Investigating Pre-service Teachers' Utilization of Written Feedback in Mathematics: A Basis for Designing Student-Centered Classrooms in Local Colleges and Universities

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Abstract

Written feedback plays a very important role in the teaching and learning process of pre-service teachers, because it allows students to reflect on their learning and clearly see their areas of improvement. Given this established importance of feedback in education, limited research has examined how pre-service teachers utilize feedback and its association with mindset orientation and feedback perception, particularly in the context of mathematics education. This convergent parallel mixed-methods study examined associations among pre-service teachers' mindset beliefs, perceptions of written feedback, and feedback utilization in mathematics at a local college in the Philippines. Quantitative data were gathered from an adapted mindset survey and pre-service teachers' resubmission behaviors and were analyzed with the chi-square test of independence; qualitative results from semi-structured interviews underwent thematic analysis, and findings were integrated with the quantitative findings through triangulation. Results indicated that growth mindset was associated with student-centered feedback perception (χ^2 = 6.18, p = .013) and with greater feedback utilization (χ^2 = 8.27, p = .004), while feedback perception and feedback utilization were not significantly associated (χ^2 = 0.49, p = .483). Qualitative themes showed how growth-oriented beliefs and student-centered feedback perception supported pre-service teachers' feedback utilization. The findings indicated that integrating feedback literacy training and growth-oriented written feedback practices, such as the Summarize, Explain, Redirect, Resubmit (SE2R) model, into teacher-education coursework may strengthen pre-service teachers' capacity to interpret feedback, act on it during revision, and apply student-centered feedback routines in mathematics classrooms.

Keywords: pre-service teachers, written feedback, mindset beliefs, student-centered learning, mathematics education, feedback utilization

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Introduction

Written feedback is an essential component of the teaching and learning process in mathematics education where students are expected to understand the concepts and solve problems. By highlighting their strengths and identifying their areas for improvement, effective written feedback fosters more profound engagement with math concepts (Brookhart, 2017). Additionally, the quality of feedback provided in higher education has a significant impact on the teaching practices of pre-service teachers during the early stages of their professional development. According to Kastberg et al. (2020), written feedback is not only structured very similarly to how students organize their work, but it also serves as a record that can be reviewed any time.

In mathematics education, pre-service teachers often experience difficulty in interpreting and engaging with written feedback provided by their mentors (Bishop, 1999). Evidence suggests that the culture, value systems, and conventions of different disciplines may influence both the nature of feedback and how students utilize it (Winstone et al., 2022). Empirical research remains limited on how pre-service mathematics teachers in the Philippines perceive written feedback and how they utilize it on their coursework. Even less is known whether pre-service teachers' mindset beliefs are associated with their perception and utilization of written feedback. This gap underscores the need for research that can guide the development of more effective, student-centered, and feedback-oriented mathematics classrooms in local colleges and universities.

Literature Review

Mindset Theory in Education

Mindset theory suggests that there are two different mindset orientations: a fixed mindset and a growth mindset. This was popularized by Dweck (2016) and suggests that mindset orientation significantly influences how a person interprets and engages with feedback received. In the context of teacher education, pre-service teachers who perceive feedback as learning opportunities or a guide to improve their instructions have growth mindset orientation (Cutumisu & Schwartz, 2018). On the contrary, those who perceive feedback as direct criticisms of their instructional abilities have fixed mindset orientation.

Having a growth mindset orientation alone does not guarantee an improvement in the instruction. Research also highlights that growth mindset becomes more effective when the environment is supportive of growth and improvement through providing clear and actionable feedback, strong support from the mentor, and institutional norms and culture that encourage continuous growth (Thurlings et al., 2015). According to Kroeper et al. (2022), for the professional growth among pre-service teachers to be sustainable, it is important to note that mindset development should be integrated with structured feedback and with supportive learning environments.

Written Feedback in Teacher Education

Written feedback plays an important role in pre-service teachers' journey in the teacher education program. Its effectiveness depends on its clarity, specificity, timeliness, and actionability. Written feedback can then guide pre-service teachers in learning their coursework, reflecting on their teaching practices, and using it to identify instructional gaps

and implement improvements on their pedagogy (Brookhart, 2017; Henderson et al., 2019; Shute, 2008).

Although written feedback is deemed important, there are several challenges to effectively engage with and utilize it, including feedback being unclear, too general or broad, or untimely, which limits its contribution to instructional improvement (Brookhart, 2017; Carless & Winstone, 2019; Shute, 2008). Mindset-related responses further influence feedback utilization. Fixed-mindset beliefs result in defensive reactions and may hinder utilization, while growth-mindset beliefs support reflection and instructional improvement (Claro et al., 2016; Kroeper et al., 2022).

