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Examining Science Self-Efficacy in Basic Science Learning Among Generation Z Pre-Service Elementary School Teachers

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Abstract

Science self-efficacy plays an important role in shaping pre-service teachers' confidence, persistence, and ability to teach science effectively. This study aimed to examine the science self-efficacy of Generation Z pre-service elementary school teachers in Basic Science learning. A mixed-methods design was employed involving 122 students from the Elementary School Teacher Education Program (PGSD). Quantitative data were collected using an 18-item self-efficacy questionnaire based on the dimensions of magnitude, generality, and strength, while qualitative data were obtained through open-ended questions. The instrument was declared valid with Corrected Item-Total Correlation (CITC) values ranging from 0.468 to 0.781 and reliable with a Cronbach's Alpha coefficient of 0.760. Quantitative findings showed that students had a high level of self-efficacy, with an overall mean score of 4.07. The strength domain obtained the highest score, indicating strong persistence and resilience in learning science. Qualitative findings revealed that students experienced difficulties in understanding abstract concepts, calculation-based materials, and practicum reports. To overcome these challenges, students commonly used strategies such as reviewing materials, peer discussion, searching for additional resources, and utilizing digital platforms and AI tools. The findings suggest that cognitive, social, and affective factors collectively influence Gen-Z students' science self-efficacy.

Keywords: Self Efficacay, Gen-Z, Science Learning

INTRODUCTION

Self-efficacy has been widely recognized as a crucial psychological factor influencing students' academic success, particularly in science learning. Recent studies emphasize that self-efficacy reflects students' confidence in their ability to successfully perform academic tasks and overcome learning challenges (von Knebel et al., 2023). In contemporary educational research, self-efficacy is strongly associated with students' engagement, persistence, and learning outcomes, making it a key variable in understanding students' academic performance in science education (Frank et al., 2025; Jayanti & Wulandari, 2024; Nomin et al., 2025; von Knebel et al., 2023). Therefore, examining self-efficacy in science learning contexts remains highly relevant, especially in higher education.

In science education, the complexity and abstract nature of concepts often pose significant challenges for students. Topics such as energy, force, and waves require not only conceptual understanding but also analytical thinking skills. Recent research indicates that many students still struggle with these abstract scientific concepts, which in turn affects their confidence in learning (Natsir, 2025; Shrestha et al., 2023). Additionally, the interdisciplinary nature of science subjects further complicates learning for pre-service teachers, particularly those with limited prior exposure to science (von Knebel et al., 2023). These

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challenges highlight the importance of self-efficacy in supporting students' ability to navigate complex scientific content.

Several recent studies have identified key factors influencing students' self-efficacy in science learning. These include prior learning experiences, peer interaction, and instructional approaches that emphasize active and meaningful learning (Escobar et al., 2023; Ilyas et al., 2025). For instance, project-based learning and hands-on activities have been shown to significantly enhance students' confidence and motivation in science learning environments (Natsir, 2025; Nizaar et al., 2025). Furthermore, the integration of digital learning tools, including online resources and technology-enhanced environments, has been found to support self-regulated learning and indirectly strengthen students' self-efficacy (Kumar, 2025; Natsir, 2025; Natsir et al., 2022). These findings suggest that both pedagogical and technological factors play an important role in shaping students' beliefs about their abilities.

In addition, the characteristics of Generation Z students also need to be considered in understanding self-efficacy in science learning. As digital natives, Gen-Z learners are highly familiar with technology, instant access to information, and online learning environments. However, recent studies suggest that this generation is also more vulnerable to academic anxiety, low stress tolerance, overthinking, and self-doubt when facing challenging tasks (Aghata, 2024; Budiman et al., 2025; Tahir & Prabowo, 2026; Tanim-Ul-islam & Ashrafuzzaman, 2025). In higher education contexts, Gen-Z students tend to prefer interactive, flexible, and personalized learning experiences, while traditional instructional approaches may reduce their motivation and confidence (Natsir et al., 2022). These characteristics are particularly relevant in science learning, where students frequently encounter abstract concepts, complex calculations, and demanding practicum activities. Therefore, examining science self-efficacy among Generation Z pre-service elementary school teachers becomes increasingly important to understand how psychological, technological, and instructional factors interact in shaping their confidence and persistence in learning science.

