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THE ROLE AND IMPACT OF SCIENCE PRACTICAL WORK TO TEACHERS: A SYSTEMATIC LITERATURE REVIEW

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Abstract:

Science practical work is an essential component of science education, offering hands-on learning opportunities that deepen understanding beyond theoretical knowledge. While its benefits for students are well-documented, this systematic literature review aims to explore its significant yet often overlooked impact on teachers. By reviewing 10 journal articles published between 2013 and 2023, this study identifies the roles of teachers in practical science work and investigates how these activities influence their professional development, instructional techniques, and overall job satisfaction. The methodology involved a comprehensive search and analysis of relevant articles from the SCOPUS database, adhering to strict inclusion and exclusion criteria to ensure the reliability of the findings. The review highlights seven key roles of teachers in science practical work: assessors, promoters of inquiry, resource providers, facilitators, demonstrators, contextualizers and organizers. These roles are critical in guiding students through scientific discovery, fostering independent thinking, and enhancing the educational experience. Additionally, the impact of science practical work on teachers includes improved subject knowledge, enhanced teaching skills, and increased professional satisfaction. Teachers benefit from the dynamic and engaging nature of practical work, which can reignite their passion for teaching and support continuous professional growth. However, challenges such as time constraints, technical issues and the need for adequate training are also discussed. This review underscores the multifaceted impact of science practical work on teachers, advocating for its integration into science curricula to not only benefit students but also empower teachers. Recommendations for future research include addressing the identified challenges and exploring strategies to maximize the effectiveness of practical work in science education.

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Keywords:

Impact Of Science Practical Work, Instructional Techniques, Professional Development, Science Practical Work, Teacher Roles

Introduction

Science practical work is a cornerstone in science education, offering a hands-on approach that surpasses textbook learning (Wei, Avraamidou and Chen, 2021). While its benefits to students are well-recognized, its significant impact on teachers is often overlooked (Moore et al., 2020; Oliveira and Bonito, 2023). This article explores the pivotal role and far-reaching impact of science practical work on teachers.

Science practical work is crucial for enriching students' learning experiences and significantly impacting teachers (Sharpe and Abrahams, 2019). According to Ferreira and Morais (2018), hands-on experimentation allows teachers to embrace inquiry-based learning, enhance their subject knowledge, and develop important skills in students. It transforms teaching paradigms, helping teachers create dynamic learning environments and reigniting their enthusiasm for teaching, providing greater fulfilment compared to traditional methods (de Winter and Millar, 2023). Embracing the transformative potential of science practical work is essential for empowering teachers and students in today's evolving educational landscape (Sharpe and Abrahams, 2019).

In conclusion, the role and impact with respect to science practical work on teachers are profound and multifaceted. It enables teachers to adapt to changing pedagogical trends and technological advancements, maintaining their effectiveness and relevance in educating students for the 21st century (de Winter and Millar, 2023). Key terminologies in this study include science practical work, science practical skills, hands-on activities, science experiments, teaching methods, impacts, benefits, and disadvantages.

This study has two main goals. First, to define and explain the many roles that teachers play during science practical work. Second, to investigate the various impacts that this practical work has on teachers. The study seeks to provide a thorough understanding of how engaging in science practical work influences teachers' professional development and teaching approaches. By thoroughly evaluating relevant literature, the study hopes to provide light on the benefits and problems of science practical work from the perspective of teachers, expanding the discussion on science education and curriculum development.

Research Objectives

Research objectives of this study are:

i. To identify the roles of teachers in science practical work.
ii. To investigate the impacts of the science practical work to the teachers.

Research Questions

i. What are the roles of teachers in science practical work?
ii. What are the impacts of the science practical work to the teachers?

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Background of The Study

The Role of Science Practical Work to Teachers

Understanding the importance of scientific practical work for teachers is critical for assessing its overall impact on science education. Ye, Mi and Bi (2021), emphasize that teachers, as key facilitators, guide students through discovery and understanding. Therefore, comprehending how practical work influences teachers' instructional methods, pedagogical approaches, and professional development is essential for improving science education (Shana and Abulibdeh, 2020; Oliveira and Bonito, 2023).

