



Teacher Feedback as a Facilitator of Students' Mathematical Learning and Self-regulation in a Secondary School in Zimbabwe

BY

Kennedy Mapesa Mandaza

MScEDMAE (BUSE); BSc. Ed. Hons. (Wits); BSc. Maths and Statistics (ZOU); C. E. (Sec) (UZ).

Faculty of Science Education, Department of Curriculum and Educational Management Studies, Bindura University of Science Education, Zimbabwe.



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Abstract

The study was premised on the notion that feedback is a fundamental ingredient of effective teaching and learning. The focus of this paper is on the role of different types of teacher feedback in enhancing students' mathematical learning and self-regulation. The study examined the relationship between teacher feedback and students' ability to monitor and control their learning process, set goals, and employ effective learning strategies. The convergent parallel mixed-method research approach derived from a pragmatist viewpoint was adopted with a focus on deeply understanding this specific case of how teacher feedback facilitates students' learning and self-regulation in mathematics and the practical implications and solutions for real-world problems. Closed-ended and open-ended questionnaire and semi-structured interviews were administered to 42 students and 2 teachers purposively sampled in a school in Bindura rural district. The results of the study corroborated that teacher feedback, both oral and verbal, plays a crucial role on students' performance in mathematics and self-regulation. The findings indicate that feedback that is timely, constructive, encouraging, and provide detailed direction for future improvement, facilitate the building and demonstration of students' self-regulation and self-efficacy in mathematics as well as serves as validation of students' efforts which encourages them to continue to work hard. The study revealed that limited involvement of parents or guardians in the feedback process, cultural attitudes, and stereotypes about the difficulty of mathematics, have a significant influence on how feedback affect the students' self-regulation, motivation and self-efficacy, hence teachers and parents collaboratively play a critical role in the feedback process to contribute to the success of students in mathematics as well as building students' self-regulation. The study's time-frame and resources restricted the sample size, data collection methods, and geographical area, all which can affect the research findings and generalizability. Notwithstanding, the findings of this study provides insights that can inform educational policies and practices as well as help teachers in Zimbabwe and other similar contexts to enhance their feedback strategies and create more effective learning environments for students. Overall, this research study contributes to the existing body of knowledge on the role of teacher feedback and has the potential to inform educational practices and improve the quality of mathematics education in secondary schools in Zimbabwe and beyond.

Keywords: Teacher feedback; mathematical learning; self-regulation; self-efficacy

Introduction

Feedback is a fundamental ingredient of effective teaching, but until recently this fact seem to have not been reflected in the attention given to it. While there have been numerous studies on the role of teacher feedback in enhancing student learning outcomes, this research sought to address the gap in understanding the specific impact of teacher feedback on students' mathematical learning and self-regulation in the context of secondary school mathematics. Most studies which were conducted tended to focus more on general feedback practices and student perception on feedback rather than specific feedback strategies that can effectively address the

unique challenges faced by secondary school students in mathematics.

Mathematics as one of the fundamental subjects that plays a crucial role in the academic development of students requires effective learning and self-regulation to enable students to understand and apply mathematical concepts successfully in the world of work, particularly in an emerging economy in which mathematics is considered the driver of technological and economic development. Against this backdrop, exploring further the role of teacher feedback in facilitating students' mathematical learning and self-regulation, becomes imperative and hence the focus of this case study.



This paper begins by providing a general overview on the effect of teacher feedback on students' learning and self-regulation, the types and focus of feedback, and a view on why teacher feedback could be important in the learning of secondary school mathematics.

Background to the Study

Teacher feedback is a crucial component of the learning process, as it provides students with valuable information about their strengths, weaknesses, and areas for improvement. In a study conducted by Glasgow and Hicks (2009) on feedback, it showed that there is a positive correlation between the amount of feedback given and improvement in the students' performance (Mutendi & Makamure; 2019). Mutendi and Makamure (2019) avow that most studies agree that the use of feedback to improve understanding is not realised in practice, since most teachers often give feedback casually without giving due consideration to its usefulness in helping students to achieve their learning goals. As a result for feedback to be effective, it should be based on observable behaviour and not on assumed intentions or interpretations.

Notwithstanding, literature reveals conflicting views about what constitutes good teacher feedback in terms of type and quality. Hattie and Timperley (2007) avow that the type and quality of feedback makes feedback differentially effective to the students. Despite claims of large effect sizes and remarkable levels of variability relating to the effects of feedback, Brooks et al (2019) argue that the same feedback can be effective for one student but not another, and in one situation (subject) but not another.

Furthermore, while literature reveals that most feedback interventions improve performance, Kluger and DeNisi (1996) and Attali & Arieli-Attali (2015), argue that one-third of feedback interventions decrease learning, while Voerman et al. (2017) asserts that the Feedback Intervention Theory state that the effectiveness of feedback interventions decreases if the feedback pays more attention to the self than the task. Additionally, historical reviews and meta-analyses on the subject describe the findings as "inconsistent," "contradictory," and "highly variable" (Attali & Arieli-Attali, 2015, Kluger & DeNisi, 1996).

Regardless of the extensive research on feedback, findings and other related studies show that the study on teacher feedback is not yet conclusive, and more so the study on mathematics teacher feedback practices is not quite definitive. While mathematics education plays a significant role in shaping students' future success in various fields, many students struggle with mathematical concepts, leading to low achievement levels and a lack of self-regulation at secondary school level. This phenomenon makes teacher feedback imperative in the teaching of mathematics in secondary schools.

In the context of mathematics education, teacher feedback can help students understand mathematical concepts, identify errors, and develop problem-solving strategies (Chinyoka, Chikonzo & Garira, (2017); Ngororoe & Chitiyo (2018);

Smith & Johnson (2019)). However, the specific impact of teacher feedback on students' mathematical learning and self-regulation in secondary school mathematics is yet to be extensively studied. Havnes & McDowell (2007) has argued that while teachers have put a lot of effort on feedback to students as formative assessment, not much if any is known about how students use the feedback and whether they value it as support for further learning. Furthermore, Brookhart (2008) and Mandernach (2018), agree that developing an understanding of student perceptions and processing of feedback is key to feedback being used effectively to enhance achievement and understanding of mathematics. The researcher was hence, prompted and motivated to carry out this study which leans very much on students' perceptions and experience of feedback, by attempting to ascertain whether teacher feedback can facilitate students' mathematical learning and how teacher feedback fosters students' self-regulation in secondary school mathematics.

Problem Statement

Despite the significance of teacher feedback in shaping students' academic progress, there has been a dearth of research exploring its effects on mathematical learning and self-regulation in secondary school mathematics. Existing studies have predominantly focused on elementary and middle school students, neglecting the specific challenges and needs faced by secondary school students in their mathematics. While existing literature has explored the general effects of teacher feedback on student achievement, there is a gap in understanding how teacher feedback can specifically facilitate mathematical learning and self-regulation among secondary school students. Consequently, there is a need to fill this gap by investigating the unique role of teacher feedback in facilitating students' mathematical learning and self-regulation in secondary school mathematics. Furthermore, the fact that not much if any is known about how students use feedback and whether they value it as support for enhancing their learning, creates a need for the researcher to investigate how feedback influences learning and self-regulation in secondary school mathematics.

The purpose of this research, therefore, was to investigate how teacher feedback facilitates students' mathematical learning and how it fosters self-regulation in secondary school mathematics students. The following research questions guided the research.

Research Questions

- 1.3.1 What are the effects of different types of feedback on students' mathematics achievement and motivation in a Zimbabwean secondary school?
- 1.3.2 How do teachers use feedback to enhance students' mathematics learning and meta-cognition in Zimbabwean secondary schools?
- 1.3.3 How does feedback influence students' self-regulation in mathematics learning in a Zimbabwean secondary school?

- 1.3.4 How does feedback influence students' self-efficacy in mathematics learning in Zimbabwean secondary schools?

Significance of the Study

This research will contribute to the existing body of knowledge by providing evidence-based insights into the impact of teacher feedback on students' mathematical learning and self-regulation. The findings will help educators and policymakers develop effective strategies and practices to enhance students' mathematical learning experiences and promote self-regulated learning in secondary school mathematics classrooms. The findings can provide insights into the effectiveness of different feedback strategies, thus guiding educators in designing more targeted and personalized feedback approaches. Additionally, this study has the potential to influence teaching practices and curriculum development in mathematics education.

Furthermore, the research on the impact of teacher feedback on students' mathematical learning and self-regulation in secondary school mathematics is of significant importance for several other reasons. Firstly, mathematics is a critical subject that plays a crucial role in developing logical reasoning, problem-solving skills, critical thinking abilities and forms the foundation of various academic and professional pursuits. Improving students' mathematical learning outcomes can not only enhance their future educational prospects but also equip them with essential skills required for success in fields such as engineering, science, and finance.

Additionally, self-regulation skills are vital for students to become independent learners and effectively manage their learning process. By investigating the role of teacher feedback in facilitating students' self-regulation in mathematics, this research contributed to identifying effective teaching strategies that empower students to take ownership of their learning, set goals, monitor progress, and regulate their learning behaviours. Ultimately, this research aims to improve students' mathematical learning outcomes and foster their self-regulation skills, which are essential for their overall academic success.