Despite the growing body of research, many studies on self-efficacy in science education still rely heavily on quantitative approaches. While such methods provide valuable statistical insights, they often fail to capture students' lived experiences, learning struggles, and adaptive strategies in depth. Recent educational research highlights the need for more comprehensive approaches that combine quantitative and qualitative data to better understand students' learning processes and perceptions (Madrio & Escandallo, 2025).

More importantly, an unresolved paradox emerges in the context of Generation Z learners. Previous studies consistently describe Gen-Z students as being more vulnerable to academic anxiety, overthinking, low stress tolerance, and self-doubt when confronted with challenging learning situations (Aghata, 2024; Budiman et al., 2025; Tahir & Prabowo, 2026; Tanim-Ul-islam & Ashrafuzzaman, 2025). However, evidence from science education contexts increasingly indicates that these students may simultaneously demonstrate high levels of confidence in

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their academic abilities and learning performance. This apparent contradiction raises important questions regarding how students who are psychologically prone to anxiety can maintain strong self-beliefs in learning science. Existing studies have not sufficiently explored the underlying reasons behind this phenomenon, particularly among pre-service elementary school teachers.

Therefore, relying solely on quantitative measures of self-efficacy may be insufficient to explain this anomaly. A mixed methods approach is needed not only to determine the level of students' self-efficacy but also to uncover the experiences, contextual factors, and coping strategies that may explain why high self-efficacy coexists with anxiety-related characteristics among Generation Z learners. Based on this gap, the present study aims to analyze the self-efficacy of pre-service elementary school teachers (PGSD students) in learning Basic Science Concepts using a mixed methods approach. This study integrates quantitative data to measure students' self-efficacy levels and qualitative data to explore their learning experiences, challenges, and coping strategies. By doing so, this research is expected to provide a more comprehensive understanding of students' self-efficacy and contribute to the development of more effective instructional strategies in science education.

RESEARCH METHODS

This study employed a mixed methods approach using a convergent parallel design, in which quantitative and qualitative data were collected simultaneously and analyzed separately before being integrated during the interpretation stage. This design was selected to obtain a comprehensive understanding of students' self-efficacy in learning Basic Science Concepts by combining numerical trends with students' personal experiences and perceptions. The population consisted of all students of the Primary School Teacher Education Program (PGSD) at Universitas Negeri Makassar, with the sample selected using purposive sampling, involving students who had taken the Basic Science Concepts course. A total of 122 students participated in the study.

The research subjects were students who had direct experience in learning science concepts. The instruments used included a self-efficacy questionnaire based on a five-point Likert scale covering three dimensions (magnitude, generality, and strength) adapted from Bandura (1977), as well as two open-ended questions designed to explore students' learning difficulties, learning strategies, and perceptions of their abilities. Data were collected simultaneously through a Google Forms questionnaire containing both closed-ended and open-ended items. Quantitative data were analyzed using descriptive statistics to determine mean scores for overall self-efficacy and each dimension, while qualitative responses were analyzed thematically to provide deeper explanations of the quantitative findings. The results from both datasets were then integrated during interpretation to identify convergences and complementarities between the quantitative and qualitative findings (Auliya et al., 2020; Gideon et al., 2023).