Examining teachers' experiences, viewpoints, and challenges in implementing science practical work provides valuable insights into its impact on their teaching philosophies and subject knowledge (Kibirige and Maponya, 2021). Additionally, understanding how practical work affects teachers' motivation, satisfaction, and professional development can inform strategies to enhance science teaching and support teacher development programs (Moore et al., 2020).

This study aims to highlight the complex role of science practical work for teachers, emphasizing its importance in fostering effective teaching practices, enriching subject expertise, and reigniting teachers' passion for teaching (Aydin et al., 2022). Addressing teachers' needs in implementing practical work can better equip them to inspire and empower future generations of scientists and innovators (Mutlu, 2020; Yusra, Nurmaliah and Sarong, 2021).

The Impact of Science Practical Work to Teachers

Science practical work is acknowledged as an essential part of science education, offering students practical experiences that improve their comprehension of scientific skills (de Winter and Millar, 2023). While the benefits of hands-on learning for students are well known, its impact on teachers is still under study (Kibirige and Maponya, 2021).

Teachers not only facilitate science practical work but also benefit significantly from it. Engaging in science experiments can enhance their instructional techniques, subject knowledge and professional development (Wei, 2010). Despite these potential benefits, there exists a gap in research focusing on the benefits of science practical work for teachers (Wei et al., 2021; Oliveira and Bonito, 2023).

This study aims to examine the benefits of science practical work for teachers, highlighting its transformative effects and making recommendations to maximize its efficacy in science classrooms. Ultimately, the goal is to empower teachers to enhance their teaching techniques through practical work and inspire a lifelong interest in science among their students.

Methodology

Research Design

The selected research method for addressing the both research questions is the systematic literature review. This method is deemed suitable because it enables a dependable and precise synthesis of the existing scholarly literature (Van Laar et al., 2017; Oliveira and Bonito, 2023). In this study the researcher developed a systematic review protocol to investigate the roles and impacts with respect to the science practical work to the teachers. This research method was

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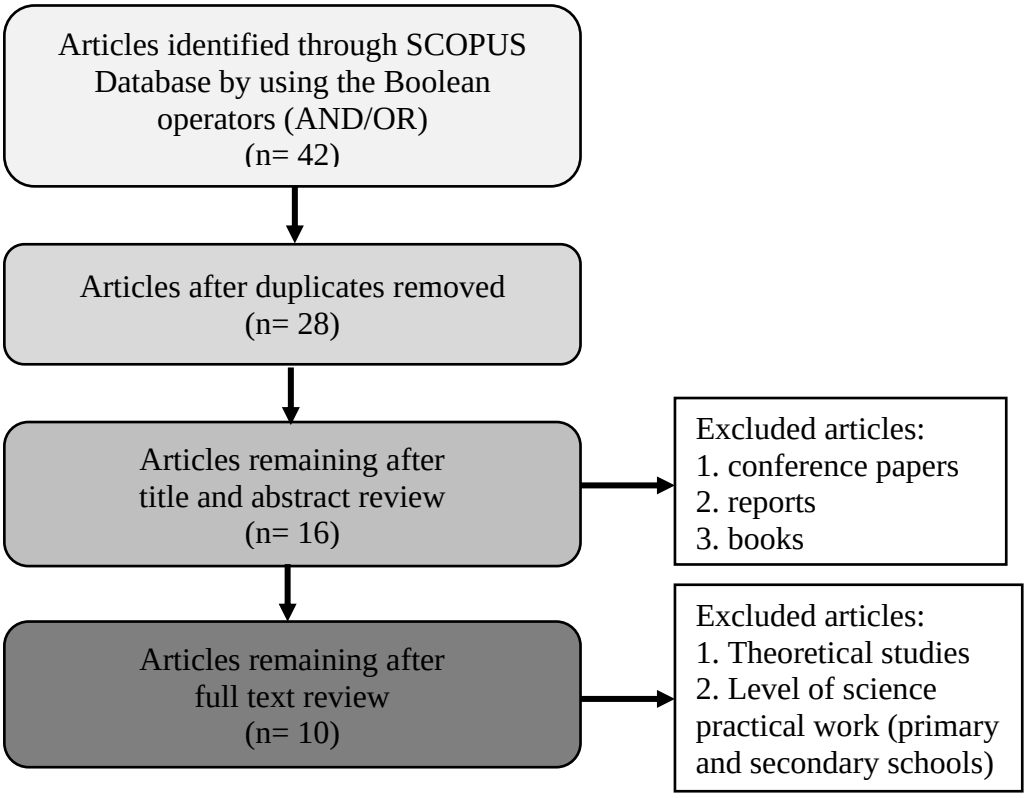
chosen because it can contribute to a synthesis of the existing literature in a more reliable as well as accurate manner (Oliveira and Bonito, 2023).