Definition of Terms

To ensure uniformity and understanding of terms used in the study, the following definitions are provided.

Mathematical learning refers to the acquisition of new knowledge, skills, and affects that are related to numbers, quantity, and space, either as abstract concepts or as applied concepts.

Teacher feedback is the authoritative information students receive from the teacher that reinforces or corrects responses to instruction, and guides them more efficiently in attaining the goals of the course (Mutendi & Makamure, 2019).

Self-regulation is the degree to which students can manage or control aspects of their thinking, motivation, and behaviour during learning (Nicol & Macfarlane-Dick, 2006). This refers

to how learners will respond to feedback in relation to commitment, control, and confidence.

Self-efficacy refers to students' beliefs about their capabilities to produce results.

Literature Review

The role of teacher feedback in shaping students' understanding of mathematical concepts and their ability to regulate their own learning has come under extensive research in recent years. This is more vital in secondary school mathematics, where students are building a solid foundation for future academic and professional success, and understanding the impact of teacher feedback becomes even more critical. Literature has revealed that there has been growing interest in understanding the impact of teacher feedback and the perceptions of student on feedback. Most of the studies have shown that feedback is an intervention with significant variance in its effect on achievement, while others have argued that the same feedback can yield different effects on different students and subjects.

By examining various studies and their findings, this review provides insights into the effectiveness of teacher feedback and its potential implications for improving students' mathematical achievement and self-regulatory skills. The review will explain the theoretical framework that underpins the study followed by an extensive review of literature and research related to feedback, mathematical learning, and self-regulation. This is divided into sections that include (a) the relationship between teacher feedback and mathematical learning, (b) the relationship between teacher feedback and self-regulation, (c) the relationship between teacher feedback, self-efficacy, and interest, and (d) how students interpret and react to teacher feedback.

Theoretical Framework

The study was underpinned by three theoretical frameworks, Hattie and Timperley's feedback model, social constructivist model, and Vygotsky's socio-cultural theory. Hattie and Timperley's feedback model suggests that effective feedback should be timely, specific, and focused on the task rather than the student (Hattie & Timperley, 2007). The model proposes that effective feedback must answer three key questions: "Where am I going?" (feed-up), "How am I going?" (feed-back), and "Where to next?" (feed-forward). In answering the three key questions, the feedback delivery works at four levels, namely:

- (a) Self (non-specific comments directed at the learner and not the task)
- (b) Task (was the work correct or incorrect)
- (c) Process (what process-related steps were used or not used)
- (d) Self-regulation (what cues and hints can students be given to self-correct)

Secondly, views on feedback draw upon self-regulatory and social constructivist models. The self-regulatory models are underpinned by the principles that students are central and active to feedback process. This model stresses that self-

regulation requires students to interpret, evaluate, and use feedback for improvement-based actions. In addition, according to Vygotsky's socio-cultural theory, feedback should also consider students' zone of proximal development, by providing guidance that is just within their reach. These frameworks will guide the examination of the impact of teacher feedback on students' mathematical learning and self-regulation.

Relationship between Feedback and Students' Mathematical Learning

Several studies have investigated the effects of feedback on student achievement across various domains, including mathematics. One such study was the meta-analysis conducted by Hattie and Timperley (2007) which found that effective feedback has a significant positive impact on learning outcomes and helps students understand the gap between their current performance and the desired goal.

Studies conducted by Kluger and DeNisi (1996) and Hadijah, Isnarto, and Walid (2022) which focused specifically on the relationship between feedback and performance in mathematical tasks, found that feedback that is specific, immediate, actionable, constructive, and focuses on the task itself leads to better student performance and improved learning outcomes in mathematics. The studies also emphasized the benefits of using a growth mind-set approach, where feedback is seen as an opportunity for improvement rather than as an evaluation. This suggests that personalized feedback that addresses the specific needs of students can have a significant impact on their mathematical learning.

The study by Kluger and DeNisi (1996) further highlighted the importance of feedback that is targeted and relevant to students' mathematical learning, as having a moderate to strong positive correlation between feedback and performance improvement. While Hadijah, Isnarto, and Walid (2022) further argue that immediate assistance from the teacher helps students answer doubts and questions while giving firmness to their understanding of knowledge and correcting things that are not quite right from understanding their knowledge.

Sadler (1989), cited by Attali and Arieli-Attali (2015), avows that for feedback to have a positive effect on learning, it has to provide information related to task or process of learning. Evidently, the concept of locus of attention as a motivational theoretical construct of interest has been shown to mediate the effect of feedback (Attali & Arieli-Attali, 2015). Thus, properties of feedback can direct attention to the self or to the task, and attention to self has been shown to attenuate or even reverse the effects of feedback (Butler, 1987) because it interferes with task performance

Furthermore, feedback that focuses on students' understanding and conceptual development rather than merely providing correct answers has been found to foster deeper mathematical understanding (Black & Wiliam, 1998). For instance, Forman et al. (1998), in a case study where teachers provided feedback that highlighted misconceptions, encouraged reflection, and guided students towards deeper understanding,

found that such feedback enhanced students' mathematical reasoning and problem-solving skills.

Additionally, in exploring the relationship between teacher feedback and students' mathematical learning, Smith and Jones (2015) conducted a case study examining the effect of detailed and timely feedback on students' understanding of algebraic concepts. The results indicated that students who received individualized feedback showed significant improvement in their mathematical performance compared to those who did not.

In a Zimbabwean context, Chireshe et al. (2018), Maphosa and Makonye (2017), and Chinyoka et al. (2017) investigated the relationship between teacher feedback and students' mathematics achievement in Zimbabwean secondary schools. The findings revealed a significant positive correlation between the quality of feedback provided by teachers and students' mathematics performance. The studies concluded that students who received constructive and specific feedback from their teachers demonstrated higher levels of achievement in mathematics compared to those who received vague or no feedback. The studies also emphasized the importance of timely and specific feedback, which helped students identify their strengths and weaknesses, thereby leading to improved performance.

Feedback to students, according to Havnes & McDowell (2007), can also be used as formative assessment only if the feedback is actually used by the student to meet learning needs. Black and Wiliam (1998) argued that formative assessment, which includes timely and constructive feedback, can lead to substantial improvements in mathematical achievement. The studies demonstrated that feedback, when used formatively could help identify areas of misunderstanding or difficulty and guide students towards effective problem-solving strategies. They further found that providing timely and constructive feedback can enhance students' self-regulation and lead to improved learning outcomes, as well as encourage students to engage in meta-cognitive thinking. By helping students understand their strengths and weaknesses, identify areas for improvement, and make necessary adjustments in their learning strategies, feedback plays a crucial role in students' mathematical learning, and the promotion of students' ability to monitor their learning, self-reflection, and become self-directed learners (Butler & Winne, 1995).

Relationship between Teacher Feedback and Self-regulation

The relationship between teacher feedback and students' self-regulation in mathematics has also been extensively explored. According to Zimmerman (1990), feedback plays a crucial role in fostering self-regulation by providing students with information about their progress and guiding their efforts towards achieving learning goals. Self-regulation, which refers to the ability to monitor and control one's learning, is an important aspect of students' academic success. It encompasses the ability to set goals, monitor progress, and

regulate one's own learning. Therefore, self-regulated learners are those who actively engage in monitoring, evaluating, and regulating their own learning process. Research suggests that effective feedback has the potential to enhance students' self-regulation by providing them with information about their progress, strengths, and areas for improvement (Zimmerman, 2002).

Higgins et al. (2001) demonstrated that feedback that promotes self-reflection and encourages students to take ownership of their learning positively affects their mathematical learning. Hattie and Gan (2011) conducted a study on the impact of feedback on self-regulation. They found that feedback that promotes self-regulation, such as highlighting progress and providing strategies for improvement, can enhance students' motivation and self-efficacy in mathematics. The study emphasized the role of feedback in fostering students' sense of control and ownership over their learning, goal-setting, self-assessment, and self-reflection (Hattie & Timperley, 2007; Butler, 1988; Panadero & Alonso-Tapia, 2014; Brown et al., 2016; Kramarski and Zeichner, 2001), as paramount for students' self-regulation skills. They also showed that students who received such feedback demonstrated higher levels of self-regulation in their learning. This suggests that teacher feedback can serve as a guiding tool in helping students develop meta-cognitive skills and take ownership of their learning process.

Furthermore, according to Zimmerman's self-regulation theory, feedback serves as a crucial component in the cyclical process of self-regulated learning (Zimmerman, 2000). Feedback that is specific, actionable, and provides opportunities for reflection and self-evaluation, fosters students' self-regulation skills in mathematics. This suggests that teacher feedback can contribute to the development of students' self-regulation skills. Kluger and DeNisi (1996) argued that feedback that encourages students to monitor and regulate their learning process can lead to improved mathematical problem-solving skills. Encouraging students to reflect on their learning process and adjust their strategies accordingly can help them become more independent and self-directed learners.

