littering seen in schools. The scholar Lin (2015) contends that when an individual collaborates with more capable peers, their potential for development increases. In other words, with the support of an expert, individuals can achieve more, which is known as potential development.

In this regard, the TE teacher 13 states, *When the learners were designing the litterbin, they were happier to carry out the activity than to be in the classroom. Usually, when they write a class activity, they would take time to finish, and I had to push them, but with this one, they were really doing the work.* Because learners can learn through a variety of models and mechanisms, the learning environment can exist both inside and outside of the classroom. Classroom learning takes place in a constrained space and is less appealing to learners (Baan, 2023). This shows the potential development of learners and the effectiveness of outdoor education activities in motivating learning. When learners engage in relevant learning tasks in their daily lives, their motivation to learn increases (Baan, 2023). Learning in an outdoor environment can positively influence children's personal and social growth, healthy development, well-being, and learning abilities (Kiviranta et al., 2023) and can incorporate knowledge and skills and their application thereof. In addition, feedback was given in response to the intervention to address the shortage of litter bins in the school. This was an indication that outdoor learning could positively influence learners and enhance their awareness of the environment. As commented by the TE teacher 4, *I wish we had more time with you to explore other strategies we planned at the beginning with you*. Owing to time constraints, other activities such as developing a booklet could not materialize.

TE teachers were motivated to integrate environmental matters into their teaching. Teaching environmental concerns in the subject will teach learners about environmental issues and ways to deal with them. *I enjoy teaching about littering and the impact of technology on the environment, as they easily relate to the topics. Like if we are talking about littering, it is easy for you to make real-life examples. You tell them to look under the table, and they see the papers on the floor, so then they become aware that this is actually littering,* TE teacher. 9. TE teachers enjoyed engaging in the PEAR activities to conscientize learners on litter, but most importantly, it had a positive effect on the

teachers. *I was reluctant at first when you were explaining the intention of your study because back then I did not see the relevancy of the study to technology. Remember, I even said, "Why don't you work with geography teachers because it fits there?" "I'm grateful I took the journey; it was fruitful,"* said the TE teacher. 8. TE teachers believed EE lacked relevance, but through PEAR activities, teachers can see the relevance of the discipline of incorporating EE into TE.

The use of Annual Teaching Plans (ATPs) was found to be problematic in integrating environmental matters. *The facilitators should align the ATPs with environmental content. Like now, when we were planning to integrate EE and TE, I felt like I was doing something different because the ATP does not talk about that*, TE teacher 2. The Annual Teaching Plans reveal not much about the environmental and indigenous content; hence, TE teachers had problems integrating EE into TE. In Baan's (2023) report that teachers encounter problems in implementing environmental-based learning, such problems are caused by internal and external factors. The problems include the lack of teachers' experience, unavailable sources of information and examples as references, media and facilities available in schools, and policy factors. The application of the PEAR activities thus becomes a valuable resource in assisting teachers in narrowing the gap between theory and practice. The PEAR activities align EE with TE content.

Discussion

The current study addressed challenges encountered in TE by integrating environmental matters. But the study focuses on the synergy of the paradigms and critical theory to explore if there is a synergy between research paradigms and critical theory applied in the AR study.

Topics of environmental matters were only integrated into TE themes, such as processing. But only topics that are silent on environmental issues were not integrated, as highlighted above, and littering was a teachable topic. EE themes were struggling to gain recognition in most of the school subjects (Damoah et al., 2024), as was the case in this study. Implementation of PEAR activities in TE made learning cooperative and engaging. Fruitful learning needs a paradigm shift in learners' and teachers' perspectives (Damoah et al., 2024). The activities promoted indoor and outdoor learning, which integrates education *in* the environment, education *about* the environment, and education *for* the environment. The activities infused the theory and practice.

Additionally, the TE teachers encounter barriers to implementing EE design activities, which are due to a low understanding of EE and design, low motivation to implement ESD design activities, insufficient teaching materials, and limited teaching time (Wang et al., 2023). The current study implemented PEAR activities (see Table 3) to address insufficient teaching materials. Waste materials were used as a teaching resource to deliver the lesson while also conscientizing learners on environmental issues. As it is common to all critical theories, they are explicitly normative, serve the practical purpose of increasing human freedom in its many forms, are interdisciplinary, and connect theory to practice through the interplay between empirical research and conceptual (normative) reflection (Skarstad, 2024). The researcher explained the paradigms and critical theory in terms of ontology (our assumptions about the nature of being/reality), epistemology (our assumptions about the nature of knowledge and knowing), and methodology (our consequent approach to problem-solving and inquiry strategy), and their inquiry is both emancipatory and systemic (Zuber-Skerritt, 2001). The identification of challenges, design, and implementation of the PEAR activities revealed action-oriented strategies to address challenges confronting TE teachers in schools. TE teachers systematically relate their work to their values and draw on those values as the standards of judgement by which they evaluate their work. The living educational paradigm is the unique explanation generated by a practitioner-researcher to explain their educational influences in learning (Whitehead & Huxtable, 2024). For that reason, engaging TE teachers in an action learning paradigm was about self-development, problem-solving, and change (Brook, 2021). Accordingly, TE teachers in the action science paradigm worked by facilitating group reflection on issues that are important to them, which allowed them to better understand their situation, make informed decisions, and improve their ability to act (Putnam, 1999). The action science paradigm is a type of critical theory in which the

theory proceeds by engaging TE teachers in self-reflection so that they can transform their self-awareness and act to change their world (Putnam, 1999).