Written feedback is particularly important in preparing pre-service teachers to implement student-centered teaching strategies. However, it is important to note that the feedback should focus on reflection, inquiry, and conceptual understanding to help in transitioning from traditional way of teaching to student-centered mathematics instruction (Gravemeijer & Cobb, 2006; Hiebert & Grouws, 2007). Moreover, its effectiveness will be strengthened when it is supplemented with on-going and continuous professional development, there is an institutional support, and it is aligned with an inquiry-based framework (Boaler et al., 2021; Sherin & van Es, 2009).

SE2R Feedback Model (Summarize, Explain, Redirect, Resubmit)

The SE2R feedback model (Summarize, Explain, Redirect, Resubmit) was made by Barnes in 2015. Barnes highlighted in his study that effective feedback should briefly explain what students already know and what their strengths and weaknesses are, direct them on how to improve their work, and encourage them to resubmit their work to improve learning and mastery of the learning standard. On the other hand, Shute (2008) noted that feedback specificity is very critical in reducing vagueness and promoting goal-directed student responses.

Carless and Boud (2018) highlighted that actionable feedback should be clear and are well-understood by the students. Moreover, Carless and Boud (2018) also noted that pre-service teachers can develop feedback literacy more effectively when they are exposed to well-structured feedback. This is supported by Cutumisu and Schwartz (2018) stating that structured feedback fosters professional growth and instructional reflection among educators.

Research shows that by using SE2R feedback model teachers can create and maintain a student-centered classroom where students are more motivated to learn and have a sense of ownership over their learning. This can be achieved by actively discussing the learning objectives with students and allowing them to monitor their own progress over time. This approach can significantly influence classroom diversity and foster student independence and self-reliance due to the well-crafted feedback structure.

Methodology

Research Design

This study utilized a mixed-methods research design, specifically the convergent parallel approach, to comprehensively investigate how pre-service teachers engaged with and utilized written feedback in mathematics and how it related to their mindset beliefs. This approach was

appropriate because it allowed the researcher to combine the strengths of both quantitative and qualitative methods. By integrating these approaches, the study achieved a deeper and more comprehensive understanding of the phenomenon, enhanced the interpretation of statistical findings, and provided a solid foundation for future research.

The quantitative aspect aimed to describe the following among pre-service teachers: demographic characteristics (age, gender, and year level), mindset beliefs (fixed or growth mindset), and perceptions on written feedback (teacher- or student-centered). A descriptive survey was administered using an adapted version of the Student Mindset Survey by Sun (2015), and teacher-created homework was assigned to examine how pre-service teachers responded to feedback and used it in improving their work. In addition to this, a statistical test of significance was conducted to determine whether a relationship existed among these variables. On the other hand, the qualitative aspect aimed to offer more profound insights into how pre-service teachers perceived the written feedback, including their experiences and challenges in engaging with written feedback, and how feedback motivates them to resubmit their work. Data were collected through semi-structured interviews via Google Meet.

This study also aimed to triangulate the results by examining both sets of data independently and then integrating them during interpretation. This enabled the researcher to have a better understanding of the statistical results and to come up with practical recommendations for how teacher education programs can implement student-centered math instruction by providing effective written feedback.

In the quantitative data analysis, the independent variable (IV) was the mindset belief of the students, categorized into two groups: growth mindset (coded as 1) and fixed mindset (coded as 0). The dependent variable (DV) was the utilization of written feedback, also categorized into two groups: utilized feedback for resubmission (coded as 1) and did not utilize feedback (coded as 0). The analysis aimed to determine whether a statistically significant relationship existed between pre-service teachers' mindset beliefs and their utilization of written feedback.

A descriptive survey was administered to identify the mindset beliefs of pre-service teachers, adapting the Student Mindset Survey by Sun (2015), and a teacher-created homework was assigned to analyze how pre-service teachers responded to feedback and used it to improve their work. A chi-square test of independence was conducted to examine the association between the mindset beliefs of pre-service teachers and their utilization of written feedback.

Participants and Sampling

The participants are 31 first- to third-year pre-service teachers from City College of San Fernando, Pampanga who satisfy the following inclusion criteria: (1) currently enrolled in a teacher education program at City College of San Fernando, Pampanga; (2) pursuing a Bachelor of Secondary Education major in Mathematics; and (3) enrolled in a mathematics class as part of their coursework. Fourth-year pre-service teachers were excluded due to their limited availability, for they are working on their practice teaching (student teaching).