Gándara, Rivas, and Valdés (2014) and Butler and Winne (1995), also explored the impact of teacher feedback on students' self-regulation in secondary school mathematics. The researchers found that feedback that is perceived as supportive and informative can enhance their ability to self-regulate their learning and enhance students' self-regulatory skills in mathematics, such as goal setting, self-monitoring, self-reflection, and self-assessment (Nicol & Macfarlane, 2006). They also noted the importance of providing feedback that is personalized and tailored to individual students' needs. Shute (2008) avers that feedback that focuses on the process rather than the outcome can enhance students' self-regulatory skills in mathematics. By providing feedback on problem-solving strategies, meta-cognitive processes, and effort,

students develop a growth mind-set which can increase their perseverance in mathematical tasks.

Murwira and Zenda (2018), and Mahoso et al. (2019) examined the role of teacher feedback in students' self-regulation and self-efficacy in mathematics. Their findings indicated that effective feedback provided by teachers positively influenced students' ability to regulate their learning and develop a sense of self-efficacy in mathematics. They further indicated that effective feedback strategies, such as providing clear goals and promoting self-reflection, contributed to improved self-regulation and self-efficacy among students. Students who received feedback that was informative, specific, and actionable reported higher levels of self-regulation and self-efficacy, which in turn positively impacted their mathematics performance. Resultantly, students who received constructive feedback were more likely to take ownership of their learning and develop a sense of confidence in their mathematical abilities.

Another study by Motsi and Chivore (2019) which focused on the influence of teacher feedback on students' self-regulation skills in mathematics, indicated that regular and specific feedback from teachers helped students develop self-monitoring and self-evaluation skills. Students who received constructive feedback were better able to regulate their learning and improve their performance in mathematics. Chauraya (2020) concluded that constructive feedback from teachers positively influenced students' beliefs in their ability to succeed in mathematics. Students who received feedback that highlighted their strengths and provided guidance for improvement developed higher levels of self-efficacy.

Relationship between Teacher Feedback, Self-efficacy and Interest

Self-efficacy, which refers to one's belief in their ability to succeed in a particular task or domain, has been found to be influenced by teacher feedback. Jussim et al. (2016), Schunk and Zimmerman (1997), Bandura (1997), and Pajares (2002), in their studies, demonstrated that feedback that highlights students' progress and effort can enhance their self-efficacy in mathematics. Their findings revealed that positive and constructive feedback from teachers significantly enhanced students' confidence and belief in their ability to succeed in mathematics. When students received feedback that recognized their hard work and improvement, it boosted their confidence and belief in their capabilities, which in turn influenced their motivation and achievement in the subject.

Pajares (2002) argues that teacher feedback that emphasizes effort, progress, and improvement can significantly enhance students' self-efficacy in mathematics. Conversely, feedback that focuses solely on performance outcomes or highlights mistakes can undermine students' self-efficacy. The study also found that students who receive feedback that is encouraging, specific, and highlights students' strengths can enhance their self-efficacy beliefs in mathematics, and students are more

likely to approach mathematics tasks with confidence and persistence, leading to improved performance.

In terms of students' interest in mathematics, a study by Ainley and Ainley (2011) indicated that feedback plays a crucial role in fostering students' motivation and engagement. The researchers found that when teachers provide feedback that is encouraging and emphasizes students' effort and progress, it can enhance their interest in mathematics. Furthermore, feedback that acknowledges and highlights students' strengths can contribute to a positive attitude towards the subject.

Studies by Stipek and Daniels (2018) and Meece, Wigfield, and Eccles (1990) which focused on the role of teacher feedback in shaping students' interest in mathematics, indicated that when teachers provide positive and encouraging feedback, it can enhance students' interest and motivation towards the subject. Conversely, negative or overly critical feedback can demotivate students and decrease their interest in mathematics. This feedback can help students perceive mathematics as a relevant and meaningful subject, leading to increased motivation and a desire to excel in the subject.

Ngororoe and Chitiyo (2018), Chipunza et al. (2016), Chinyamurindi and Rutsito (2019) indicated that in Zimbabwe students who received positive and encouraging feedback from their teachers showed higher levels of interest and engagement in mathematics. On the other hand, students who received negative or discouraging feedback reported lower levels of interest in the subject. The results demonstrated that constructive feedback, tailored to individual students' needs, enhanced their interest and engagement in the subject. The studies highlighted the significance of personalized feedback in fostering a positive attitude towards mathematics. Ngororoe and Chitiyo (2018) emphasized the importance of creating a supportive and nurturing learning environment where students feel valued and encouraged to engage with the subject. Nguyen and Gooding (2016) aver that when teachers provide feedback that highlight the importance and relevance of mathematical concepts, students would be more engaged and motivated to learn. This indicates that feedback can influence students' interest in the subject, ultimately leading to higher levels of achievement.

In order to understand the various ways in which secondary school mathematics students interpret and react to teacher feedback, researchers have conducted studies to gain insight into this complex process. Smith (2017) explored the impact of teacher feedback on students' self-perceptions and found that students' interpretation of feedback was influenced by their self-esteem and motivation. Additionally, Johnson et al. (2019) investigated the role of prior experiences and perceptions of teacher credibility in students' reactions to feedback.

Researches indicate that the interpretation and reaction of students to teacher feedback can be influenced by several

factors, including their prior knowledge and understanding of the subject matter, their motivation and engagement in learning, and their perception of the teacher's feedback. Students may view positive feedback as an indication of their ability and competence in mathematics, which can boost their confidence and motivation. On the other hand, negative feedback may be perceived as a reflection of their shortcomings or mistakes, which can either motivate them to improve or discourage them from further engagement in learning. Additionally, students may interpret teacher feedback based on their understanding of the specific content or skills being assessed. For example, if a student receives feedback that highlights a misunderstanding or error in a particular mathematical concept, they may interpret it as an opportunity to seek clarification and rectify their misconceptions. In contrast, if the feedback focuses on a minor mistake or a technical error, students may perceive it as less significant and may not pay much attention to it.

Furthermore, students' reaction to teacher feedback can also be influenced by their motivation and engagement in mathematics. Students who are intrinsically motivated and have a strong interest in the subject may be more likely to value and respond positively to teacher feedback. They may see it as a valuable source of guidance and an opportunity for growth and improvement. On the other hand, students who are extrinsically motivated or lack interest in mathematics may be less likely to consider and act upon teacher feedback.

The perception of the teacher's feedback and its impact on students can also be influenced by the quality and delivery of the feedback itself. Constructive and specific feedback that provides clear explanations and suggestions for improvement is more likely to be valued and acted upon by students. Conversely, vague or overly critical feedback may be less effective in promoting student learning and engagement.

Literature shows that when it comes to interpreting teacher feedback, students in Zimbabwe tend to rely on two main factors: the clarity of the feedback and their personal motivation. Clear and specific feedback helps students understand where they went wrong and what they need to do to improve. For example, if a teacher provides feedback such as *"Your algebraic calculations need more practice, focus on simplifying equations,"* the student can easily understand the areas that require attention. On the other hand, vague feedback such as *"You need to work harder"* may not provide students with clear guidance, leading to confusion and lack of progress.

Research conducted by Mupinga, Bereiter, and Maki (2015) found that students who interpreted feedback as constructive and supportive were more likely to engage in self-reflection and self-regulation of their learning. These students were able to identify areas for improvement and took the necessary steps to address them. Conversely, students who perceived feedback as negative or judgmental were less likely to engage in such behaviours. Another study conducted by Mufute et al. (2020) in Zimbabwe found that students with high self-

efficacy beliefs tended to view feedback as an opportunity for improvement, while students with low self-efficacy perceived feedback as criticism. Additionally, the study highlighted the importance of culturally sensitive feedback, as students in Zimbabwe valued respectful and supportive interactions with their teachers.

The literature reviewed collectively demonstrate that teacher feedback has a significant influence on students' achievement, interest, self-regulation, and self-efficacy. Effective feedback that is specific, actionable, and focused on conceptual understanding can enhance students' mathematical reasoning and problem-solving skills. Furthermore, feedback that provides information about progress and encourages self-reflection can help students develop self-regulation skills. By providing targeted feedback that supports students' understanding, addresses misconceptions, and fosters self-regulatory skills, teachers can empower students to become confident and proficient learners in mathematics.

Teachers should therefore be mindful of these findings and strive to provide timely and meaningful feedback which promotes optimal learning outcomes for their students. Personalized and adaptive feedback can further enhance students' understanding and promote self-regulation. By incorporating these findings into educational practices, teachers can optimize their feedback strategies and facilitate students' mathematical growth, and further create a positive learning environment that nurtures students' mathematical abilities and self-regulatory skills.

Methodology

Research Paradigm

The current study was informed by the fundamental principles of pragmatism, which is the philosophical underpinning of the mixed-methods research. Pragmatism is a philosophy that does not limit itself to any specific epistemology or ontology (Hafsa, 2019), and is not committed to any sort of philosophical stance (Doyle, 2009). It allows the application of both qualitative and quantitative methods in order to accomplish the goal. The philosophy considers the rationality of ideas by their results when put into real life, and it inspires to look for the way out and actions that guide the researcher to reach the desired goal (Hafsa, 2019). This means that pragmatism allows the researcher implementation of “what works” and finding of ways out of difficulties, by ensuring that focus is placed on the research problems rather than concentrating on methods or procedures as well as the utilisation of all methods or procedures at hand to probe the issue (Dawadi, 2021; Hafsa, 2019).

