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The Impact of a Rural School-Based Solid Waste Management Project on Learners' Perceptions, Attitudes and Understanding of Recycling

Busisiwe Mkhonto and Lindelani Mnguni *

Department of Science & Technology Education, University of South Africa, Pretoria 0001, South Africa; busisiwemkhonto24@gmail.com
* Correspondence: lindelani.mnguni@wits.ac.za

Abstract: Continued environmental degradation necessitates innovative strategies to improve society's attitude towards and understanding of recycling solid waste. Previous research has shown that school-based projects integrated into the school curriculum could effectively enhance learners' knowledge of recycling and attitudes towards recycling. However, not much is known about the impact of such projects if they are driven by learners, particularly in under-resourced rural schools. Therefore, in the current research, we aimed to determine the impact of a school-based recycling project, integrated as practical work, on learners' understanding of recycling, their attitude towards recycling, and the perceived impact of the project on the school environment, in an under-resourced rural school. Our findings showed that participating in a rural school-based recycling project may not enhance Grade 7 Natural Sciences learners' perceptions of, attitudes towards, and understanding of recycling. We posit that various factors may affect the effectiveness of a recycling project. Further research is required to explore these factors further.

Keywords: attitudes; content knowledge; environmental education; recycling project; science learners

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1. Introduction

Global challenges, such as HIV/AIDS, COVID-19, and global warming, have necessitated revisiting the extent to which scientific knowledge is applicable in everyday life. In science education, including environmental education, researchers report an urgent need to support the use of scientific knowledge in everyday decision-making [1]. There is, however, a growing body of evidence that shows a disconnect between what is taught in the science classroom and learners' everyday life experiences [1–3]. This disconnect is attributed to various factors, including the underlying curriculum ideology, instructional design, and the learning environment [4,5].

Various initiatives to bridge the gap between classroom-based science education and everyday life have been considered. These include teaching and learning socio-scientific issues through practical work. Researchers suggest that integrating socio-scientific issues in practical science could enhance learners' understanding and acceptance of scientific knowledge, particularly environmental sciences topics [2,6]. This is because practical work allows learners to discover knowledge for themselves through constructivist scientific methods which in turn promotes their content understanding. Practical work has also been shown to enhance learners' attitudes and motivation for learning science [6,7].

Similarly, socio-scientific issues allow for presenting scientific content in a realistic context, integrating "attitudes and ethics in making judgments about scientific information" [2] (p. 425). Additionally, socio-scientific issues have been shown to promote functional science literacy by helping learners apply evidence-based scientific content knowledge to real-world socio-scientific scenarios [8]. Consequently, teaching socio-scientific issues through practical work could lead to improved scientific knowledge in everyday life.

1.1. Recycling in Socio-Scientific Issues

In light of the continued environmental degradation, Herman et al. [9] suggest that socio-scientific topics in environmental education could be integrated into formal education as practical work. In such contexts, these topics could emphasize scientific principles and processes, environmental advocacy, affective, cultural, and social justice dimensions to promote pro-environmental dispositions [9].

In Africa, addressing socio-scientific topics in environmental education, such as recycling solid waste, is relatively urgent. This is because rapid urbanization and over-population have increased the rates of waste generation and depletion of landfills. As a result, there is an urgent need for individuals, especially the youth, to be involved in waste management initiatives to reduce emergent environmental degradation [10]. Schools could also integrate socio-scientific issues in practical work to improve learners' understanding of relevant scientific knowledge and their attitudes towards environmental management. Additionally, school-based projects and informal social projects which enhance environmental consciousness could be implemented. As suggested in the Tbilisi Declaration, this could ensure that learners have the necessary awareness, knowledge, attitudes, and skills and participate in relevant initiatives to reduce environmental degradation. According to the Tbilisi Declaration, through environmental education, learners should:

- "acquire an awareness and sensitivity to the total environment and its allied problems";
- "gain a variety of experiences in and acquire a basic understanding of, the environment and its associated problems";
- "acquire a set of values and feelings of concern for the environment and motivation for actively participating in environmental improvement and protection";
- "acquire the skills for identifying and solving environmental problems"; and,
- be given "an opportunity to be actively involved at all levels in working toward resolution of environmental problems." [11] (p. 26).