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Table 1. Indicators of Self-Efficacy Instrument

Indicator	Dimension	Sub - Indicators
Confidence in completing responsibilities	Magnitude	Confidence in completing science tasks from simple to complex levels (assignments & practicum)
	Generality	Confidence in completing various types of science tasks (individual, group, practicum, theory)
	Strength	Persistence in completing science tasks despite difficulties
Confidence in mastering concepts or situations	Magnitude	Confidence in understanding science concepts from simple to complex
	Generality	Ability to understand science concepts in various situations and forms of questions
	Strength	Consistency and perseverance in understanding science concepts when facing difficulties
Confidence in achieving expected outcomes	Magnitude	Confidence in achieving learning outcomes at various levels of evaluation difficulty
	Generality	Confidence in obtaining good results across various forms of science assessment
	Strength	Strength of belief in achieving good results despite facing obstacles

The instruments used included a self-efficacy questionnaire based on a Likert scale (1–5) covering three dimensions (magnitude, generality, and strength) adapted from Bandura (1977), as well as two open-ended questions to explore students' learning difficulties, strategies, and perceptions of their abilities. Data were collected through online questionnaires using Google Forms and open-ended responses from students. Quantitative data were analyzed using descriptive statistics to determine mean scores for overall self-efficacy and each dimension.

Moreover, the qualitative data were analyzed using an interactive model, which consists of three main stages: data reduction, data display, and conclusion drawing/verification. In the data reduction stage, all student responses were first transcribed and organized. The researcher then conducted initial coding by identifying meaningful units related to students' experiences, difficulties, strategies, and perceptions of self-efficacy in science learning. Similar responses were grouped into categories, and irrelevant or repetitive data were eliminated. This process aimed to simplify the data while maintaining essential information.

Further, the reduced data were organized into thematic categories and presented in the form of tables. These included categories such as learning difficulties, learning strategies, and factors influencing self-efficacy. Each theme was supported by frequency counts to indicate the dominance of responses. This step allowed for clearer interpretation and facilitated comparison across themes.

In the conclusion drawing and verification stage, patterns and relationships among themes were

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identified and interpreted. The researcher examined how the qualitative findings supported the quantitative results, particularly in explaining variations in students' self-efficacy across domains. To ensure validity, the conclusions were continuously reviewed by re-checking the data and ensuring consistency across responses. This process strengthened the credibility of the findings.

RESULTS AND DISCUSSION

Result

Instrument Validity and Reliability Test

The validity and reliability of the instrument were examined prior to the main data analysis. The validity test using the Corrected Item-Total Correlation (CITC) across 18 items showed values ranging from 0.468 to 0.781. All items exceeded the minimum threshold of 0.30. Therefore, all items were declared valid and suitable for measuring students' self efficacy. This indicates that the instrument meets the required validity criteria. In line with that, reliability test using Cronbach's Alpha also shows a coefficient of 0,760 which it exceeds the acceptable threshold of 0.70. Therefore, the instrument is categorized as reliable and has good internal consistency.

Overall Self-Efficacy of Gen-Z Pre-Service Teachers

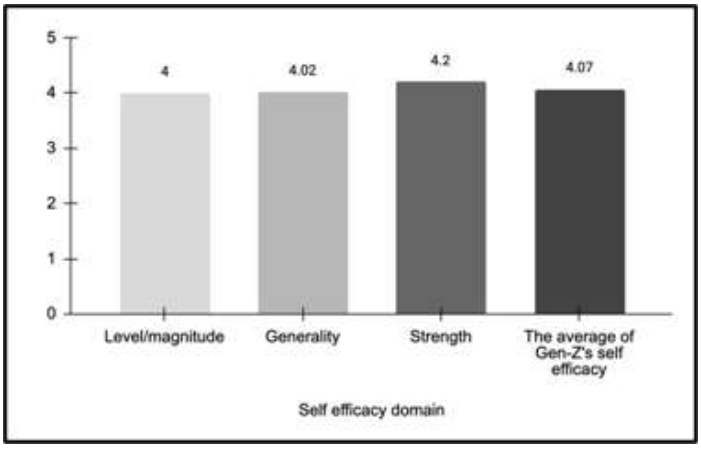

Figure 1. Gen – Z's Self Efficacy Score

Figure 1 presents the mean self-efficacy scores of Gen-Z pre-service elementary school teachers across the three dimensions of self-efficacy, namely Magnitude, Generality, and Strength. The results indicate that the overall mean self-efficacy score was 4.07 on a five-point Likert scale, reflecting generally positive responses across all dimensions. Among the three dimensions, Strength obtained the highest mean score (M = 4.20), followed by Generality (M = 4.02) and Magnitude (M = 4.00).