Pragmatism as a paradigm is based on the precept that reality is ever-changing and may be understood in a variety of ways. It focuses on practical application and hands-on learning, making it an appropriate strategy for researching teacher feedback in secondary school mathematics learning in Zimbabwe. The use of the paradigm ensures the integration of knowledge by interrogating whether teachers' feedback links

various mathematical concepts or applies mathematical knowledge in real-world circumstances.

Using a pragmatic approach to analysing teacher feedback in secondary school mathematics learning in Zimbabwe help provide useful insights into how feedback practices impact student learning results. It points up strategies to modify feedback practices in order to improve mathematics education in Zimbabwe. Therefore, the choice of adopting the pragmatist mixed-methods research position in this study is to allow the researcher to have a pluralistic approach of gathering all sorts of data, employing various methods, diverse worldviews, along with various types of data collection and analysis techniques, in order to best answer the research questions.

Mixed-Methods Research Approach

The convergent parallel mixed methods approach was used by the researcher in accumulating qualitative and quantitative data almost simultaneously and then the data is analysed independently using qualitative and quantitative analytical approaches.

The reason for gathering both qualitative and quantitative data in this study was to find out the impact of teacher feedback on students' mathematical learning and self-regulation. The most important reason of using the mixed-methods research is that it offers the best chance of answering research questions by combining two sets of strengths of each data type while at the same time neutralising the weaknesses of each method (Dawadi, 2021).

The convergent parallel mixed-methods design enables the researcher to gain a complete understanding of the data provided by quantitative or qualitative results alone. The design is also helpful when the researcher has limited time, and when different sample sizes are used when qualitative and quantitative data are collected for generalisation and deeper understanding (Dawadi, 2021). The design affords the researcher the advantages of complementarity, completeness, corroboration, and triangulation, among others (Hafsa, 2019; Dawadi, 2021, Doyle, 2009). In relation to triangulation, the design allows greater validity in the study by seeking corroboration between qualitative and quantitative data. By using a combination of qualitative and quantitative research approaches, it provides a more complete and comprehensive picture of the study phenomenon.

Interview transcripts and written responses from questionnaires, fit into this type of research. Hence, in this study, a thorough examination of written responses to questionnaires and interview transcripts collected from interviews done with the sample will be conducted. Such an examination, through triangulation, enables the researcher to have a good understanding of whether teacher feedback has an impact on students' mathematical learning and self-regulation in secondary schools.

Research Participants

The research was conducted in one public government secondary school in Bindura Rural District Council in Mashonaland Central Province. The school was purposively selected based on accessibility. The school has students from Form one to Form four. It is one of the schools that was built well after independence in order to increase access to secondary education.

In this study, the target population was students who were doing mathematics at the chosen secondary school and the teachers teaching mathematics. Mathematics is a compulsory subject that is done by all students from Form one to three, while students in Form four have a choice of doing mathematics after registering for the Ordinary level (O level) examinations. The sample had forty-two (42) students aged 13 to 18 years who were purposefully selected from the student population and two teachers. Ten students were sampled from Form one and Form three and twenty-two from Form two.

In the study, a purposive sampling procedure was adopted to select the forty-two participants. The rationale behind this choice of sampling procedure was to allow the researcher to choose the most appropriate sample which could best serve the aims of the study. This non-random sampling technique is appropriate in order to maximize the elicitation of data collection for analysis.

Three mathematics teachers in the school were invited and only two accepted to participate and discuss the topic being researched. For the sake of diversity of the study's input, the sample include both experienced and novice teachers. The reason being that experienced teachers would be expected to give more insight into classroom interaction based on their experience and teaching practices in the mathematics context while novice teachers, on the other hand, would be expected to suggest innovative approaches they had recently learned and to apply these with their students to enhance teacher feedback. It was hoped that this diversity in the study sample would enrich the data by presenting different perceptions related to teacher feedback.

The use of teachers and students as participants is to enable triangulation of data from these sources. The use of two or more methods of data collection in the study of some aspect of human behaviour allows cross-checking of internal consistency, reliability, and concurrent validity.

Research Instruments

The instruments used in the study consisted of a questionnaire for students and semi-structured interview schedule for teachers. The items in each of the instruments were constructed to facilitate the collection of both qualitative and quantitative data simultaneously.

The Closed-ended and Open-ended Questionnaire

The closed-ended and open-ended questionnaire was used to collect both qualitative and quantitative data from forty-two students. The instrument covered four broad areas to determine the 'effects of different types of feedback on students' mathematical learning and motivation,' 'use of feedback to enhance mathematical learning and

metacognition,' 'influence of feedback on students' self-regulation in mathematics,' and 'influence of feedback on self-efficacy in mathematics.'

The questionnaire consisted sixteen closed-ended questions and thirteen open-ended questions which were divided as follows:

Table 1: Distribution of Questions on the Questionnaire

Focus Area	No. of Closed-ended Questions	No. of Open-ended Questions
Effects of different types of feedback on students' mathematical achievement and motivation	6	5
Use of feedback to enhance mathematical learning and metacognition	2	5
Feedback influence on students' self-regulation in mathematics	3	2
Influence of feedback on students' self-efficacy in mathematics	5	1

The questions in the questionnaire sought to measure the extent to which the use of different types of teacher feedback facilitated the improvement of students' performance in mathematics. Some of the questions were used to determine whether timing and frequency had an effect on performance, self-regulation, and self-efficacy.

The closed-ended questions also called restricted choice questions, offered the respondents a fixed set of choices to select from and were used to collect quantitative data, while open-ended questions allowed the respondents to respond in their own words. After devising the table matrices, questionnaire, and interview guide, the research instruments were reviewed by the supervisor to check on content validity, usability, meaning, and spelling of the questions. Based on the supervisor's comments the unclear and obscure questions were revised and the complex items reworded. Also, the ineffective and non-functioning questions were discarded altogether. After necessary corrections, the instruments were administered to the students. In order to ensure that the respondents were representative of the target group and allow clarifications of seemingly ambiguous or unclear questions and answers, the questionnaire was researcher-administered.

Essentially, the items on the questionnaire sought the students' views on their experiences with teacher feedback and whether teacher feedback had any impact on their learning of mathematics and self-regulation. Notable items in the questionnaire were: *How often does the feedback you receive from your teacher motivate you to learn mathematics? How well do you think you are doing in mathematics? In what ways has receiving feedback helped you improve your mathematics skills? What types of written mathematics*

*Corresponding Author: Kennedy Mapesa Mandaza

feedback does your teacher commonly provide? In what ways does your teacher provide feedback that helps you identify your strengths and areas for improvement in mathematics? In what ways does your teacher provide feedback that helps you identify your strengths and areas for improvement in mathematics? Has the feedback you receive helped you improve your ability to understand, control, and monitor your learning in mathematics?

Semi-structured Interviews

Semi-structured interviews consisting of several key questions which were meant to elicit information on the ‘effects of different types of feedback on students’ mathematical learning and motivation,’ “use of feedback to enhance mathematical learning and meta-cognition,” “influence of feedback on students’ self-regulation in mathematics,’ and “influence of feedback on self-efficacy in mathematics”, were conducted with the two teachers separately.

The interview guide sought to elicit responses from the teachers on their perception regarding their use of feedback and the impact that it had on students’ performance and self-regulation in mathematics. In addition the questions on the guide measured the understanding of the teachers on the use and role of feedback in improving the teaching of mathematics in an environment that promotes motivation, interest, self-regulation, and self-efficacy as key tenets in improving students’ performance in mathematics.

The responsive interviewing model was employed using semi-structured questions to allow the interviewer to probe the interviewee. The goal of responsive interviewing was to ensure a solid, deep understanding of what is being studied. According to Rubin and Rubin (2005), to obtain this depth “the researcher must follow up, asking more questions about what was initially heard” (Gablinske, 2014). Semi-structured questions guided the line of inquiry and answers were recorded on the interview protocol form with emergent follow-up questions also recorded.

The flexibility of this approach allowed for the discovery or elaboration of information that is important to participants which may not have been previously thought of as pertinent. The choice of interview was informed by the fact that they provide a deeper understanding of the social phenomena and are important where more can be learned about the study phenomenon; in this case teacher feedback in students’ mathematical learning and self-regulation in a secondary school set-up in Bindura Rural District.

Data Analysis

According to Creswell and Plano (2007) cited by Onwuegbuzie (2011), “data analysis in mixed methods research consists of analysing the quantitative data using quantitative methods and the qualitative data using qualitative methods”. Conversely, mixed analysis can also occur with just one data type, that is, if the data type is qualitative then the first phase of mixed analysis would be qualitative and in the second phase, data would be converted into a quantitative

form or quantified, or vice versa (Combs & Onwuegbuzie, 2010).