Foregoing the argument, teachers do not have documents for implementing environment-based learning (Baan, 2023). Schools did not have an environmental policy, which could have contributed to TE teachers not implementing environmental activities in their teaching. Baan (2023) reiterates that most teachers do not yet have the necessary guidance and program documents as a reference for implementing environmental-based learning. Insufficient teacher training and subject knowledge (Munasi, 2025) contribute to partial EE integration. The ATP that teachers follow to teach in the classroom does not offer much guidance on the implementation of environmental topics/matters in TE, which acts as a barrier to teaching and learning. In addition, schools lack an environmental policy, which should guide teachers on addressing environmental issues, among others. It is for this reason that schools' policies do not support the use of the learning environment as a learning resource (Baan, 2023). Moreover, although the syllabus requires developing EE design activities in the TE curriculum, most schools did not do it well due to the lack of strategies (Wang et al., 2023). Munasi (2025) reports that without tailored interventions, many teachers are left without the resources or strategies to fully align their teaching practices with EE objectives. Teachers need to have adequate EE and TE knowledge to implement environmental learning in their subject. In light of that cooperative paradigm, TE teachers worked together to define the questions they wanted to explore and the methodology for that exploration (propositional knowing); together or separately, they applied this approach in the world of their practice (practical knowing), resulting in new forms of encounter with their world (experiential knowing); and they found ways to represent this experience in significant patterns (presentational knowing), which feeds into a revised propositional understanding of the originating questions (Heron & Sohmer, 2019). TE teachers participated in AR, cycling through the four forms of knowledge several times with one another to strengthen their mutually beneficial grounding and to improve how they uplift and embrace one another (Section 4 and Figure 3).

The relatedness of the paradigms, as discussed in Sections 2 and 4, facilitates the application of critical theory to achieve desired outcomes. Figure 4 depicts the paradigm synergy that resulted in the actual realization of critical theory in the study. The paradigms used to question and address routine and habits (living educational paradigm), promote teamwork over individualism (action learning and cooperative paradigm), question and address organizational defensive routines in teamwork (action science paradigm), and question and empower TE teachers from their challenges. The paradigms paved the way for critical theory to achieve its goal of challenging the status quo and encouraging collaboration.

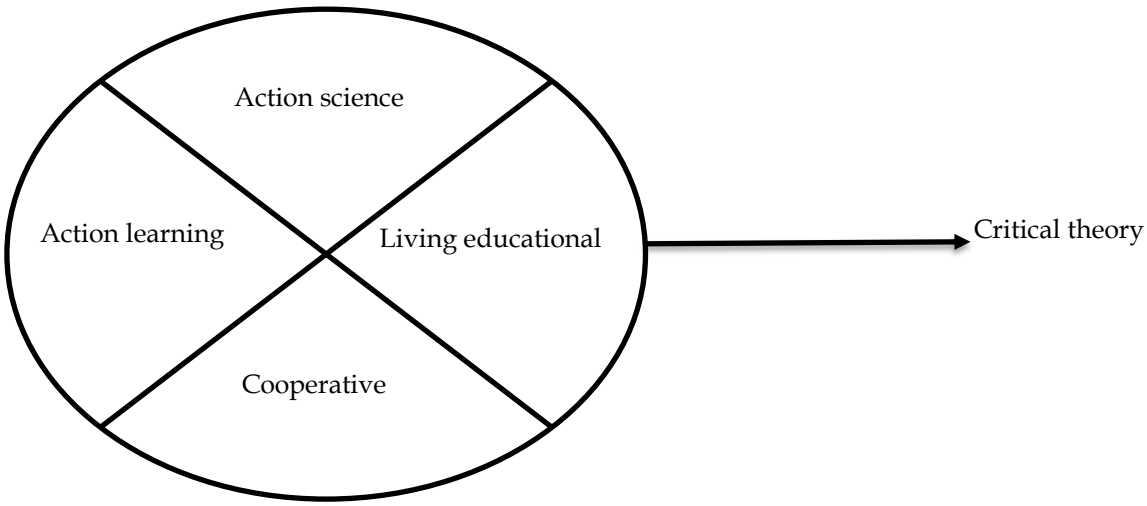

Figure 4. Synergy of paradigms and critical theory (Matsekoleng, 2023).

CONCLUSION

The study explored the synergy of research paradigms and critical theory in an AR study. The synergy was drawn from TE teachers' PEAR activities in addressing their challenges to raise learners' awareness of littering. However, the study focused on how TE teachers addressed such challenges through the application of research paradigms and critical theory. The PEAR activities addressed the TE challenges experienced by teachers but also shared insights on the synergy of research paradigms and critical theory in schools. School subjects such as TE advocate collaborative problem solving, and so do research paradigms and critical theory. Research paradigms and the theory are collaborative in nature and improve situations, as was the case in the study.

The study shared the applicability and the influence of the paradigms and critical theory in an AR study where TE teachers worked together to address barriers experienced in their respective schools. Therefore, the study concludes that there is a synergy between research paradigms and critical theory, as identified during the study, and that problems encountered by TE teachers are turned into workable solutions. The study's findings are useful for TE teachers and other stakeholders when planning activities that promote collaborative learning, as advocated by research paradigms and critical theory. Furthermore, the findings contribute to future studies by serving as a reference for creating theories and problem-solving pedagogical practices. The study was undertaken only in one district in Gauteng Province of South Africa; the results cannot be generalized to other research settings, as it focused only on Grade 8 TE teachers. The study recommends further studies to explore the inadequate integration of environmental matters in TE themes and the lack of environmental programs in schools to guide teachers on the integration of environmental matters.

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