Research Instruments

Three instruments were utilized: an adapted Student Mindset Survey (Sun, 2015), mathematics homework assignment in algebra, trigonometry, and calculus, and a semi-structured interview guide adapted from Carroll (2022). Written feedback on the homework assignments followed

the SE2R model, emphasizing formative feedback and voluntary resubmission prior to final grading.

Instrument Reliability and Validity

The instrument used in this study was adapted from existing validated questionnaires developed by previous researchers. While the original instrument demonstrated acceptable validity in prior studies, no additional validity testing was conducted in the present study. The adapted instrument was utilized based on the assumption that it retained its validity within the current research context. This limitation is acknowledged and is recommended to be addressed in future research.

The research instrument used in this study was adapted from existing validated tools. To ensure its internal consistency, Cronbach's alpha was computed using the responses gathered from the participants. Prior to the analysis, one negatively worded item was reverse-coded to align its scoring with the other items. The analysis yielded a Cronbach's alpha coefficient of 0.727 for the six items included in the instrument, indicating an acceptable level of internal consistency based on the criteria set by the researcher's institution (Cronbach's alpha > 0.70). This result suggests that the instrument was reliable for use in the present study.

Data Collection Procedure

Data collection followed institutional ethical guidelines and approval from the Research and Extension Services Office. After obtaining informed consent, the survey was administered, followed by the distribution of homework tasks with written feedback based on the SE2R model. Selected participants then engaged in one-on-one semi-structured interviews to further explore their engagement with written feedback.

Data Analysis

Quantitative data were analyzed using descriptive statistics and chi-square tests of independence at a significance level of $\alpha = .05$. Qualitative data were analyzed thematically following Braun and Clarke's (2006) framework. Findings from both data sets were triangulated during interpretation to provide an integrated understanding of how mindset beliefs and feedback perceptions relate to the utilization of written feedback in mathematics.

Results and Discussion

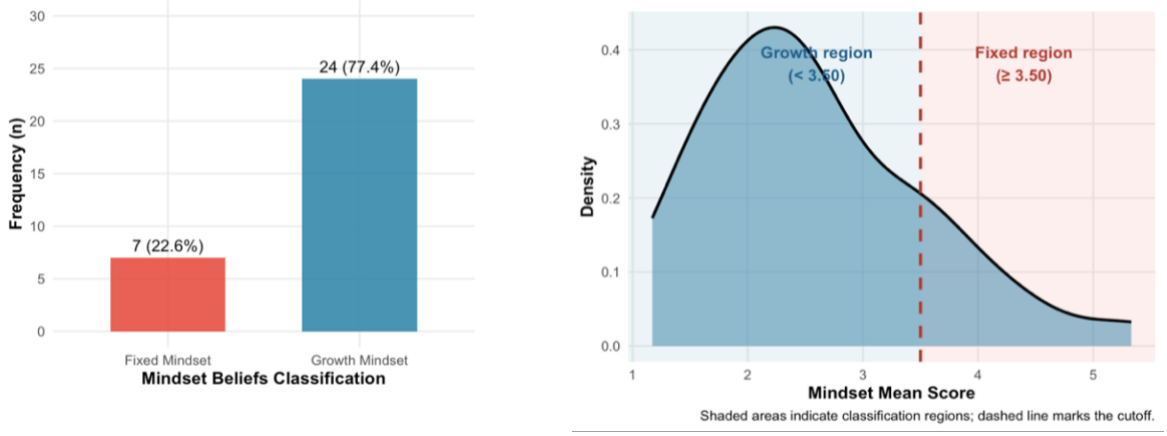
Quantitative data were analyzed using descriptive statistics such as frequency counts, percentages, and the Chi-Square Test of Independence. On the other hand, qualitative data from semi-structured interviews were thematically analyzed to recognize recurring patterns and themes.

Table 1
Demographic Profile of the Participants

Characteristics		Frequency (n)	Percentage (%)
Age (in years)	18	6	19.4
	19	6	19.4
	20	9	29.0
	21	3	9.7
	22	4	12.9
	23	2	6.5
	24	1	3.2
Gender	Female	19	61.3
	Male	12	38.7
Year Level	1st Year	19	61.3
	2nd Year	6	19.4
	3rd Year	6	19.4

Note. The table presents the age, gender, and year level distribution of the 31 pre-service teacher participants

Figure 1
Mindset Beliefs Classification and Distribution of Mindset Mean Scores (N = 31)



Note. Density Plot of Mindset Mean Scores
Cutoff for Growth Mindset is Mean Score < 3.5 (1–6 scale)

Figure 1 presented the corresponding mindset belief classifications of pre-service teachers based on the mean score of their responses to the Mindset Belief Survey. Participants were grouped into two categories: fixed mindset and growth mindset. These classifications were derived from their mean scores, where scores less than 3.5 indicated growth mindset beliefs and scores greater than 3.5 indicated fixed mindset beliefs.