Search Strategy

The researcher used a systematic literature search by using the SCOPUS database only. This database gave access to a comprehensive list of science practical work related articles. All articles were chosen from the publication year of 2013 to 2023. First the researcher, search in the Sources field of the SCOPUS. Then, the researcher set the subject area and set to Social Sciences. Under the Social Science the researcher set the Education. The main search term was "science AND curriculum", "science practical work," OR science hands-on activities", "role of teachers in science practical work" AND/OR "the impacts of science practical work to teachers". There were 42 results in the search action.

Then, 28 articles were identified after the search in database and the exclusion of duplications. Next, the researcher also used the inclusion and exclusion criteria to screen the full text of those articles. Finally, from these processes, only 10 articles were included in this review and analysis. (Refer Flowchart 1).



Flowchart 1: Summary of Search Strategy Used by The Researcher to Find The 10 Articles

Inclusion and Exclusion Criteria

The inclusion criteria for this review were English language publications, journal articles, all online articles, articles published from the year 2013 to 2023, published worldwide, empirical

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investigation articles, articles either qualitative or quantitative study, and level of science practical from primary to secondary school only. Articles will be excluded if they are non-English articles, articles from conference papers, reports or books, theoretical studies, and level of science practical work at the tertiary level (Universities).

Table 1: Inclusion and Exclusion Criteria of This Study

Types of criterions	Criteria	Inclusion	Exclusion
Language	Malay language		/
	English language	/	
Type of publication	Journal articles	/	
	Books		/
	Conference papers		/
	Reports		/
Access	Online	/	
	Paper		/
Publication period	2013 - 2023	/	
Place of publication	Worldwide	/	
	Asia		/
	Africa		/
	North/ South America		/
	Europe		/
	Australia		/
Type of study	Empirical investigation	/	
	Theoretical studies		/
Research methods	Qualitative	/	
	Quantitative	/	
Level of science practical work	Primary school	/	
	Secondary school	/	
	Tertiary level (Universities)		/

Data Analysis

The researcher extracted data from the retrieved articles that met all the inclusion criteria. The researcher collected data using the following headings: author, year, county of origin, design, data collection, respondents, and main findings/results (Refer to Table 2). The researcher also identified common themes and grouped them into 2 main headings, which were the roles of teachers in science practical work and the impacts of the science practical work to the teachers.

Results

All the papers reviewed were able to address the study's research questions. All the papers discussed the roles of teachers in science practical work and the impacts of the science practical work on the teachers. The researcher summarised the research questions' findings of this study systematically in the table and figures below (Refer to Table 2/Refer Figure 1 and 2). The blue highlighted phrases were the teachers' role in science practical work (Refer to Table 2). The yellow highlighted phrases were the impacts of the science practical work on the teachers (Refer to Table 2).

The researcher discussed the roles of teachers in science practical work and the impacts of the science practical work on teachers from the USA, United Kingdom, Namibia, South Africa,

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China, Portugal, and the United Arab Emirates. Through the study findings, the researcher highlighted that there were 2 major themes. First, the roles of teachers in science practical work, and second, the impacts of the science practical work on the teachers. Each of these themes will be explained below.

The Roles of Teachers in Science Practical Work (Research Objective 1)

This study found that the role of teachers in science practical work was as assessors, promoters of inquiry, resource providers, facilitators, demonstrators, contextualizers, and teacher as organizers (Ferreira and Morais, 2013; Kibirige and Maponya 2021; James de Winter and Robin Millar, 2023; Wei et al., 2021). Each of these roles is discussed in Table 2 of the 10 articles.

A total of 5 studies clearly highlighted on the teachers' role in science practical work. These studies discussed the role of the teachers with quantified data and supported the previous studies (James de Winter and Robin Millar, 2023; Ferreira and Morais, 2013). Most of the studies that discuss the role of the teachers in science practical work used the mixed method approach (Ferreira and Morais, 2013; Kibirige and Maponya, 2021; James de Winter and Robin Millar, 2023; Wei et al., 2021; Sharpe and Abrahams, 2019). This is because the authors wanted to explore a deep insight for the phenomena.