The mean scores were calculated using a weighted Likert-scale scoring system in which Strongly Agree (SA) = 5, Agree (A) = 4, Undecided (U) = 3, Disagree (D) = 2, and Strongly Disagree (SD) = 1. Therefore, higher proportions of Agree and Strongly Agree responses contributed directly to higher domain mean scores. As shown in Table 2, the indicators within the Strength dimension

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were dominated by positive responses, particularly on items related to persistence in completing learning tasks and carrying out academic responsibilities. For example, the indicator concerning responsibility in practicum and theoretical activities received 45.08% Strongly Agree responses and 48.36% Agree responses, while the indicator related to completing various science learning tasks received 37.70% Strongly Agree responses and 53.28% Agree responses. These response distributions contributed to the highest mean score observed in the Strength dimension.

Similarly, the Generality dimension achieved a mean score of 4.02, supported by a high proportion of Agree responses across indicators related to understanding science concepts in various learning contexts. The Magnitude dimension obtained a mean score of 4.00, with most students reporting confidence in completing science-related tasks of varying difficulty levels. Overall, the distribution of responses across all indicators demonstrates that positive responses (Agree and Strongly Agree) were substantially more frequent than neutral or negative responses, resulting in relatively high mean scores across all self-efficacy dimensions.

Distribution of Self-Efficacy Responses Across Indicators

Table 2 illustrates the distribution of students' responses across the three self-efficacy dimensions: Magnitude, Generality, and Strength. Overall, the response patterns were dominated by positive responses (Agree and Strongly Agree), while only a small proportion of students selected Disagree and Strongly Disagree categories.

Within the Magnitude dimension, students demonstrated confidence in completing science-related tasks with varying levels of difficulty. The highest positive responses were observed in the indicator related to completing practicum reports, with 46.72% of students selecting Strongly Agree and 42.62% selecting Agree. Similarly, 66.39% of students agreed that they were able to understand Basic Science concepts ranging from simple to complex levels. Across all Magnitude indicators, negative responses remained below 3%, indicating that most students perceived themselves as capable of handling academic challenges in science learning.

For the Generality dimension, positive responses were also dominant across indicators. The indicator related to completing various types of tasks in Basic Science courses recorded 37.70% Strongly Agree and 53.28% Agree responses. Likewise, the indicator concerning responsibilities in practicum and theoretical activities showed 45.08% Strongly Agree and 48.36% Agree responses. These findings indicate that students perceived their competencies as transferable across different learning situations and academic tasks.

Table 2. The Percentage Gen-Z's Self Efficacy

Self Efficacy Domain	Indicators	SA (%)	A (%)	U (%)	D (%)	SD (%)
Magnitude	Completing Basic Science tasks with varying levels of difficulty (low to high).	25.41	49.18	22.95	2.46	0.00