Figure 2

Pre-service Teachers' Feedback Perception Within Each Mindset Classification

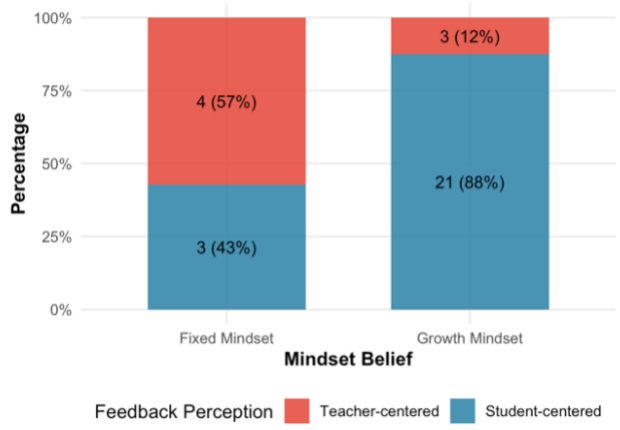


Figure 2 presented 31 pre-service teachers' feedback perception (student-centered or teacher-centered) based on their mindset beliefs (growth or fixed mindset). Most pre-service teachers with growth mindset beliefs had a student-centered written feedback perception. Conversely, those with fixed mindset beliefs were more likely to have a teacher-centered written feedback perception. Results suggested an association between mindset beliefs and written feedback perception. While this association is evident, a few cases still deviated, indicating that there might have been some other factors influencing how written feedback is perceived beyond mindset belief alone.

Table 2

Pre-service Teachers' Utilization of Written Feedback

Utilization of Written Feedback	n	%
Did Not Utilize Written Feedback	6	19.4
Utilized Written Feedback	25	80.6
	N = 31	100%

Note. This table shows the distribution of pre-service teachers based on their utilization of written feedback.

Figure 3

Utilization of Written Feedback by Mindset Belief

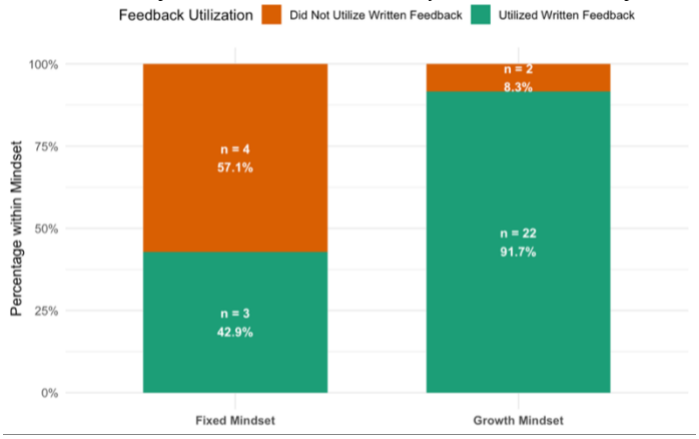


Figure 3 revealed a significant contrast in feedback utilization between pre-service teachers with fixed and growth mindsets. Among 24 pre-service teachers with a growth mindset (n = 24), 91.7% utilized written feedback, while only 8.3% did not. On the other hand, 57.1% of

pre-service teachers with a fixed mindset (n = 7) did not utilize written feedback, while only 42.9% of them did. These results suggest that pre-service teachers with a growth mindset were significantly more likely to engage with and utilize written feedback than those with a fixed mindset.

Table 3

Chi-Square Test of Independence Between Mindset Beliefs and Feedback Utilization

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	8.272[a]	1	.004		
Continuity Correction[b]	5.440	1	.020		
Likelihood Ratio	7.133	1	.008		
Fisher's Exact Test				.014	.014
N	31				

Note. a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 1.35.
b. Computed only for a 2x2 table

A Chi-Square Test of Independence was conducted to determine the association between pre-service teachers' mindset beliefs (fixed vs. growth mindset) and their utilization of written feedback. The test yielded a statistically significant result, $\chi^2(1, N = 31) = 8.272$, $p = .004$, indicating that feedback utilization was significantly associated with mindset orientation. Results conclude that the likelihood of engaging with and utilizing written feedback depended on the mindset beliefs of pre-service teachers (fixed or growth mindset).