A study used the case study approach, and the result presented in this article was very impressive (Kibirige and Maponya, 2021). The authors of this article used a robust data collection method, which clearly showed the triangulation of data. Hence, the data analysis of this article is able to record deep and rich data on the role of teachers in science practical work (Santanen, 2015).

The Impacts of The Science Practical Work to The Teachers (Research Objective 2)

This research discovered that impacts of the science practical work to the teachers can be divided into two parts. One of the impacts referred to the positive impact of the science practical work on the teachers, and the second impact referred to the negative impact with respect to the science practical work on the teachers. The positive impacts were improving teaching efficacy, personal satisfaction, opportunities for differentiation, empowering students, evaluating their teaching methods and improving professional growth and development

The positive impacts were practical work can be time-consuming for teachers, assessing students' performance during practical work is an additional hurdle, technical issues and lack of proper training or expertise (Akuma and Callaghan, 2019; Ferreira and Morais, 2018; Shana and Abulibdeh, 2020; Moore et al., 2020; Sharpe and Abrahams, 2019; Utete and Ilukena, 2019). Each of these impacts had been discussed in Table 2 from the 10 articles.

A total of 11 studies highlighted the science practical work impact on teachers clearly. There were 5 studies discussed the impact with respect to science practical work to teachers with quantified data and supported with the previous studies (Ferreira and Morais, 2018; Shana and Abulibdeh, 2020; Moore et al., 2020; Sharpe and Abrahams, 2019; Utete and Ilukena, 2019). There were 2 studies that discussed the negative impacts of science practical work to teachers clearly with the support of past literature (Shana and Abulibdeh, 2020; Moore et al., 2020). One study used the quasi-experimental approach and was able to discuss the negative impact

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of the science practical work, although the sample of the study was school students (Shana and Abulibdeh, 2020). These authors support the findings with past studies.

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Table 2: Summary of The Results

Author, year, and country of origin	Design	Data collection method	Respondents	Main findings/results
Ferreira and Morais (2013) USA	Quantitative and qualitative methods	1. Document analysis (curriculum) 2. Semi-structured interview 3. Questionnaire	12 science teachers	• The study systematically identifies and examines the conceptual demands given by practical tasks using a strong conceptual framework. • This study also highlighted that **teachers act as assessors**. The author mentioned that teachers evaluate students' performance in practical work by evaluating their comprehension of scientific principles, data-gathering abilities, and capacity to analyse and interpret outcomes.
Kibirige and Maponya (2021) South Africa	Qualitative method (Case study)	1. Semi-structured interview 2. Classroom observation 3. Document analysis (teachers' lesson plan/assessment activities)	4 11th Grade science teachers	• The study found that teachers encountered challenges such as a shortage of resources and inadequate time to complete all assigned practical tasks. • This study mentioned that science **teachers act as promoters of inquiry and resource providers.** Teachers will encourage students to be curious and participate in the scientific process by asking questions about the natural world, making hypotheses about possible answers, and designing experiments to test these hypotheses. • Second, by supplying these resources, teachers enable students to engage fully in the practical aspects of their scientific education, facilitating hands-on learning experiences.

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James de Winter and Robin Millar (2023) England	Quantitative and qualitative methods	1. Semi-structured interview 2. Questionnaire	43 pre-service science teachers	• This study underpinned that **teachers serve as facilitators** during practical work, helping students through experiments and ensuring that they grasp instructions and follow safety standards. • The authors discussed that **teachers serve as demonstrators**, demonstrating suitable experimentation techniques and processes while demonstrating how scientific principles are applied in the real world. Teachers model best practices to help students grasp the practical application of scientific concepts, developing a deeper understanding.
Wei, Avraamidou and Chen (2021) Province in Western China	Qualitative method (Single case study)	1. Semi-structured interview 2. Classroom observation 3. Document analysis (teachers' lesson plan)	1 beginning science teacher (Zheng)	• The author came up with 2 main themes on the role of the teachers in science practical work. The first theme is teacher as contextualizer, and the second theme is the teacher as Organizer. • Teachers who **serve as contextualizers** help to bridge the gap between practical activity and the larger scientific framework. They link the experiments students conduct to real-world applications and scientific achievements, allowing students to understand why the experiments are important. • **As organizers**, teachers ensure that practical sessions operate smoothly and efficiently. They plan the sequence of experiments, taking into account complexity, learning objectives, and safety criteria.