The extent to which learners in South Africa and other countries demonstrate these qualities is a subject of continuing research, particularly given the increasing environmental impact. For example, Şahin and Erkal [12] found that in Turkey, primary school learners generally have positive attitudes towards environmental management, including recycling solid waste. Such attitudes are related to socio-economic and science literacy in the family. Mahmud and Osman [13] found that while the attitudes towards recycling solid waste among learners may be positive in Malaysia, these are not a predictor of environmentally friendly behavior. Imamura [14] and Kodama [15] report that government policies require integrating environmental education into the curriculum in Japan. However, there has been no significant progress due to various socio-political dynamics that hinder effective integration between schools, local communities, and government. In Nigeria, Ajiboye and Olatundun [16] report using outdoor school practical activities to improve learners' knowledge and skills related to environmental education. They found that participating in outdoor environmental education activities enhances learners' knowledge and skills related to environmental issues. In South Africa, Rosenberg [17] shows that Eco-schools could effectively enhance learners' environmental awareness and a commitment to the environmental agency in rural schools.

1.2. Problem Statement

There is overwhelming evidence to suggest that teaching socio-scientific issues could enhance learners' knowledge, science literacy, argumentation skills, attitudes and awareness towards environmental management. Similarly, practical work has been shown to improve learners' content knowledge and attitude towards science. However, what has not been firmly established is the extent to which integrating socio-scientific issues, such as recycling, through practical work could impact learners' content knowledge, attitudes, and perceptions related to environmental management, particularly within the rural African context. The rural African context is of particular interest given the high levels of illiteracy, poor performance in science, lack of educational resources, high poverty and rapidly increasing population growth [18]. These factors have been predicted to impact learners' attitudes and awareness towards environmental management. As a result, there is a need to investigate strategies to enhance attitudes and awareness towards environmental management.

1.3. Aims and Questions

In light of the above discourse, we sought to explore the impact of integrating a socio-scientific issue within practical work as an additional learning activity on content knowledge development, attitudes, and perceptions of socio-scientific issues. In particular, the research aimed to determine the impact of a school-based recycling project (as a form of practical work) on Grade 7 Natural Sciences learners' understanding of recycling (as a socio-scientific issue), their attitude towards recycling and the perceived impact of the project on school environment. The hypothesis tested in this research stated that participating in a rural school-based recycling project does not enhance Grade 7 Natural Sciences learners' perceptions of, attitudes towards, and understanding of recycling.

1.4. Theoretical Framework and Its Application

The theoretical framework used in the current research guided the integration of a socio-scientific issue into practical work. The idea here was to explore whether teaching a socio-scientific issue (solid recycling waste) through practical work (school-based recycling project) could enhance learners' understanding of recycling, their attitude towards recycling, and the perceived impact of the project on the school environment. Consequently, Abrahams and Millar's [19] (p. 1947) model of the process of design and evaluation of a practical task was used to develop a school-based recycling project and assess its impact. Additionally, Zeidler et al.'s [8] framework for socio-scientific issues education was used to identify the topic of recycling as a proxy in determining the impact of practical work on socio-scientific issues.

According to Zeidler et al. [8] (p. 358), socio-scientific issues help learners develop a variety of skills, including "informed decision making; the ability to analyze, synthesize, and evaluate information; dealing sensibly with moral reasoning and ethical issues; and understanding connections inherent among socio-scientific issues." To achieve this, teachers could integrate socio-scientific issues through four entry points, namely, "nature of science issues, classroom discourse issues, cultural issues, and case-based issues" [8] (p. 361). Natural science issues help learners develop an understanding of how scientific knowledge is generated to develop skills for construction, selection, and evaluation of knowledge in everyday life. Discourse issues help learners develop argumentation and reasoning skills to evaluate their own beliefs and moral and ethical considerations about accepting or rejecting scientific knowledge. Cultural issues help learners develop interpersonal skills such as tolerance towards differing views, normative values, and cultural beliefs about the natural world. Case-based issues help learners develop skills required to adopt habits, attitudes, values, and ethical awareness related to scientific issues. Overall, socio-scientific issues help learners understand scientific phenomena and personal cognitive and moral skills through everyday controversial issues. In the current research, recycling was identified as a socio-scientific issue, a controversial real-world problem that is socially relevant, informed by science [20]. The need to recycle is informed by the scientific, moral, and ethical need for all citizens to participate in activities that will reduce global warming, partly due to environmental degradation. While learners are generally not 'academically' obliged to participate in recycling projects, it is scientifically, morally, and ethically crucial for them to do so.