Additionally, a Fisher's Exact Test was also performed to address the expected count assumption violation of the chi-square test—two cells had expected counts being less than 1.35. The results of the Fisher's Exact Test also revealed a statistically significant result, $p = .014$, therefore strengthening and supporting the initial chi-square results that mindset beliefs of pre-service teachers and their feedback utilization had significant association.

In conclusion, the results indicate a statistically significant association between pre-service teachers' mindset orientation and their written feedback utilization. Pre-service teachers with a growth mindset were more likely to engage with and utilize written feedback than those with a fixed mindset. This conclusion was supported by both the chi-square test of independence and Fisher's exact test, and this also underscored the importance of integrating mindset interventions in teacher education programs.

Figure 4

Pre-service Teachers' Mindset Beliefs and Their Feedback Perception

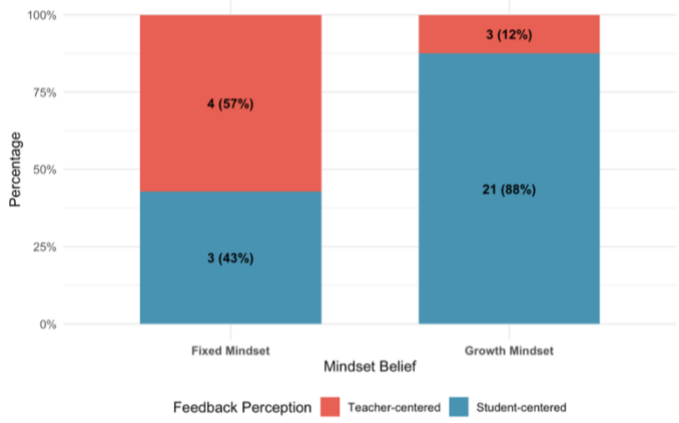


Table 4
Cross-Tabulation of Pre-service Teachers' Mindset Beliefs and Feedback Perception

			Student-Centered	Teacher-Centered	Total
Interpretation	Fixed Mindset	Count	3	4	7
		% within Interpretation	42.9%	57.1%	100.0%
		% within Feedback Perception	12.5%	57.1%	22.6%
	Growth Mindset	Count	21	3	24
		% within Interpretation	87.5%	12.5%	100.0%
		% within Feedback Perception	87.5%	42.9%	77.4%
Total		Count	24	7	31
		% within Interpretation	77.4%	22.6%	100.0%
		% within Feedback Perception	100.0%	100.0%	100.0%

Note. The table presents the cross-tabulation between pre-service teachers' mindset beliefs and their feedback perception.

Table 4 presents the cross-tabulation of pre-service teachers' mindset beliefs and their written feedback perception. Among 24 pre-service teachers with a growth mindset, 87.5% perceived the feedback as student-centered, while only 12.5% perceived it as teacher-centered. On the other hand, among seven pre-service teachers with a fixed mindset, 57.1% perceived written feedback as teacher-centered, while 42.9% perceived it as student-centered. Results suggest that there was an association between mindset beliefs and feedback perception.

It is also important to note that while SE2R feedback model (Summarize, Explain, Redirect, Resubmit) was utilized in this study—a framework that focuses on student-centered learning—it still cannot guarantee that all pre-service teachers will perceive the feedback as student-centered. This is evident among seven pre-service teachers who perceived the given written feedback as teacher-centered. These results suggest that even well-structured, student-centered feedback can still be misinterpreted due to some moderating factors such as student's prior experience or class/institution norms and culture.

Table 5
Chi-Square Test of Independence Between Mindset Beliefs and Feedback Perception

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	6.178[a]	1	.013		
Continuity Correction[b]	3.888	1	.049		
Likelihood Ratio	5.472	1	.019		
Fisher's Exact Test				.029	.029
N	31				

Note. a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 1.58.
b. Computed only for a 2x2 table

A Chi-Square Test of Independence was conducted to determine the association between pre-service teachers' mindset beliefs (fixed vs. growth mindset) and their feedback perception (teacher-centered or student-centered). The test yielded a statistically significant result, $\chi^2(1, N$

= 31) = 6.178, p = .013, indicating that feedback perception was significantly associated with mindset belief. Results concluded that the interpretation of written feedback (teacher-centered or student-centered) depended on the mindset beliefs of pre-service teachers (fixed or growth mindset).