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Akuma and Callaghan (2019) South Africa	Qualitative method (Case study)	1. Semi-structured interview 2. Classroom observation 3. Document analysis (learners' worksheet)	6 science teachers	• This study emerges three themes based on the science practical work impact to teachers (Improved Teaching Effectiveness, Personal Satisfaction, Opportunities for Differentiation) • The authors highlighted that practical work **improves teaching efficacy** because it can better engage children by doing hands-on experiments that allow them to explore scientific topics in concrete ways. • The authors also mentioned that **personal satisfaction** motivates teachers to continue developing engaging and effective learning experiences through science practical work. • The authors also mentioned science practical work offers teachers valuable **opportunities for differentiation**, allowing them to tailor instruction to meet the diverse needs of their students.
Ferreira and Morais (2018) Portugal	Quantitative and qualitative methods	1. Document analysis (lesson plans) 2. Semi-structured interview 3. Questionnaire	4 10th Grade science teachers	• The authors agreed that the 4 teachers were able to **develop their professional**. By introducing hands-on experiments into their classes, teachers can improve their capacity to communicate complicated scientific concepts and engage students in active learning. • Second, the finding also revealed that **teachers use practical work to empower students** to become independent thinkers and lifelong learners, giving them the tools they need to succeed in an increasingly complicated and competitive environment.

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Shana and Abulibdeh (2020) United Arab Emirates	Quantitative method (Quasi-experimental)	Pre-post designs (Pre-Test Questions/Post Test Questions	Control group: 49 students Experimental group: 49 students	• Although this study focuses on the students, the authors clearly underlined the cons of the science practical work in the findings. • The authors underpinned that **practical work can be time-consuming for teachers** because of the meticulous planning and execution required. • The findings also revealed that **assessing students' performance during practical work is an additional hurdle** due to its inherent complexity. Unlike traditional evaluations, evaluating practical work frequently requires subjective judgment, especially when grading abilities like experimental technique and data interpretation.
Moore et al. (2020) United Kingdom	Quantitative and qualitative methods	1. Semi-structured interview 2. Classroom observation 3. Questionnaire	23 science teachers	• This study clearly revealed that **technical issues** can cause problems for teachers during practical work sessions, disturbing the flow of the class. Teachers frequently confront equipment malfunctions, experimental errors or unexpected consequences. • The author also mentioned that a **lack of proper training or expertise** in performing practical experiments can limit teachers' capacity to develop and implement hands-on activities in the classroom.

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Sharpe and Abrahams (2019) United Kingdom	Quantitative and qualitative methods	1. Focus group discussion 2. Lesson observation 3. Questionnaire	607 students	• This study clearly highlighted on 2 aspects. First, this study highlighted the role of the teacher and the positive impact of science practical work to teachers. • The finding showed **teachers serve as facilitators** of reflection on practical work experiences, guiding students to analyse their findings, identify patterns, and draw conclusions. Teachers encourage students to reflect on their experiments, which helps them build metacognitive skills. • Second, reflecting on the outcomes of practical work sessions permits teachers to **evaluate their teaching methods** and propose areas for improvement. This process of continual development allows teachers to adapt and refine their teaching techniques as well improving the quality of future lessons.
Utete and Ilukena (2019) Namibia	Quantitative and qualitative methods	1. Focus group discussion 2. Semi-structured interview 3. Questionnaire	30 science teachers	• The authors clearly highlighted the impact of science practical work to teachers in their research. • The authors underpinned that one comprehensive impact with respect to science practical work on teachers is **improved professional growth and development**. Practical experiments help teachers to expand their topic knowledge, fine-tune their educational skills and stay current with innovations in their profession.