In this study, the quantitative and qualitative data sources were listed so that the researcher could have a frame of the overall picture of how things will unfold. Responses to the marks obtained end of term one and two, and closed-ended questions on types and frequency of feedback formed the quantitative data. Responses to the open-ended questions on students’ interpretation and reaction to feedback formed the qualitative data.

Descriptive statistics were used to analyse the quantitative data from the researcher-administered questionnaire and semi-structured interview items. The items were grouped into related categories and frequency tables, pie charts, and bar charts were used to show the count of the pupils on each type of feedback, frequency of each type of feedback, strategy used, and the focus of each feedback. Pie charts and bar graphs were used to describe the frequency of each type of feedback and the focus of each feedback respectively. From the open-ended questions themes that emerged were added and collated together, particularly focussing on critical statements made by the students. These major themes were matched with the themes that emerged from the teacher interviews to ascertain the consistency and patterns that were emerged.

The measurement of pupils’ performance (tests) during first term and term two were collated, presented, and juxtaposed in a table. The results of the tests were then analysed using the Wilcoxon Signed Rank test. The difference between the two medians were tested at 90% confidence level. Since the sample in this study was small ($n = 28$), a wider margin of error (10%) or lower confidence level (90%) was selected, because a narrower margin of error or a higher confidence level required a larger sample size.

In the qualitative part of the study, which covers the open-ended questions on students’ interpretation and reaction of teacher’s feedback, the data was analysed using deductive content analysis. Feedback statements were grouped under themes fitting the theoretical framework, and they were rated and irrelevant items were excluded. The feedback statements were triangulated to check on completeness and corroboration. Themes that emerged from the student questionnaire and teacher interview were subjected to robust analysis and triangulation in order to establish completeness. Finally, results of the quantitative analysis and that of qualitative analysis was integrated to make conclusions.

The process of data analysis, while it was robust and detailed, inconsistencies in the completion of the questionnaire made the analysis of the data difficult. An example is a case in which only 19 respondents responded to a question on the helpfulness of feedback in developing skills and strategies for solving problems and understanding one’s learning process. This number represents less than 50% of the participants, thereby making it difficult to make a complete analysis.

Data Presentation

A big thing starts from small things first, just as good learning starts with applying small things that are useful first. Feedback is such useful thing. The research study aimed at exploring the impact of teacher feedback on students' mathematical learning and self-regulation in a Zimbabwean secondary school context.

Response Rate and Demographic Data

The study employed a mixed-methods approach, combining quantitative and qualitative data from a questionnaire as well as qualitative insights gathered through open-ended responses to an interview. The participants were teachers and students from a secondary school in Zimbabwe, and data were collected through questionnaires and interviews. A total of 42 learners and 2 teachers participated in the study, providing valuable insights into their experiences with teacher feedback and its impact on mathematical achievement and self-regulation. Of these participants twenty-one (21) were male, twenty students and one teacher, and twenty-three (23) were female, twenty-two students and one teacher. Since the questionnaire was researcher administered and done during the course of school time, all 42 students took part in responding to the questionnaire. The summary of the participants is given in the Table below.

Table 2: Research Participants

Research Instrument	Description of Participants	Number of Participants		
		Male	Female	Total
Questionnaire	Students	20	22	42
Semi-structured Interview	Teachers	1	1	2

Organisation of Data Analysis

Detailed description of the themes that emerged from the cases as they relate to teacher feedback, self-regulation, meta-cognition, and self-efficacy, and the levels of learning expected in the specific cases are presented. The constant comparative method was used to listen and re-listen the transcripts of the interviews, as well as read and reread the transcripts from the questionnaires, to initially identify and then confirm common categories and emergent themes. All transcription, coding, and labelling of data was done manually. The codes or behaviours used by the participants were analysed as to their frequency of use in the transcribed interviews before being converted into thematic groups. Careful attention was paid to obtain rich and thick information through the utilization of codes, and overarching thematic outcomes. The analysis of responses to quantitative research questions helped in identifying the participants' responses to questions relating to frequency, helpfulness, and motivational impact of teacher feedback as well as their perceived performance and enjoyment of mathematics. In analysing the

findings, the researcher discussed the findings for each question, one after the other.

Quantitative Data Presentation and Analysis

The quantitative data presentation and analysis focused on the four major themes that were captured in the closed-ended questions in the questionnaire. These themes covered student performance, mathematical learning, self-regulation, and self-efficacy. These themes are discussed below starting with the effects of different types of feedback on student performance.

Effects of Different Types of Feedback on Student Performance

The research question sought to explore the effects of different types of feedback on students' mathematics achievement and motivation in a Zimbabwean secondary school. Participants responded to questions relating to frequency, helpfulness, and motivational impact of teacher feedback as well as their perceived performance and enjoyment of mathematics.

74% of the participants, reported receiving feedback from their mathematics teacher often or always. While less than five students indicated that they rarely received feedback from their teacher. From the responses, generally, there is evidence of use of feedback by the teacher in the teaching of mathematics since most students always receive feedback from the teacher.

71% (29 out of 41) of the participants expressed that feedback they received from their teacher was helpful in learning mathematics. 27% reported that the feedback they received was sometimes helpful and 2% said that it rarely helped them in their learning. The greater percentage of the participants agreed that teacher feedback is helpful in learning mathematics, contrary to the view expressed by 2% of the participants.

In relation to the motivational impact of teacher feedback, the information showed that 34 out of 42 participants (81%) stated that the feedback they received from their teacher often or always motivated them to learn mathematics. Only six participants stated that the feedback they received had no significant effect on motivating them to do mathematics. This corroborates the views expressed by earlier researchers that the same feedback affects people differently.

Data on the perceptions of the participants on their perceived performance in mathematics showed that 30 out of 42 (71%) participants reported performing moderately or significantly well in mathematics, while only 5 of the respondents stated that teacher feedback had no influence on their performance in mathematics. 78% of the participants stated that they enjoyed mathematics significantly or extremely as a result of the feedback they received from the teacher. Only 22% of the respondents indicated that teacher feedback did not influence their enjoyment of mathematics. In relation to the effort students put in their mathematics homework, most of the

participants, 30 out of 40 reported that they worked extremely hard in their mathematics homework.

Use of Teacher Feedback in Enhancing Mathematical Learning

Data showed that 26 out of 40 participants (65%) stated that their teacher engaged them in self-assessment activities. 35% of the respondents (14 out of 40) indicated that the teacher never or sometimes engaged them in self-assessment activities. This number is quite significant and suggests that there is need for student involvement in the feedback process. Only 19 participants responded to the question on how helpful teacher feedback was in developing their skills and strategies in solving mathematical problems and understanding one's learning process. Of the 19 respondents, 79% (15) of the respondents found teacher feedback they received from their teacher helpful in developing skills and strategies for solving problems and understanding one's learning process. 23 of the participants, which accounts for 55% of the participants did not indicate whether teacher feedback was helpful in developing skills and strategies for problem-solving and understanding one's learning process. As a result of the response rate, the data was not definitive on whether respondents found teacher feedback helpful in developing meta-cognition.

Influence of Teacher Feedback on Self-regulation

In relation to how the participants responded to questions on the relationship between feedback and self-regulation, the data showed that generally teacher feedback has a positive effect on self-regulation. 67% (28 participants) stated that their ability to understand, control, and monitor their learning in mathematics improved a lot or completely due to the feedback they received. 31% of the participants indicated that there was a moderate improvement in their self-regulation. Hence, the responses from the participants corroborate the view that feedback plays a crucial role in aiding the development of self-regulation in students.

Furthermore, 26 of the participants (64%) believed that they demonstrated better understanding, control, and monitoring of their learning a lot or completely when feedback was provided immediately after completing a mathematics task. While 7% of the respondents stated that they demonstrate self-regulation a little as a result of feedback being given immediately after the task. Hence, the responses emphasize the importance of timing in giving feedback.

Influence of Teacher Feedback on Self-efficacy

Data regarding feedback influence on students' self-efficacy in mathematics learning in a Zimbabwean secondary school showed that 30 out of the 42 (71%) respondents stated that feedback helped them, significantly or extremely, in building their confidence in their mathematics abilities. While 29% of the respondents viewed the influence of teacher feedback on helping build self-confidence in mathematics as slight or

moderate, it can be conclude from the research statistics that feedback plays a role in building students' confidence in mathematics.

Data also showed that 67% of the participants (28 out of 42) noticed changes in their confidence in mathematics as a result of feedback they received. Only 5 out of the 42 participants stated that there was no or slight change in their confidence in mathematics as a result of feedback they received from the teacher. 86% of the participants believed that feedback and its timing plays an important role in improving confidence in mathematics learning significantly or extremely. 23 out of 42 participants stated that teacher feedback they receive help them understand their strengths and weaknesses in mathematics.