As mentioned earlier, the school-based recycling project was presented as a practical activity. Abrahams and Millar [19] posit that practical work improves learners' motivation to learn science, their content understanding as well as their appreciation for science as an evidence-based endeavour. In their model of the process of design and evaluation of practical work, they propose four stages of design and evaluation of practical tasks. In this regard, Abrahams and Millar [19] suggest that in the first stage, teachers ought to develop attainable learning objectives. This must be followed, in the second stage, by design features of tasks, which indicate the actual tasks and activities that learners have to do in order to achieve the set objectives. In the third stage, learners are then allowed to carry out these activities, during which learners carry out the activities with, or without, the teachers' supervision. Abrahams and Millar [19] (p. 1948) caution, however, that "what the learners actually do as they undertake the task may differ to a greater or lesser extent from what was intended by the teacher (or the author of the practical task)". This may be due to a lack of skills, resources, faulty apparatus, or misunderstanding of instructions. The fourth stage relates to what learners learn during the practical activities in stage three and whether this aligns with the intended learning objectives set in stage one. According to this model, therefore, the effectiveness of practical activities could be determined in two stages. Firstly, what learners do in the practical activity compared to what the teacher wanted them to do, and, secondly, what learners learn compared to what the teacher wanted them to learn.

Therefore, in the current research, the school-based recycling project was the practical activity that learners participated in. The teacher developed the learning objectives, as well as the activities that the learners needed to do. The learners were then allowed to carry out the activities to acquire knowledge, skills, attitudes, and perceptions. The research objective in this regard was to determine the extent to which the school-based recycling project could enhance learners' perceptions of, attitudes towards, and understanding of recycling.

2. Methods

2.1. General Background

We adopted research methods based on theoretical perspectives of research methodology as recommended by Creswell [21] and Somekh and Lewin [22]. This is because a research methodology is "the collection of methods or rules by which a particular piece of research is undertaken" as well as the "principles, theories, and values that underpin a particular approach to research" [22] (p. 346). Therefore, the research followed a positivist research paradigm, which "relies on the hypothetico-deductive method to verify a priori hypotheses that are often stated quantitatively, where functional relationships can be derived between causal and explanatory factors (independent variables) and outcomes (dependent variables)" [23] (p. 690).

2.2. Research Design

Creswell and Creswell [24] posit that researchers use a quantitative research approach that utilizes experimental and non-experimental research designs in a positivist paradigm. In the current research, therefore, a quasi-experimental research design was adopted. Here, participants were randomly assigned into the experimental group (n = 90) and the control group (n = 55). These learners were all selected to participate in the research using non-random purposive sampling. In particular, the school was selected because it had a relatively large class of grade 7 Natural Sciences learners, was under-resourced, and was the only school in the area with a natural sciences teacher who held a Bachelor's degree in environmental education.

Additionally, before the current research, the school had no recycling project and did not participate in any particular environmental management project. The Grade 7 class was selected because they are taught recycling in their Natural Sciences curriculum, where they are taught basic recycling concepts. This includes learning about separating mixtures, methods of physical separation, sorting, and recycling materials. The curriculum document [25] (p. 23) states explicitly that learners should be taught that:

- "It is every person's responsibility to dispose of waste properly.
- Only certain materials are suitable for recycling, such as metals, plastics, and glass.
- Organic waste can be made into compost. Material that cannot be recycled has to be dumped.

- Local authorities have systems for sorting and disposing of waste materials.
- There are negative consequences associated with poor waste management such as pollution of water, soil and the environment; health hazards and diseases; blockage of sewage and water drainage systems; waste of land used for landfills."

According to the curriculum document [25] (p. 10), the aims of this subject are that learners should:

- "be able to complete investigations, analyze problems and use practical processes and skills in evaluating solutions.
- Have a grasp of scientific, technological, and environmental knowledge and apply it in new contexts.
- understand the uses of natural sciences and indigenous knowledge in society and the environment."