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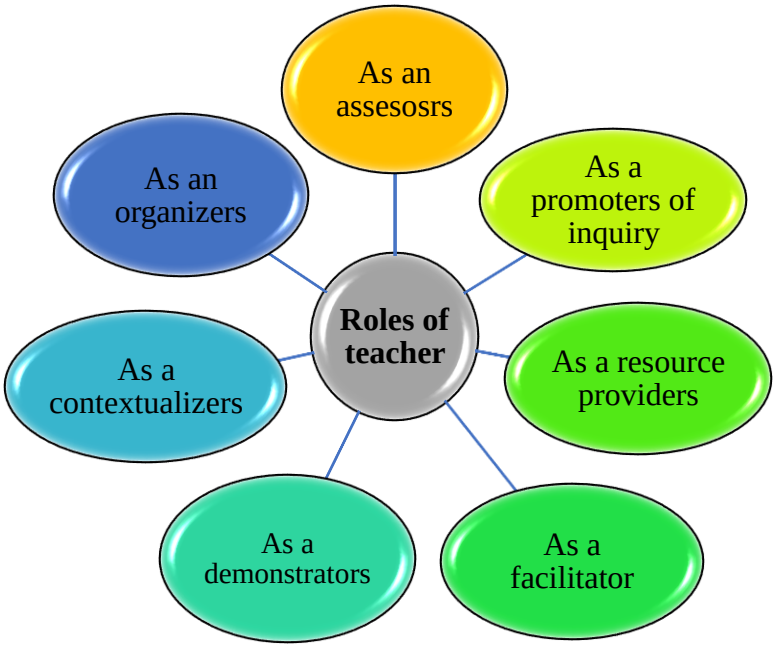

Figure 1: Teachers' Role In Science Practical Work

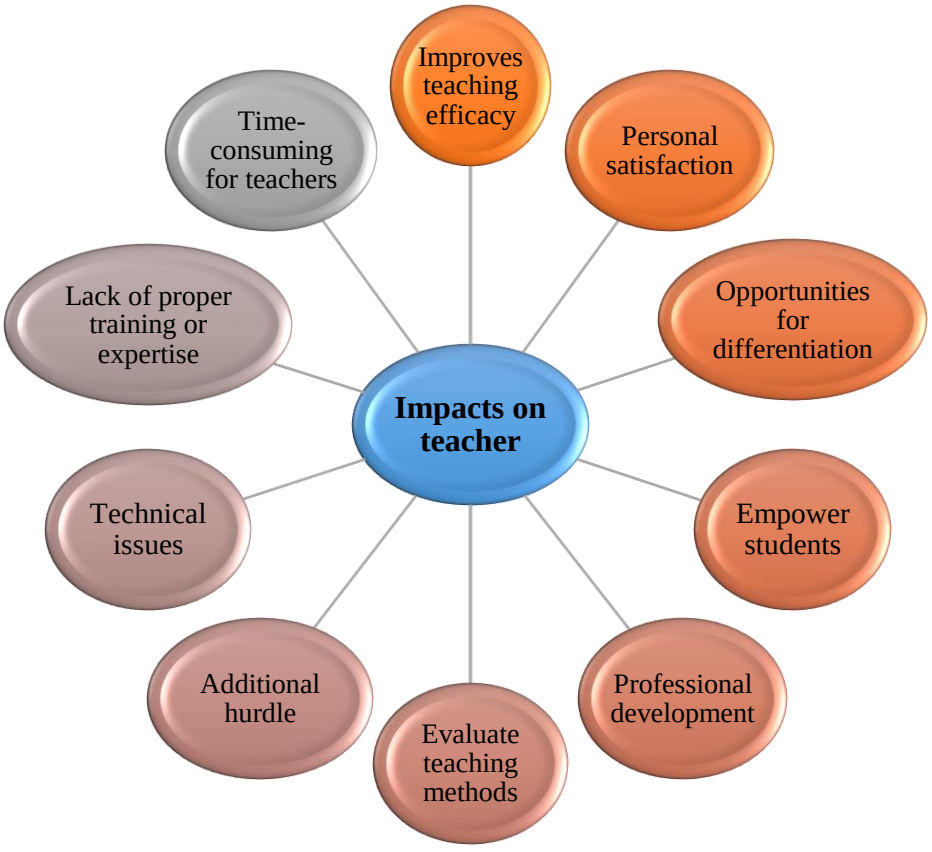

Figure 2: Impacts Of The Science Practical Work On The Teachers

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Discussion

The primary goal of this systematic review was to identify the roles of teachers in science practical work and to investigate the impacts of science practical work on teachers. First, this systematic review identified that there were 7 roles of teachers in science practical work. All 7 roles were discussed in depth in each of the studies. James de Winter and Robin Millar (2023) believe that teachers serve as facilitators who guide students through the scientific discovery process during hands-on activities. Great facilitators help students do experiments while pushing them to think critically and solve problems on their own (James de Winter and Robin Millar, 2023; Hofstein, 2015).