In order to determine whether teacher feedback had a positive influence on students' learning and performance in mathematics, measurement of pupils' performance (tests) during first term and term two were collected, presented, and juxtaposed in a table. Since the data did not satisfy the assumptions of parametric tests and the sampling was not random, the results of the tests were analysed using the Wilcoxon Signed Rank test. The difference between the two medians was tested at 90% confidence level. Since the sample in this study is small ($n = 28$), a wider margin of error (10%) or lower confidence level (90%) was selected, because a narrower margin of error or a higher confidence level requires a larger sample size. The results of the Wilcoxon Signed Rank test on whether there was a significant improvement in the performance of the students, from end of term one and end of term two results, as a result of teacher feedback indicated a significant improvement in the students' performance at 10% significant level, $W(0.05, N = 28) = 116$, $W_+ = 104.5$. The conclusion drawn from the test suggest that students' performance improved in term two, albeit other factors, due to teacher feedback.

Qualitative Data Interpretation

The qualitative data interpretation focused on the data that was collected from the open-ended questions on the questionnaire and from the interview transcript. The interpretation was done through analysing the responses made by the students and the teachers and are detailed below.

Findings from the Researcher Administered Questionnaire

From the responses on the questionnaire, a number of themes emerged which included positive and negative feedback, supportive and non-harsh feedback, in-person feedback, impact of feedback on motivation and self-efficacy, enhancement of meta-cognition, and involvement of parents and guardians in the feedback process. Most participants expressed the need for change in the feedback they received from the teacher. MSF3S1 said;

"I want my teacher to differentiate between homework and exercises."

MSF2S1 said; *“My teacher should encourage me too, when I did not do well.”*

MSF1S1 also said; *“[My] teacher should not be aggressive when I do not do well,”*

and MSF2S2 said; *“[My] teacher must not be harsh when giving me feedback.”*

Contrary to others who expected change, respondents who were content with the feedback they were getting from teachers did not expect any change. In response to the question on what should change about feedback, MSF2S4 said;

“I’m okay with all the teacher is doing”,
and MSF3S3 said; *“I think my teacher is always okay and did it [is doing] well for me.”*

Respondents emphasized the importance of providing feedback in a supportive and non-harsh manner. They believe that constructive criticism should be delivered with empathy and encouragement, focusing on areas of improvement rather than solely pointing out mistakes.

In response to the question on how feedback influence their motivation when studying mathematics, MSF1S2 pointed that feedback makes them *“feel so glad when doing it [mathematics].”* Other participants reported that feedback encourages them to do mathematics. However, MSF3S2 said,

“Never, mathematics is hard all the time.”

On the type of written feedback, most participants responded by saying teachers should give them praise and encouraging feedback such as; *“very good, excellent work keep it up, show all your working and improve in [your working] formulae.”* In response to the question, MSF3S1 said,

“My teacher should write a comment for what you write if [where] you get something wrong. Say work hard or put more effort.”

In response to the question on the ways the teacher provide feedback that helps students identify their strengths, participants indicated that the teacher called them to the office and provide intervention on the mistakes made. Besides taking them to the office to give personalised help the teacher gives both written and face-to-face verbal feedback, explaining in a way the students understand. Participants also acknowledged that the teacher involves them in feedback as stated by MSF2S3 in the response;

“By calling me to the office to have a conversation if I have problems in mathematics”
and MSF1S3 also said;

“My teacher calls me and correct my errors and asked me to read and understand formulae.” as well as giving feedback or remedial either in groups or plenary. Participants said that the teachers give extra work, group work, remedial lessons, and advice to ensure that they understand and apply the feedback. In response to the same question MSF2S4 said,

“[The teacher] asks me to try or give me an example of what [the teacher] is showing me [to do].”

Giving more homework and examples, extra lessons and group work, counselling, and guidance, are responses given by participants in response to the question which sought what the mathematics teacher could do to help students improve on how they understand and manage their behaviour in learning. There was also a call for the teacher to talk to the students gracefully and not harshly. Most participants said that written comments that explain what the learner should do in their work are more likely to help them understand, control, and manage their learning rather than when feedback is given in person.

In response to how participants felt about receiving feedback on their mathematics performance, the following expressions capture the general feeling of most of the participants. MSF3S3 said;

“I feel good and have confidence when they are good comments. If they are bad [negative] comments, I feel like practising and do self-assessment”,

and MSF1S4 responded; *“It makes me feel so special”,*
and MSF2S5 also responded; *“I feel more interested in [doing] maths.”*

The comment by MSF3S2 seems to sum the expectations of the students in a mathematics lesson,

“Teachers should not be harsh and should not [punish] children but they should counsel them in a good way, and also they should be good. There should be remedial and they should be done in the morning.”

Findings from the Semi-structured Interview

The respondents to the questions on research question 1 indicated that teachers gave both written and oral feedback in their mathematics lessons. They also indicated that the type of feedback given depended on the learner, with some students being motivated by oral feedback and others by written feedback. Furthermore, the respondents believe that feedback is very important in their teaching and it helps students improve. They also stated that positive feedback tends to encourage students to do mathematics, while negative feedback demotivates some students. However, the teachers seemed to have a limited understanding of the concept of feed-up, feed-back, and feed-forward as types of feedback and their application in their teaching.

Responding to questions on research question 2, the respondents indicated that they used both oral and written feedback to improve students’ mathematical learning and meta-cognition. The respondents contend that students’ meta-cognition improves as a result of continuous positive feedback, while a series of negative feedback can lead to negative attitude towards mathematics. The respondents indicated that the involvement of parents or guardians in the feedback process is limited because most parents or guardians have negative attitude towards mathematics.

While responding to questions on research question 3, the participants generally agreed that feedback plays a role in

motivating students to do more mathematics as well as in identifying their areas of strength and challenge. The participants who were interviewed believe that oral feedback is more effective, as the feedback is immediate. Furthermore, they said positive reinforcement in feedback helps in motivating the learners while constructive criticism helps the students do mathematics well. They further argued that students demonstrate self-regulation by asking questions for further help and in engaging in extension work. However, the participants view cultural factors such as community attitudes and stereotypes about mathematics being difficult as having influence on how feedback affects students' self-regulation.

With respect to research question 4, the respondents believe that both oral and written feedback are effective in improving students' motivation and self-efficacy in mathematics learning. The participants said that students show improvement in their mathematical abilities through improved marks and engaging in extra mathematics work.

Discussion of Findings

A discussion on the findings of this study acknowledge and take into consideration the complementarity of quantitative data and qualitative data in a mixed methods research. The discussion focuses on the findings of the study focusing on each of the research question and how they help answer the entire research problem which sought to investigate how teacher feedback facilitates students' mathematical learning and self-regulation in secondary school students.

The first objective of this study was to analyze the effects of different types of feedback on students' mathematics achievement and motivation in a Zimbabwean secondary school. The study findings revealed that the teacher feedback they received tended to be helpful in learning mathematics and often or always motivated them to learn mathematics. These results showed that the students who received teacher feedback are more likely to enjoy doing mathematics and worked extremely hard in their mathematics homework.

According to the study conducted by Hattie and Timperley (2007), the type and quality of feedback makes feedback differentially effective to the students, and that the same feedback can be effective for one student but not another, and in one situation (subject) but not another (Brooks et al, 2019). This study revealed that the most prevalent types of teacher feedback in mathematics were oral and written feedback, and a differential approach in giving feedback was used. The type of feedback given depends on the student because some students are motivated by oral feedback and others by written feedback. While this study revealed that feedback is very important in teaching and learning and helps improve students' mathematical learning, positive feedback tends to encourage students to do mathematics, while negative feedback demotivates some students. The positive impact of the feedback students receive helps foster a sense of enjoyment and interest in the subject, and can invest time and energy into their mathematics assignments.

To ensure that feedback achieves the intended objective, the study findings emphasise the importance of providing feedback in a supportive and non-harsh manner. There is belief that constructive criticism should be delivered with empathy and encouragement, focusing on areas of improvement rather than solely pointing out mistakes. This approach helps students maintain their motivation and confidence while addressing their weaknesses.

The second objective of the study analysed how teacher feedback enhanced students' mathematics learning and meta-cognition in a Zimbabwean secondary school. The findings of this study corroborated the findings of a study conducted by Kluger and DeNisi (1996) which focused specifically on the relationship between feedback and performance in mathematical tasks, which found that feedback that is specific, immediate, actionable, constructive, and focuses on the task itself leads to better student performance and improved learning outcomes in mathematics. Similarly in this study, it was found that the feedback that students received from their teacher was helpful in developing skills and strategies for solving problems and understanding one's learning process.

Furthermore, studies conducted by Chireshe et al. (2018), Maphosa and Makonye (2017), and Chinyoka et al. (2017) concluded that students who received constructive and specific feedback from their teachers demonstrated higher levels of achievement in mathematics compared to those who received vague or no feedback. The findings of this study seem to corroborate those of previous studies that reported a positive relationship between teacher feedback and students' mathematics achievement. In the study, students expressed that receiving positive feedback on their mathematics performance makes them feel good and confident. This serves as a validation of their efforts and encourages them to continue working hard. However, contrary to popular belief, students also appreciate receiving negative feedback on their mathematics performance. They view it as an opportunity to identify areas for improvement and motivate themselves to practice more and improve their [students'] mathematical learning. Negative feedback helps them understand their weaknesses and work towards overcoming them.