However, since 25% of the cells had expected counts less than 5, the Fisher's Exact Test was also performed. The result still showed statistically significant association (p = .029), thereby confirming and strengthening the initial conclusion from the chi-square test that pre-service teachers' perception of written feedback was significantly associated with their mindset belief. In conclusion, the results show a significant association between mindset belief and feedback perception, however, even well-structured feedback may still be misinterpreted by students. This highlights the importance of promoting a growth mindset culture within teacher education programs to maximize the effectiveness of written feedback and to be able to create a more conducive student-centered classroom. When teacher education programs have a growth-mindset culture, students will believe that their abilities are not fixed, and they will perceive feedback as a constructive guidance and not a judgment of their abilities.

Figure 5

Pre-service Teachers' Feedback Utilization and Their Feedback Perception

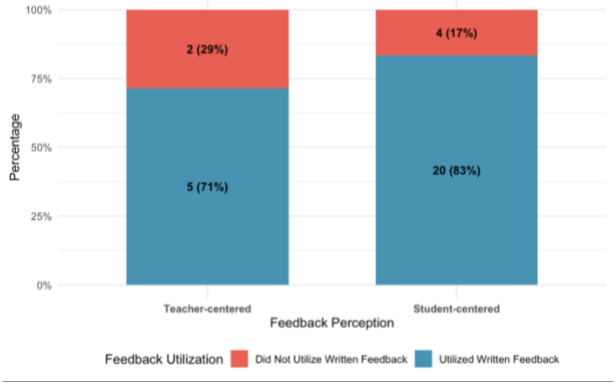


Table 6

Chi-Square Test of Independence Between Feedback Perception and Feedback Utilization

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.492[a]	1	.483		
Continuity Correction[b]	.025	1	.875		
Likelihood Ratio	.460	1	.498		
Fisher's Exact Test				.596	.413
N	31				

Note. a. 2 cells (25.0%) have expected count less than 5. The minimum expected count is 1.35.
b. Computed only for a 2x2 table

A Chi-Square Test of Independence was conducted to determine the association between pre-service teachers' feedback perception (teacher-centered or student-centered) and their feedback utilization. The test yielded no statistically significant association, $\chi^2(1, N = 31) = .492$, p = .483, indicating that there is not enough statistical evidence to conclude the existence of a meaningful association between the two variables. Results suggested that pre-service teachers' feedback perception does not necessarily determine whether they will utilize the received written feedback.

This means that other factors, such as feedback clarity, students' intrinsic motivation, and the amount of time given or allowed to react to and engage with feedback, may have a stronger influence on students' feedback utilization. Perceiving written feedback as student-centered may not always guarantee feedback utilization especially if students lack feedback literacy. Moreover, some pre-service teachers with a teacher-centered perception also utilized the feedback, confirming that feedback perception is not a predictor of feedback utilization.

In conclusion, while student-centered feedback perception is often associated with better learning outcomes, the results indicate that it is not a sufficient predictor of feedback utilization. Academic institutions should integrate feedback literacy training with complementary strategies that develops students' ability to reflect on their own learning and self-regulation learning. This approach could strengthen their ability to interpret and engage with constructive written feedback.

Thematic Analysis

Thematic analysis was performed to analyze qualitative data because it is a systematic way to identify and report recurring patterns or themes (Braun & Clarke, 2006). The analysis followed Braun and Clarke's six-phase framework: (1) familiarization with the data, (2) generation of initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, and (6) producing the report.

Table 7
Triangulation of Survey and Interview Data on Pre-service Teachers' Perceptions of Written Feedback

Participant	Mindset Orientation	Interview Theme	Triangulation Result	Remark
R002	Growth Mindset	Student-centered	Convergent	Strong match between survey and interview
R003	Fixed Mindset	Teacher-centered	Convergent	Strong match between survey and interview
R005	Fixed Mindset	Student-centered	Divergent	Interview suggests student-centered perception despite having a fixed mindset result in the survey.
R006	Growth Mindset	Teacher-centered	Divergent	Interview suggests teacher-centered perception despite having a growth mindset result in the survey.
R009	Fixed Mindset	Teacher-centered	Convergent	Strong match between survey and interview
R030	Growth Mindset	Student-centered	Convergent	Strong match between survey and interview

Note. This table presents the triangulated results between survey-based perceptions and interview-derived themes of six pre-service teachers regarding written feedback.