Next, one of the studies brilliantly suggested that teachers serve as demonstrators, modelling proper experimental methodologies and procedures (James de Winter and Robin Millar, 2023). The explanation was eye-opening for the readers because this role is critical in ensuring that students can precisely duplicate experiments, preventing errors, and providing a smoother, more productive learning experience (James de Winter and Robin Millar, 2023).

One study highlighted the role of the teacher as a promoter of inquiry. This study was able to discuss this role in depth because it was a case study approach (Kibirige and Maponya, 2021). Teachers who act as promoters of inquiry encourage students to ask questions, develop hypotheses, and design their own experiments. This role involves guiding students to think critically about the experiments they do and the data they acquire, assisting them in drawing meaningful conclusions (Kibirige and Maponya, 2021; Avraamidou, 2018).

Second, this systematic review investigated the impacts of the science practical work to the teachers. All the 11 impacts were discussed in depth by each of the studies. There were 7 impacts that discussed the positive impacts (Akuma and Callaghan, 2019; Ferreira and Morais, 2018; Sharpe and Abrahams, 2019; Utete and Ilukena, 2019). There were 4 impacts discussed the negative impacts of the science practical work to the teachers (Shana and Abulibdeh, 2020; Moore et al., 2020).

Two studies revealed another positive impact is science practical work can contribute to the teachers' professional development. Both studies gave an example for this impact where science practical work frequently requires collaboration with coworkers, engagement in professional learning groups, and attendance at science workshops and trainings (Utete and Ilukena, 2019; Ferreira and Morais, 2018).

Another interesting study discussed the negative impact of the science practical work to teacher. This research investigated that science practical work is often time-consuming and requires significant preparation as well as planning. The author gave an example where, during practical work, teachers must set aside time to guide students, provide instructions, and successfully manage classroom dynamics. Hence, this substantial time commitment can be tough, especially when managing other teaching duties (Shana and Abulibdeh, 2020; Osborne, 2014).

A study by Moore et al. (2020) revealed another negative impact of science practical work on teachers. This study revealed that teachers commonly face technical difficulties when doing scientific practical practice. These obstacles include handling and maintaining complex

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laboratory equipment, troubleshooting technical issues that happen during investigations, and ensuring that all materials and reagents are available and operational (Moore et al., 2020).

Limitations and Recommendations for Future Study

This study only discussed on 2 main dimensions (the role and impact of the science practical work on teachers) that focus on the teachers. The reasons for exclusion criteria set for the current review resulted in the exclusion of the student's role and the impacts to the students. Science practical work is primarily for the students but this this study solely focuses on the teachers.

Furthermore, this research objective of the current literature review refers specifically to the discussion of science practical work in the context of primary and secondary schools, which made the finding publications solely focusing on this education level a challenge. This is because a very small number of articles focus on the science practical work in primary and secondary schools. Thus, this awakens the question of whether all levels can be emphasized equally at each education level, such as from primary schools, secondary schools, and in the tertiary level (universities). This identified research gap could be interesting to investigate in the future study.

Conclusion

The main contribution of this study is it able underscores the significance of incorporating science practical work into the curriculum to offer experiential learning opportunities. It indicates that practical work aids in contextualizing theoretical concepts, fosters inquiry-based learning, and boosts student engagement and understanding, thereby contributing to a stronger and more effective science curriculum.

The role of teachers in science practical work is vital, encompassing responsibilities as facilitators, demonstrators, organizers, assessors, promoters of inquiry, resource providers, and contextualizers. This science practical work not only enriches students' understanding of scientific concepts but also significantly impacts teachers by enhancing their subject knowledge, refining their pedagogical skills, and fostering professional growth.

Despite the time constraints and technical difficulties, the benefits of science practical work, such as increased teaching effectiveness and student engagement, are able to emphasize its importance in science education. This will ultimately lead to a more dynamic and inspiring educational experience for both teachers and students.

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