The above curriculum specifications were central to the current research as we sought to ensure the extent to which practical work could help learners attain the required learning outcomes. Therefore, the underlying assumption was that these learners possessed a certain level of recycling knowledge, which could be enhanced through hands-on practical activities such as conducting a school-based recycling project. The participants were aged between 12 and 14. Ethical clearance guaranteed voluntary participation, and children's rights to safety were obtained from the host institution and the Department of Basic Education (Reference 2018/02/14/36500704/46/MC).

2.3. The Recycling Project and Data Collection

The researchers designed the school-based recycling project based on Bullman's [26] guidelines for teachers to implement successful school recycling programs in her handbook. In this project, the teacher of the natural sciences, who was one of the researchers, was designated as a Recycling Coordinator for the school, mainly because of her academic background in environmental education. In line with the theoretical framework, her roles as the Recycling Coordinator included:

(a) developing the worksheet, which included the learning objectives and learning tasks that the learners had to do during the project (Table 1);
(b) monitoring what learners did during the project without interference to ensure learners drove the project.
(c) assessing the extent to which learners did what they were supposed to do and learned what they were supposed to learn.

Table 1. The school-based recycling project worksheet used by learners. The worksheet included the learning objective, specific aims of the project, science process skills to be developed, and instructions for learners.

Sub-Topic	Sorting and Recycling Materials
Lesson objectives	By the end of the lesson, learners will be able to: • understand the responsibility to recycle • list recyclable materials • name systems for sorting and disposing of waste • identify negative consequences associated with poor waste management • identify roles of the different role players in the recycling • demonstrate positive attitudes towards recycling • demonstrate positive perceptions towards recycling
Specific Aims (adapted from the CAPS document)	Doing science Knowing the subject content and making connections Understanding the uses of sciences and indigenous knowledge

Table 1. *Cont.*

Sub-Topic	Sorting and Recycling Materials
Science process skills	Accessing and recalling information Sorting and classifying Raising questions Identifying problems and issues Planning investigations Doing investigations Recording information Interpreting information Communicating
Instructions for learners *	Divide yourselves into groups of ten. Each group must have a group leader who will record the activities according to the instructions below. 1. There are four dumpsters placed around near the Grade 5–7 classrooms. 2. Each dumpster is labelled according to the type of waste that should be placed in it. 3. Identify and collect recyclable solid waste in the school and place it in the dumpsters accordingly. 4. Record the type of waste collected. 5. Record the impact waste collection has on the school environment 6. Consult the waste management company that collects waste from school, and find out how the different forms of waste are recycled. Record the information in your project book

* Waste collection must be done on Wednesdays and Fridays during the Natural Sciences practical session.

The Recycling Coordinator supervised all learner activities and ensured that a private collector collected the collected materials for recycling at a secure site.

The worksheet was adapted from the prescribed Natural Sciences curriculum statement. It was then validated through a panel of experts who indicated it was suitable for developing the intended skills and attitudes and acquiring the intended content knowledge.

In the project, learners developed a solid waste collection timetable, in which materials were collected and sorted according to their types twice a week. The learners also identified roles and responsibilities through which they coordinated their activities, kept records of waste materials collected, and discussed their activities. They also identified collection points and locations at which waste dumpsters were located. They decided on the type of waste and how these were to be collected and sorted.

Data for the research were collected prior, during, and after the recycling project. In this regard, a closed-ended multiple-choice test was used to probe learners' understanding of recycling in both the experimental and control groups. The aim in this regard was to compare the recycling content knowledge of learners between and within groups concerning participating in the recycling project. In line with the content knowledge taught in the Natural Sciences, the test probed learners' knowledge of what recycling is, examples of recyclable materials, key role players in recycling, the definition of biodegradability of recyclable materials, impact of solid waste on the environment, as well as strategies for waste management at school. In the test, each of these concepts was probed three times differently to minimize the probability of responses being guessed, after which the average score for each concept was calculated. Data collected during the research were not used as part of formative or summative assessment in the subject.