Table 7 presents the triangulation of survey responses and interview themes on pre-service teachers' perceptions of written feedback. The table highlights pre-service teachers' mindset

orientation, derived interview themes, triangulation result (convergent or divergent), and remarks. Only six of 31 pre-service teachers were selected for this triangulation procedure because they were identified as needing improvement on their classwork assignment, while the other 25 pre-service teachers did not need to improve their work.

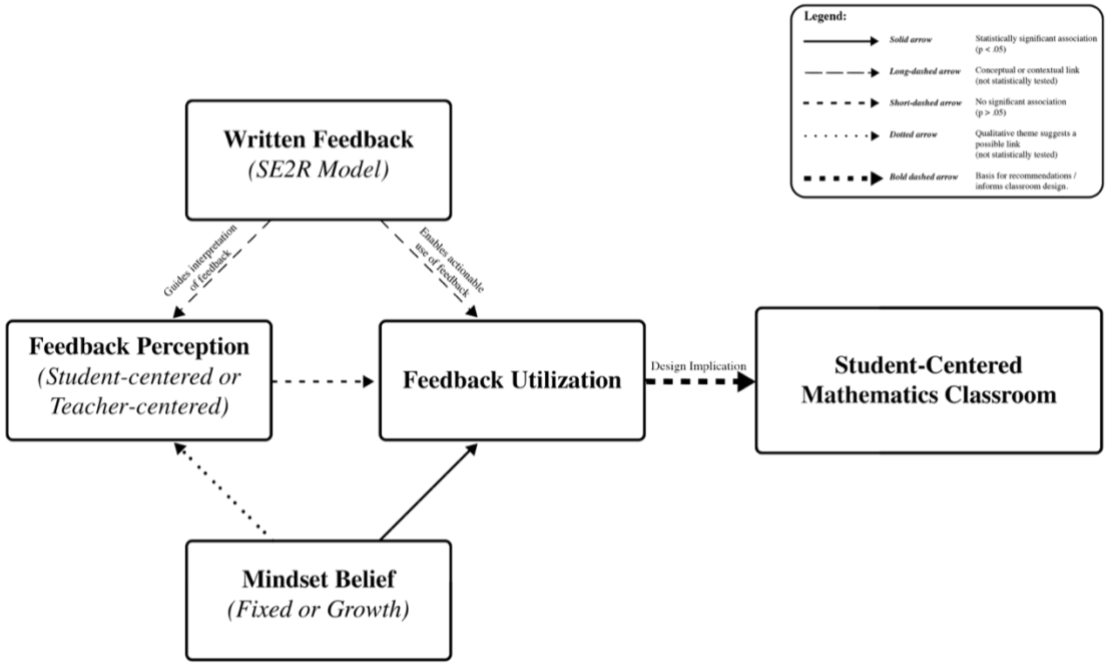
In summary, there were four convergent results and two divergent results. Convergent results indicate a strong match between pre-service teachers' survey-based mindset belief and derived interview themes, such that growth mindset corresponded with a student-centered feedback perception and a fixed mindset corresponded with a teacher-centered feedback perception. On the contrary, divergent results suggest otherwise, in which fixed mindset corresponded with a student-centered feedback perception and a growth mindset corresponded with a teacher-centered feedback perception.

In conclusion, the triangulation results revealed a more comprehensive understanding on how pre-service teachers made sense of the written feedback. Evidence showed that most cases translated as convergent, indicating that pre-service teachers' survey-based mindset orientation corresponded to their interview-derived theme. However, the emergence of few divergent results should not be overlooked. This suggests that survey-based mindset orientation does not always strongly match the interview-derived themes, and that other factors may influence how pre-service teachers interpret and engage with the received written feedback. Further and deeper qualitative analysis is recommended.

Final Conceptual Framework

Figure 6

Final Conceptual Framework Linking Written Feedback, Mindset Belief, Feedback Perception, Feedback Utilization, and the Design of a Student-Centered Mathematics Classroom



This conceptual framework shows written feedback, following the SE2R feedback model, as an instructional context that guides how pre-service teachers perceive and utilize written feedback. Moreover, mindset belief is modeled as a factor that is significantly associated with

feedback utilization ($p < .05$), which indicates that mindset is related to how pre-service teachers engage with and utilize written feedback. On the contrary, feedback perception and feedback utilization revealed no significant association ($p > .05$), which suggests that interpreting or perceiving feedback as student-centered does not translate into higher feedback utilization. However, it is recommended to further investigate other moderating factors that may have to non-significant association such as, but not limited to sample size limitations, self-efficacy of pre-service teachers, assessment culture and structure, and workload constraints. Qualitative theme further suggests a possible link between mindset belief and feedback perception. Overall, the framework reveals that feedback utilization functions as a pragmatic basis for designing and creating a student-centered mathematics classroom.