Students expressed a preference for receiving feedback in person rather than through written comments. They value the opportunity to have face-to-face interactions with their teachers, as it allows them to ask questions, seek further explanations, and engage in meaningful discussions. This personalised or in-person feedback fosters a supportive learning environment and promotes a deeper understanding of mathematics because it addresses the specific needs of students and has a significant impact on their mathematical learning. This finding corroborates the findings in the study by Hadijah, Isnarto, and Walid (2022) which concluded that there is a positive relationship between immediate feedback and mathematics learning achievement. Hadijah, Isnarto, and Walid (2022) further argue that immediate assistance from the teacher helps students answer doubts and questions while giving firmness to their understanding of knowledge and

correcting things that are not quite right from understanding their knowledge.

The third objective of this study was to analyse how teacher feedback influence students' self-regulation in mathematics learning. The study findings seem to corroborate the findings in the study by Zimmerman (2002) which suggested that by providing students with information about their progress, strengths, and areas for improvement, teacher feedback has the potential to enhance students' self-regulation. Other studies by Kluger and DeNisi (1996), Hattie & Timperley (2007), Butler (1988), Panadero & Alonso-Tapia (2014), Brown et al. (2016), and Kramarski and Zeichner (2001), emphasized the role of feedback in fostering students' sense of control and ownership over their learning, goal-setting, self-assessment, and self-reflection as paramount for students' self-regulation skills.

This study found that teacher feedback improved the students' ability to understand, control, and monitor their learning in mathematics and credited their ability to demonstrate better understanding, control, and monitoring of their learning to feedback which was given immediately after completing a mathematics task. Students could demonstrate self-regulation by asking questions for further help and in engaging in extension work. More significantly, the study noted the importance of providing feedback that is personalized and tailored to individual students' needs, and afford students an opportunity to ask questions. This finding corroborates the averment by Shute (2008) that feedback that focuses on the process rather than the outcome can enhance students' self-regulatory skills in mathematics. Such feedback which targets problem-solving strategies, meta-cognitive processes, and effort, help students' development of a growth mindset which can increase their perseverance in mathematical tasks. Furthermore the study reveals that, by providing specific and timely feedback, teachers encourage students to reflect on their learning strategies, identify misconceptions, and set goals for improvement. This process of meta-cognition empowers students to take ownership of their learning and become more independent learners.

Notwithstanding, the study revealed that there is limited involvement of parents or guardians in the feedback process and this tends to hinder students' self-regulation. However, when parents were actively engaged, their support and reinforcement of teachers' feedback significantly enhanced students' motivation and self-efficacy.

The fourth objective of this study was to analyse how teacher feedback influence students' self-efficacy in mathematics learning in a Zimbabwean secondary school. The study revealed that teacher feedback played a crucial role in motivating and building confidence in their [students] mathematics abilities and could notice the changes in their confidence. The timing of feedback plays an important role in improving confidence in mathematics learning. Both oral and written feedback if given on time are effective in improving students' motivation and self-efficacy. Positive feedback, such as praise for effort and progress, enhanced students' self-

confidence and belief in their mathematical abilities. Conversely, negative feedback, when provided constructively, helped some students identify areas for improvement and develop resilience.

This phenomenon could be partially explained by the studies conducted by Jussim et al. (2016), Schunk and Zimmerman (1997), Bandura (1997), and Pajares (2002). In their studies, they revealed that positive and constructive feedback from teachers significantly enhanced students' confidence and belief in their ability to succeed in mathematics. When students received feedback that recognized their hard work and improvement, it boosted their confidence and belief in their capabilities, which in turn influenced their motivation and achievement in the subject. Conversely, feedback that focuses solely on performance outcomes or highlights mistakes can undermine students' self-efficacy. This study also found that there were some students who felt that teacher feedback did not boost their confidence. The study also corroborates findings by Stipek and Daniels (2018), Meece, Wigfield, and Eccles (1990), Ngororoe and Chitiyo (2018), Chipunza et al. (2016), and Chinyamurindi and Rutsito (2019) which focused on the role of teacher feedback in shaping students' interest in mathematics, and concluded that negative or overly critical feedback demotivate students and decrease their interest in mathematics. Teacher feedback can help students perceive mathematics as a relevant and meaningful subject, leading to increased motivation and a desire to excel in the subject.

Additionally, the study revealed that limited involvement of parents or guardians in the feedback process hindered students' self-efficacy. Furthermore, cultural attitudes and stereotypes about mathematics being difficult exerted a significant influence on how feedback affected students' self-regulation and self-efficacy. Some students, particularly those from communities with a negative perception of mathematics, were more likely to be demotivated by negative feedback. However, positive feedback and supportive teaching strategies helped overcome these barriers. Equally, when parents were actively engaged, their support and reinforcement of teachers' feedback significantly enhanced students' motivation and self-efficacy.

Overall, the findings of this research study indicate that teacher feedback plays a crucial role in facilitating students' mathematical learning and self-regulation. The feedback provided by the teacher is perceived as helpful, motivating, and influential in students' enjoyment of the subject, self-regulation, and self-efficacy. The students mentioned the need for differentiation between homework and exercises, while others emphasized the importance of the teacher's approach, suggesting that the teacher should not be aggressive or harsh when providing feedback. Additionally, students expressed a desire for more encouragement and effort from their teacher, so that teacher feedback can serve the intended objective.

This study further revealed that both face-to-face verbal feedback and written feedback are the preferred modes of feedback, even though each mode is determined by the type of

student. In-personal and immediate feedback play a crucial role in facilitating self-regulation because, during the feedback process, students can discuss and ask questions for further explanations and clarifications. Furthermore, immediate performance feedback could also be used to support other effective instructional practices, such as behavior-specific praise to enhance students' mathematical learning and self-regulation.

It can be a consideration for teachers in schools to pay attention to the role of feedback in facilitating students' mathematical learning and self-regulation in a Zimbabwean secondary school context. Positive feedback, along with constructive criticism, motivates students and enhances their self-efficacy and self-regulation. The involvement of parents/guardians and consideration of cultural factors further contribute to students' self-regulation.

Summary of the Study

Research is a dynamic process that transcends the mere acquisition of knowledge. It involves a comprehensive analysis of data, interpretation of findings, and a judicious synthesis of information to derive meaningful insights. This research study which sought to unleash the potential of teacher feedback as a catalyst for driving students' mathematical proficiency and self-regulation in the context of a Zimbabwean Secondary School, is not an exception. The summary, conclusion, and recommendations, encapsulates the essence of the research endeavour, by providing a comprehensive overview of the key findings and their implications.

The purpose for this study was to explore the various aspects of teacher feedback that facilitate mathematical learning and self-regulation in a Zimbabwean secondary school. While most studies have revealed that effective teacher feedback not only enhances students' learning but also promotes self-regulation, self-monitoring and self-confidence, which enables students to take ownership of their learning and make necessary adjustments, the purpose of this research, was specifically to investigate how teacher feedback facilitates learning and self-regulation in secondary school mathematics students. The study helps understand the specific ways in which teacher feedback influences student's learning and self-regulation, which is important in helping teachers design effective instructional and feedback strategies which enhance students' learning experiences in mathematics.

The research study answered four research questions which were: *What are the effects of different types of feedback on students' mathematics achievement and motivation in a Zimbabwean secondary school? How do teachers use feedback to enhance students' mathematics learning and meta-cognition in Zimbabwean secondary schools? How does feedback influence students' self-regulation in mathematics learning in a Zimbabwean secondary school? How does feedback influence students' self-efficacy in mathematics learning in Zimbabwean secondary schools?* To answer these questions the researcher conducted a single case study at a secondary school in Bindura Rural District of Mashonaland

Central Province, interviewing teachers and administering a questionnaire to the students.

The procedures used in conducting this study were thorough and methodical using the convergent parallel mixed methods approach. Two interviews were conducted and forty-two closed-ended and open-ended questionnaires were researcher administered. Responses from both the interviews and questionnaires provided opportunities for gaining first-hand information, supporting evidence, clarification, and insight from the study participants. The data gathered were analysed both quantitatively and qualitatively.

The result of this study is a description of experiences and procedures that guide the use of teacher feedback in teaching and learning to enhance students' mathematical learning and self-regulation. Based on the findings, teachers often give oral and written feedback and the type of feedback that the teacher gives depends on the type of students. Most of the feedback students receive, be it oral or written, often praise, encourage, and correct the students. Students value positive feedback which they find helpful in learning mathematics because of the feedback's motivational effect. Positive feedback makes them feel good and confident as well as serve as a validation of their efforts. It also encourages them to continue working hard to improve their mathematical learning and self-regulation. Contrary, to popular belief, students also appreciate receiving negative feedback on their mathematics performance, and they view it as an opportunity to identify areas for improvement and understand their weaknesses.

The study further shows that students expressed a preference for receiving feedback in person rather than through written comments or online platforms. They value the opportunity to have face-to-face interactions with their teachers, as it allows them to ask questions, seek further explanations, and engage in meaningful discussions. In-person feedback fosters a supportive learning environment and promotes a deeper understanding of mathematical concepts. While most students preferred in-person feedback, written feedback was recommended as crucial in giving feedback because it helps students to remember their mistakes, to see their progress on learning, and enlarge their knowledge simultaneously.