A closed-ended questionnaire was used to collect data to determine learners' attitudes towards recycling, perceived impact of the school-based recycling project on learners' understanding of recycling, and the perceived impact of the school-based recycling project on the quality of the environment in the school. Concerning attitude towards recycling at school, learners were asked to indicate whether they felt that recycling solid waste generated at a school was good on five Likert scale type items. Regarding the perceptions of the school-based recycling project, learners were asked, on a six Likert scale type items, to indicate whether they felt that the school-based recycling project helped improve their understanding of recycling and improve the quality of the environment in the school. Responses to these items were then aggregated to determine the overall nature of the attitudes towards recycling at school and perceptions of the school-based recycling project.

The test and the questionnaire were validated through a pilot group of learners (n = 34) in the same grade as the participants but from a different school. The data were used to determine the instrument's reliability and construct, face, and content validity. A panel of eight independent experts was also asked to determine the two instruments' face and content validity. In validating the instrument, the pilot group and the panel of experts were asked to respond to a closed-ended questionnaire which, as recommended by Taylor-Powell [27], was aimed at determining that:

The items in the instruments measure what they are supposed to measure.
The respondents correctly understand all the words.
All respondents interpret the item in the same way.
All response choices are appropriate.
The range of response choices is used.
The respondents correctly follow the instructions.
The questionnaire creates a positive impression that motivates learners to respond.
The length of time available to complete the questionnaire is adequate.

The emerging data from the pilot group and the panel of experts were then used to calculate the construct, face, and content validity indices as suggested by Hyrkäs et al. [28], using the formula:

Validity Index = the number of raters reporting satisfactory validity/Total number of raters.

Data showed that the construct validity index was estimated at 84%, face validity index, 93%, and content validity index, 89%. From the pilot data, we determined a reliability coefficient (Cronbach alpha) of 0.767. From the primary data, a reliability coefficient of 0.812 was obtained.

Having satisfied that the instruments were valid and reliable, we collected the primary data sample over two months in the third term of the school calendar. This period was used because learners had learned about recycling in natural sciences at the beginning of the term (mid-July). Pre-test data were therefore collected soon after the completion of this topic in July. Post-test intervention data were collected towards the end of the term in early September, with the experimental group participating in the recycling project for four weeks in August.

3. Results

3.1. Learners Understanding of Content Knowledge Related to Recycling

The pre-test results (Table 2) showed that learners in the experimental group obtained high scores on items testing the knowledge of the definition of recycling (M = 0.91), strategies for waste management (M = 0.54), and the recyclable materials (M = 0.52). The similarly high scores were also observed in the control group for the same items. Both groups struggled on items that probed their knowledge of the definition of biodegradability and the impact of not recycling.

While the results from the pre-test (Table 3) showed that both groups of learners have a relatively satisfactory level of understanding of recycling as probed in the research, the control group had a slightly higher mean score (M = 0.56, *S.D.* = 0.19) than the experimental group (M = 0.51, *S.D.* = 0.16). However, there was no significant difference between the control and experimental group mean scores in the pre-test ($p > 0.05$). The effect size analysis also showed that the mean difference between the two groups was trivial (Cohen's d = 0.285, glass's *delta* = 0.318, and Hedges' g = 0.293). However, Levene's test for homogeneity of variances showed a significant difference between the variances in the population, which are unlikely to have occurred based on random sampling from a population with equal variances.

Table 2. Pre-test results comparing learner performance in the experimental and control group. The table shows learners' performance scores in the different topics assessed in the research.

Groups		Average Content Knowledge	Recycling Definition	Biodegradability Definition	Strategies for Waste Management at School	Recyclable Materials	Recycling Role Players	Impact of Not Recycling
Experimental Group	N	95	95	95	95	95	95	95
	Mean	0.51	0.91	0.32	0.54	0.52	0.42	0.35
	Std. Error of Mean	0.016	0.025	0.048	0.051	0.048	0.037	0.047
	Std. Deviation	0.157	0.245	0.467	0.495	0.467	0.355	0.456
	Variance	0.025	0.060	0.218	0.245	0.219	0.132	0.210
Control Group	N	55	55	55	55	55	55	55
	Mean	0.56	0.85	0.28	0.68	0.74	0.46	0.36
	Std. Error of Mean	0.026	0.048	0.059	0.064	0.054	0.061	0.062
	Std. Deviation	0.192	0.356	0.440	0.474	0.402	0.452	0.461

Table 3. A comparison of the experimental group and control group performance in the pre-test. The two groups were compared according to their average scores obtained before participating in the recycling project.