Conclusion

Empirical data and related literature reinforced the claims and conclusions about pre-service mathematics teachers' mindset beliefs, their perception and utilization of written feedback, and how these could inform the design of student-centered mathematics classrooms in local colleges and universities.

The study revealed that most pre-service teachers exhibited a growth mindset (77.4%), which is consistent with the claim of Claro et al. (2016). This implies that majority of the pre-service mathematics teachers were more likely to engage with feedback and perceive learning as a continuous process and that their math ability can improve overtime through consistent practice. However, a small percentage (22.6%) exhibited fixed mindset beliefs, which reveals perennial challenge for teacher education programs that aims to foster reflective thinking and adaptive future educators (Yeager & Dweck, 2020).

Although the study employed a structured student-centered feedback model (SE2R), not all pre-service mathematics teachers perceived it as student-centered. The feedback was mostly perceived as student-centered (77.4 %), which implies that pre-service teachers valued the feedback that gave them clearer steps for improvement and that was actionable. This reinforces the claim that employing a structured feedback model, such as the SE2R, can support more meaningful student learning outcomes.

The results of the study indicated a statistically significant association between pre-service mathematics teachers' mindset belief and their feedback utilization ($p < .05$). In mathematics context, this suggests that pre-service teachers with a growth mindset are more likely to compare the written feedback against their work or solution, reflect on the errors committed, and make the necessary revisions to improve the quality of their work. This is aligned with the findings of Cutumisu and Schwartz (2018) that students who exhibit growth mindset beliefs are more open to and are more likely to engage with and utilize feedback. In contrast, those with fixed mindsets may completely disregard the written feedback, take no further action such as clarifying misconceptions or revising the work, or interpret it as direct criticism of their mathematics ability. These findings strengthen the claim that even in a localized context, mindset beliefs significantly influenced how individuals engage with and utilize written feedback.

Additionally, the findings also revealed a statistically significant association between pre-service teachers' mindset beliefs and their perception of written feedback ($p < .05$). This means that those with growth mindset were more likely to perceive written feedback as actionable, constructive, timely, and specific, while those with fixed mindset were more likely to perceive

it as evaluative and corrective. Therefore, these observed significant associations reinforce the need to cultivate a growth mindset culture and an explicit feedback literacy in teacher preparation programs to strengthen student-centered feedback utilization and to inform the design of student-centered mathematics classroom.

Although pre-service teachers' mindset beliefs demonstrated significant associations between feedback perception and feedback utilization, further statistical analysis revealed that the association between feedback perception and feedback utilization is not significant. This implies that pre-service mathematics teachers' feedback perception—whether student-centered or teacher-centered— does not meaningfully influence whether they engage with and utilize written feedback they receive. Moreover, this also means that having a student-centered feedback perception alone does not always translate to feedback utilization. This highlights the need to address other moderating factors such as sample size limitations, self-efficacy of pre-service teachers, assessment culture and structure, and workload constraints.

Finally, the triangulation data revealed that most pre-service teachers' mindset beliefs (fixed or growth mindset) and their feedback perception (student-centered or teacher-centered) are convergent. However, some mismatches still occurred, which indicates that pre-service teachers' mindset belief alone does not determine how they perceive the given feedback. These inconsistencies must not be overlooked because they suggest that some other factors may have also influenced the change in perception. Some possible factors are student's prior experience or class/institution norms and culture, and feedback literacy. Therefore, integrating feedback literacy training, particularly using SE2R, with mindset development can help with the alignment of beliefs with practices, promote growth mindset culture and student-centered learning, and prepare future educators to interpret and engage with written feedback purposely and constructively.

In summary, the conclusions highlighted that there exist a significant association between pre-service teachers' mindset beliefs and feedback perception and utilization. The findings are aligned with existing literature and theoretical frameworks while also presenting context-specific recommendations that inform the development of student-centered mathematics classrooms in local colleges and universities.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

The author declares that ChatGPT and QuillBot, AI-assisted writing software, were used in proofreading and refining the language used in the manuscript. The usage was limited to correcting grammatical and spelling errors and rephrasing statements for accuracy and clarity. The author further declares that, apart from ChatGPT and QuillBot, no other AI or AI-assisted technologies have been used to generate content in writing the manuscript. The ideas, design, procedures, findings, analyses, and discussion are originally written and derived from careful and systematic conduct of the research.

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