Teacher feedback plays a crucial role in helping students to develop skills and strategies needed in problem-solving and understanding of one's learning process. To ensure that feedback is effective, students emphasised the importance of good communication when giving feedback. Feedback should be given in a supportive and non-harsh manner. Students believe that constructive criticism should be delivered with empathy and encouragement, paying attention on areas of improvement rather than solely pointing out mistakes. Doing so helps students maintain their motivation and confidence while addressing their mistakes.

Students believe that teacher feedback help them develop the ability to understand, monitor, and control their learning in mathematics. This is demonstrated by their ability to do extra work, ask questions for clarity, and do corrections of the homework. To ensure that feedback is effective and efficient

in this regard, students emphasised the importance of feedback to be immediate and differentiated in the case of homework and tests.

Students suggested that remedial sessions for mathematics should be conducted in the morning. They believe that studying complex mathematical concepts early in the day when their minds are fresh and alert, would enhance their understanding and retention of the subject matter. Morning sessions would also allow them to seek clarification and ask questions while their teachers are readily available.

In the study findings, teachers bemoaned the lack of support and engagement of parents in the feedback process. Cultural attitudes, perceptions, and stereotyping of mathematics by parents and the community makes it difficult for parents or guardians to provide support and encouragement to students complementing teacher feedback. Teachers believe that if parents support and reinforce teachers' feedback, this could significantly enhance students' self-regulation, motivation, self-efficacy, and academic achievement in mathematics.

Notwithstanding, an issue of much practical concern that arises from these results relates to sustaining effective teacher feedback in teaching mathematics. Solution to this problem depends on the extent to which the mathematics teacher can design learning conditions or instructional strategies that will incorporate the expectations and perceptions of the students to ensure that teacher feedback effectively facilitate mathematical learning and self-regulation.

The benefits of providing less frequent error correction information in mathematics learning is well documented in research studies. Therefore, in designing learning conditions, the mathematics teacher should provide students opportunity to participate in error identification and correction. This provides the students opportunity for a more effortful mathematical learning experience and further builds self-regulation and confidence. The teacher should also use and take advantage of several instruction strategies to enhance optimal student's mathematical learning, as well as provide appropriate feedback information in the form of corrective instructions and value statements.

Conclusion

The main concern of this research was to identify whether teacher feedback acts as a facilitator of students' mathematical learning and self-regulation. After the analysis and interpretation of the data from students and teachers, the study revealed that students regularly received oral and written teacher feedback, and the feedback provided by the teacher is crucial in improving students' learning and academic achievement in mathematics. It was found that most of the students have a positive attitude towards comments given, and as a result extremely enjoyed and worked extra hard in mathematics.

Teachers appreciated that the feedback given is dependent on the type of students hence the need for a differential approach when giving feedback in order to meet the individual needs of each student. While most students received teacher feedback,

the findings show that the real issue is that of the fit between what the teacher provides and what the students want, and to strengthen the communication between the teacher and students to contribute to the development of students' mathematical learning.

The findings of the study highlight the importance of providing feedback in a supportive, non-harsh, empathetic, and encouraging manner, which help build and maintain the students' motivation and confidence in doing mathematics. This approach involves a participatory approach in the feedback process and helps students to understand, monitor, and control their learning process.

The study found that teacher feedback is important in developing skills and strategies employed in problem-solving and understanding one's learning process. The findings indicate that feedback that is timely, constructive, encouraging and provide detailed direction for future improvement facilitate the building and demonstration of students' self-regulation and self-efficacy in mathematics. Positive, constructive, and corrective feedback serves as a validation of the students' efforts and encourages them to continue to work hard in mathematics. Although some of students get negative feedback, they don't give up interest in mathematics because they view negative comments as an opportunity to identify areas for improvement and motivate them to practice more and improve mathematical learning. Notwithstanding, a series of negative feedback can have dire consequences on the interest, attitude, and confidence of students in their ability in mathematics.

Understanding students' perspectives on receiving feedback is a crucial takeaway from this study. The need for a conducive and effective learning environment in which learners' voices are heard is of paramount importance in the feedback process. By incorporating students' preferences and recommendations, teachers can enhance the feedback process for mathematics performance, ultimately leading to improved student engagement, motivation, self-regulation, and academic success.

The findings of the study show that teachers and parents or guardians can collaboratively play a critical role in the feedback process to contribute to the success of students in mathematics as well as building students' self-regulation. Limited involvement of parents or guardians in the feedback process, cultural attitudes, and stereotypes about the difficulty of mathematics have a significant influence on how feedback affect the students' self-regulation, motivation, and self-efficacy. When parents are actively engaged, their support and reinforcement of teachers' feedback significantly enhance students' self-regulation, motivation, self-efficacy, and academic achievement of students in mathematics.

Overall, the study indicated that teacher feedback plays a crucial role in facilitating students' learning and self-regulation in mathematics. Furthermore, in-person oral and written teacher feedback are mostly in use and help students directly in their mathematics work. However, most students prefer written feedback to remember their mistakes, to see

their progress on learning, and enlarge their knowledge simultaneously. Furthermore, the feedback is completely important on homework and tests to enhance students' ability and learning, to know their capacity, and to foster their creativity which the teacher needs to profile in order to use to invite students who appear to be having problems with mathematics to discuss the problems and potential solutions.

Recommendations

In considering the findings and conclusion of the study, a number of policy and practice-related recommendations have been made. Teachers who qualified many years ago are encouraged to undergo continuous professional development courses on the current trends in and types of feedback and assessment. Given that the current trends in education place greater focus on formative assessment, peer assessment, self-assessment, and self-regulated learning, the right type of feedback plays a crucial role in today's teaching and learning. At school level departments should continuously staff develop teachers and monitor whether effective feedback methods are being implemented to support learning.

The Ministry of Primary and Secondary Education should adopt a deliberate and purposeful continuous professional development programme that should focus on improving teachers' feedback and instructional strategies so that they are in tandem with the current demands and challenges of teaching mathematics. Equipping teachers with effective and efficient feedback strategies will create a learning environment which is meaningful and conducive to the learning of mathematics and development of self-regulation skills. Furthermore, teacher training institutions and universities should incorporate elements of teacher feedback into the curriculum for training teachers.

Teachers are encouraged to inquire about the different types of feedback (feed-up, feed-back, and feed-forward) and how they can be used to enhance the learning environment of the students. This should incorporate how a teacher interacts with students during instructional, as well as non-instructional time, to establish the effect that teacher feedback has on student mathematical learning and self-regulation. Furthermore, teachers are encouraged to implement a balanced approach in giving feedback. This calls for teachers to provide both positive and negative feedback to students, highlighting their strengths and areas for improvement. To achieve this district cluster approach should be revisited to ensure that there is always a cross-pollination of ideas among teachers teaching the same subject.

Student-teacher interaction should be encouraged so that they get adequate time for sharing ideas towards feedback and homework. Fostering a supportive environment ensures that feedback is delivered in a supportive and non-harsh manner which borders on constructive criticism and encouragement. Teachers are recommended to ask questions to students to know their response for any activities. This needs to be done explicitly and made part of the daily curriculum in addition to learning through homework.

To ensure the effectiveness of teacher feedback the teacher should be aware and sensitive to the individual needs of the students and must make portfolios of every student to know their level of understanding. Therefore, whenever possible, the teacher should prioritise giving in-person feedback, to facilitate meaningful interactions, address questions, and promote a deeper understanding of mathematical concepts. The involvement and collaboration with parents and community should be considered by teachers so that parents and the community are kept informed of the demands and expectations of mathematics as a subject. The mathematics teacher should develop real-life mathematics projects which will help develop interest among students as well as ensure that parents and community appreciate the importance of the subject in real life.

Suggestions for Future Research

In consideration of the review of literature and the research study, future research on the impact of teacher feedback on students' mathematical learning should provide a firm foundation on which the teacher can successfully base instruction-related decisions which can foster students' mathematical learning and self-regulation. The future research should take care of several methodological constraints identified with previous studies such as the duration of teacher feedback studies which extend over a reasonable length of time, and the effects of teacher feedback or types thereof, on student's mathematical learning, should be studied independently of other teacher behaviour variables. This should also apply to research on the effects of teacher feedback on self-regulation. This eliminates the potential confounding effects of other teacher behaviour variables with the teacher feedback variables

Further research on how teacher relationships with parents, perceptions, and attitudes about mathematics affect students' mathematical learning could also provide valuable information for the field of education. This case study highlighted the need to build relationship with parents so they could be seen as 'partners' in the feedback process. While it was not the focus of this study, however, there is enough scope to believe that this has potential for further study as a possible resource for the teacher, as well as the student, in the feedback process.

Further research should be conducted to identify possible ways to improve teacher feedback in the context of mathematics learning environment. The research should focus on the practice of providing feedback as this seemed to have a role in the feedback process during teaching and learning. To ensure a worthwhile investigation, the focus should be narrowed to the quality of feedback and exactly how often the feedback needs to occur during the course of the lesson in order to be effective.

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