	Levene's Test for Equality of Variances		*t*-Test for Equality of Means						
	F	Sig.	t	df	Sig. (2-Tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	4104	0.045	−1713	148	0.089	−0.04947	0.02889	−0.10656	0.00761
Equal variances not assumed			−1623	95,515	0.108	−0.04947	0.03048	−0.10999	0.01104

A *t*-test also showed that there was no significant difference between the two groups ($p > 0.05$). Effect size analysis also showed the same results suggesting that the difference between the performance observed in the control and experimental groups was insignificant (Cohen's $d = 0.025$, glass's $delta = 0.027$, and Hedges' $g = 0.026$). Here the control group mean score was 0.537 (*S.D.* = 0.209) whereas the experimental group mean score was 0.542 (*S.D.* = 0.187). Notably, the mean score in the control group dropped slightly from 0.56 in the pre-test to 0.537 in the post-test, while the mean score in the experimental group increased from 0.51 to 0.542. In the control group, the mean difference was not statistically significant ($p > 0.05$) (Table 4). Levene's test for equality of variance, in this regard, also showed that there was no significant difference in the variance ($p = 0.517$). Results in the control group however showed that learners' knowledge of recyclable materials, the definition of biodegradability, recycling role players, and strategies for waste management in schools had improved slightly, as reflected in the post-test mean score.

Table 4. A comparison of control group learners' content knowledge in the pre-and post-tests. The table shows the comparison of scores obtained by learners who did not participate in the recycling project.

	Levene's Test for Equality of Variances		*t*-Test for Equality of Means						
	F	Sig.	t	df	Sig. (2-Tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	0.422	0.517	0.564	99	0.574	0.02256	0.03998	−0.05678	0.10190
Equal variances not assumed			0.560	92,464	0.577	0.02256	0.04030	−0.05746	0.10258

The improved mean difference in the experimental group was also not significant ($p > 0.05$, Table 5). There was, however, a significant change in the variance ($p = 0.018$). It was also observed that learners' understanding of the recyclable materials, recycling role players, the definition of biodegradable, and strategies for waste management at school improve, albeit not statistically significantly.

Table 5. A comparison of experimental group learners' content knowledge in the pre-and post-tests. The table shows the comparison of scores obtained by learners who participated in the recycling project.

	Levene's Test for Equality of Variances		*t*-Test for Equality of Means						
	F	Sig.	t	df	Sig. (2-Tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	5666	0.018	−1261	188	0.209	−0.03158	0.02504	−0.08098	0.01783
Equal variances not assumed			−1261	182,392	0.209	−0.03158	0.02504	−0.08099	0.01783

The significant observation in these results is that the school-based recycling project does not seem to have improved learners' understanding of recycling to any significant degree. Learners participating in the experimental group did not have any significant understanding of recycling than those who did not.

3.2. Learners' Attitudes towards Recycling, Perceptions of Recycling, and the Role of Education in Recycling

Results from both the control and experimental groups showed that learners generally had positive attitudes towards recycling in pre- and post-tests. For example, in the pre-test, 78% of the control group (43 of 55) and 84% of learners in the experimental group (80 of 95) had a positive attitude towards recycling. In the post-test, 100% of learners in the control group (55 of 55) and 76% in the experimental group (72 of 95) reported positive attitudes towards recycling. Notably, learners from the control group reported slightly more positive attitudes than learners from the experimental group before and after implementing the project. There was a decrease in the experimental group's positive attitudes from 84% in the pre-test to 76% in the post-test.

Learners from both groups reported positive perceptions regarding the impact of the school-based recycling project on the school environment. In the experimental group, 85%

and 87.4% of learners reported positive perceptions of the impact of the school-based recycling project on the school environment before and after the implementation of the project, respectively. In the control group, 91% and 96% of learners reported positive perceptions regarding the impact of the school-based recycling project on the school environment before and after implementing the project, respectively. These results suggest that learners in the control group had slightly more positive perceptions of the impact of the school-based recycling project on the school environment, which increased from 91% in the pre-test to 96% in the post-test.

Results regarding the school-based recycling project's perceived impact on learners' knowledge of recycling, results from both groups showed that learners believed that the project could improve their understanding of recycling. Here, pre-test results showed that 88% of learners in the experimental group and 85% in the control group had a positive perception of the impact of the school-based recycling project on learners' knowledge of recycling. These numbers remained relatively the same in the post-test, with 89% and 85% of learners in the experimental group and control group had a positive perception of the impact of the school-based recycling project on learners' knowledge of recycling.

In light of the lower number of learners in the experimental group reporting positive attitudes towards recycling, a Mann–Whitney U test was used to determine whether the change was significant. Results in this regard showed that there was no significant difference between learners' attitudes before and after the recycling project (Table 6). There was also no significant difference in learners' perceived impact of the school-based recycling project on the school environment and their pre-and-post implementation. Similarly, there was no significant difference in learners' perceived impact of the school-based recycling project on learners' content understanding of recycling.

Table 6. A comparison of learner's attitudes towards recycling, perceived impact on content knowledge, and perceived impact on the school environment in the experimental group were measured before and after participation in the school-based recycling project.

	Attitude Towards Recycling	Perceived Impact on the School Environment	Perceived Impact on Content Knowledge
Mann-Whitney U	4,132,500	4,198,500	4,511,500
Wilcoxon W	8,692,500	8,758,500	9,071,500
Z	−1444	−0.869	−0.011
Asymp. Sig. (2-tailed)	0.149	0.385	0.992

However, the control group showed a significant difference between learners' attitudes towards recycling before and after the recycling project ($p = 0.001$, Table 7) even though these learners did not participate in the recycling project. There was, however, no significant difference in learners' perceived impact of the school-based recycling project on the school environment and their perceived impact of the school-based recycling project on learners' content understanding of recycling before and after the implementation of the project.

Table 7. A comparison of control group learners' attitudes towards recycling, perceived impact on content knowledge, and perceived impact on the school environment, measured before and after the school-based recycling project.

	Attitude towards Recycling	Perceived Impact on the School Environment	Perceived Impact on Content Knowledge
Mann-Whitney U	989,000	1,044,000	1,265,000
Wilcoxon W	2,070,000	2,125,000	2,346,000
Z	−3354	−1603	0.000
Asymp. Sig. (2-tailed)	0.001	0.109	1000

Data were also analyzed to determine if there was a significant difference between the two groups' attitudes towards recycling, perceived impact of the school-based recycling project on learners' understanding of recycling, and perceived impact of the school-based recycling project on the school environment, before and after the implementation of the school-based recycling project. Results here showed that there was no significant difference between the two groups (p = 0.316, p = 0.676, and p = 0.280). However, in the post-test, there was a significant difference in the attitudes of the two groups (p < 0.001). There was no significant difference in the two groups' perceived impact of the school-based recycling project on learners' understanding of recycling and the perceived impact of the school-based recycling project on the school environment.

4. Discussion

Given the peculiarity of our results, which showed better improvement in the control group than the experimental group, it is essential to highlight that the intervention was validated through an independent panel of experts and piloted through a similar group of participants. The intervention and the instruments satisfied the content validity, construct validity, and face validity through this. This intervention was developed in line with Abrahams and Millar's [19] model. We also verified that our record-keeping was accurate to avoid mixing up the two groups. In light of these measures, therefore, we are confident that our findings are accurate.

In the current research, we sought to determine the impact of integrating recycling of solid waste materials, as a socio-scientific issue, within practical work on content knowledge development, attitudes, and perceptions of socio-scientific issues. We tested the hypothesis that participating in a rural school-based recycling project does not enhance Grade 7 Natural Sciences learners' perceptions of, attitudes towards, and understanding of recycling. Our results show that participating in intervention may have had:

- no significant effect on learners' knowledge of recycling,
- a statistically insignificant but negative effect on learners' attitudes towards recycling, and,
- a statistically insignificant but positive effect on learners' perceptions regarding the impact of the school-based recycling project on the school environment.

On the contrary, not participating in the intervention seems to have had:

- no significant effect on learners' knowledge of recycling,
- a significant positive effect on learners' attitudes towards recycling, and,
- A statistically insignificant but positive effect on learners' perceptions regarding the impact of the school-based recycling project on the school environment.

Therefore, based on these findings, we accept the hypothesis that participating in a rural school-based recycling project does not enhance Grade 7 Natural Sciences learners' perceptions of, attitudes towards, and understanding of recycling.

The findings of the current research contradict several previous studies, which suggest that "learners' involvement in environmental projects had a statistically significant positive impact on their environmental knowledge and science attitudes" [29] (p. 213). Traditional research suggests that actively involving learners in educational activities improves their mental engagement and content understanding [30] and attitudes [29]. Our findings also contradict reports that practical work improves learners' attitudes and content understanding [6,7]. Additionally, our research did not show a significant impact of the integration of socio-scientific issues in science learning on learners' content understanding, as suggested in research [2].

The observed contradictions cannot be explained by our data, as this was not within the scope of our research. Based on Kokotsaki et al. [31], we hypothesize that the observed insignificant impact of the intervention may be due to various factors. These could include:

(a) Inadequate learner support. According to Kokotsaki et al. [31] (p. 274), "learners need to be effectively guided and supported; emphasis should be given on effective time management and learner self-management." In our research, learners were selfregulating, as we used self-directed learning. While learners were given instructions and monitored, they essentially ran the recycling project independently.

(b) Ineffective group work. Kokotsaki et al. [31] (p. 274) suggest that "high-quality group work will help ensure that learners share equal levels of agency and participation." Group dynamics may likely have led to ineffective group work during the project in a self-directed learning context.

(c) An imbalance between didactic instruction and independent inquiry method. According to Kokotsaki et al. [31] (p. 274), there needs to be a balance between didactic instruction and independent inquiry. In our research, it appears that didactic instruction may have had a higher impact than independent inquiry. This may explain why learners in the control group reported better results than the experimental group. The didactic instruction was received by both groups, while only the experimental group was exposed to the intervention. In these instances, the teacher-directed didactic instruction may have been more effective than the intervention's self-directed independent inquiry learning opportunity.

We also hypothesize that while learners may have voluntarily chosen to participate in the intervention, they may have developed 'intervention fatigue'. Intervention fatigue is well documented in science education, particularly health education where it has been shown that extended participation and discourse about socio-scientific issues, such as HIV/AIDS, may lead to "fatigue among young people," which leads to "dead-end attitudes" due to information overload [32]. A similar phenomenon has been described in environmental education, where researchers suggest that learners could develop "environmental fatigue" [33] (p. 146). In fact, Kerr [34] (p. 927) warns that "sounding the alarm too loudly ... could be driving potentially sympathetic audiences to tune them out or could even provoke a backlash". Therefore, in light of our findings, we posit that the intervention may have led to undesirable outcomes. This view, however, requires further exploration, including a collection of qualitative data through which the observed phenomena could be explained. We concede that our research did not explore this phenomenon, given its limited scope.

5. Conclusions

The current research sought to determine the impact of integrating a socio-scientific issue within practical work as an additional learning activity on content knowledge development, attitudes, and perceptions of socio-scientific issues. To contextualize the research, we explored the impact of a school-based recycling project on Grade 7 Natural Sciences learners' understanding of recycling, their attitude towards recycling, and the perceived impact of the project on the school environment.

Based on the findings, we conclude that participating in a recycling project as practical work may not enhance learners' perceptions of, attitudes towards, and understanding of recycling. In the current research, we did not explore factors affecting the impact of the recycling project on learners' perceptions of, attitudes towards, and understanding of recycling. We acknowledge that several factors could affect learners' content knowledge, attitudes, and perceptions of environmental management within and outside of the formal education and curricula. Within the formal education curriculum, these factors could include school dynamics, availability of resources, teacher qualification, preparedness, and curriculum and instructional design. Group dynamics amongst learners may also impact the effectiveness of interventions, which may necessitate more stringent learner support.

However, based on existing literature, we hypothesize that, in the current research, inadequate learner support, ineffective group work, the imbalance between didactic instruction and independent inquiry method, and intervention fatigue may have impacted the effectiveness of the intervention. We, however, recommend further research to test this emerging hypothesis. We also acknowledge the limited scope of our research, particularly the lack of qualitative data to explain the ineffectiveness of the intervention. We, therefore, recommend further research to understand further factors that could enhance the impact of integrating socio-scientific issues within practical work as an additional learning activity on content knowledge development, attitudes, and perceptions of socio-scientific issues. Such research is relatively urgent given the continued environmental degradation, particularly in the developing world.

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