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	Completing practicum reports, including tasks requiring complex analysis.	46.72	42.62	10.66	0.00	0.00
	Understanding Basic Science concepts ranging from simple to complex levels.	16.39	66.39	17.21	0.00	0.00
	Able to explain difficult science concepts using one's own understanding.	9.84	44.26	44.26	1.64	0.00
	Confidence in achieving good academic performance across tasks and exams of varying difficulty.	29.51	45.08	25.41	0.00	0.00
	Able to achieve targeted academic performance in Basic Science courses.	27.05	49.18	22.95	0.82	0.00
Generality	Able to complete various types of tasks (individual and group) in Basic Science courses.	37.70	53.28	8.20	0.82	0.00
	Able to carry out responsibilities effectively in both practicum and theoretical activities.	45.08	48.36	6.56	0.00	0.00
	Understand science concepts across different learning contexts (discussion, practicum, digital learning).	15.57	59.84	23.77	0.82	0.00
	Able to master science concepts presented in various forms or contexts.	9.02	44.26	44.26	2.46	0.00
	Confidence in obtaining good results across different forms of assessment (exams, assignments, practicum).	27.05	51.64	20.49	0.82	0.00
	Confidence in achieving good learning outcomes across various science topics.	21.31	51.64	26.23	0.82	0.00
Strength	Persistence in completing Basic Science tasks despite experiencing difficulties.	61.48	34.43	2.46	1.64	0.00
	Resilience in facing challenges and not easily giving up when completing academic responsibilities.	49.18	40.98	7.38	1.64	0.82
	Confidence in understanding science concepts despite learning difficulties.	30.33	43.44	25.41	0.82	0.00
	Persistence in learning until fully understanding science material.	30.33	58.20	10.66	0.82	0.00
	Confidence in achieving good results despite encountering learning obstacles.	30.33	50.00	18.85	0.82	0.00
	Strong belief in one's ability to achieve expected academic outcomes in science learning.	24.59	47.54	26.23	0.82	0.82

The most prominent pattern was observed in the Strength dimension, which achieved the highest mean score in Figure 1 (M = 4.20). This result corresponds to the high proportion of positive responses across all Strength indicators. For example, the indicator measuring persistence in completing learning tasks despite challenges received 45.08% Strongly Agree and

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43.44% Agree responses. Similarly, the resilience indicator showed 49.18% Strongly Agree and 40.98% Agree responses, while the indicator related to confidence in understanding difficult science concepts received 30.33% Strongly Agree and 43.44% Agree responses. Because the majority of responses were concentrated in the Agree and Strongly Agree categories, the weighted mean score of the Strength dimension was higher than those of the Magnitude and Generality dimensions.

These response distributions demonstrate that positive perceptions were consistently reported across all self-efficacy dimensions, contributing to the overall self-efficacy mean score of 4.07 among Gen-Z pre-service elementary school teachers.

Qualitative Findings of Gen-Z's Learning Experience

The qualitative findings revealed several themes related to students' learning experiences in Basic Science Concepts courses, including learning difficulties, adaptive learning strategies, social support, and emotional challenges.

The first theme concerned learning difficulties. Students reported challenges in understanding abstract science concepts, particularly topics related to energy, force, and waves. In addition, several students indicated difficulties in solving calculation-based problems that required mathematical reasoning and conceptual understanding. Difficulties were also reported in completing practicum reports and understanding scientific terminology used in science learning materials.

The second theme was adaptive learning strategies. To overcome learning difficulties, students reported reviewing course materials repeatedly, searching for additional learning resources, and participating in discussions with classmates. Many students also utilized digital learning resources, including online videos, educational websites, and AI-based platforms, to obtain explanations and examples related to science concepts.

The third theme involved social support during the learning process. Students frequently mentioned discussing difficult topics with peers, exchanging ideas, and seeking clarification from classmates when encountering learning obstacles. Peer interaction was identified as one of the common approaches used to improve understanding of science concepts.

The fourth theme related to emotional experiences during learning. Some students reported feelings of anxiety, confusion, and lack of confidence when dealing with difficult concepts or assessment tasks. Nevertheless, many students stated that they continued trying to complete learning activities despite experiencing such challenges.

Overall, the qualitative findings indicate that Gen-Z students encounter various cognitive, social, and emotional challenges in learning science. At the same time, they employ multiple strategies, including the use of digital technologies, peer collaboration, and independent learning efforts, to support their learning process.

Discussion

Self-Efficacy Profile of Gen-Z Pre-Service Teachers in Science Learning

The findings indicate that Gen-Z pre-service elementary school teachers demonstrated a high level of self-efficacy in learning Basic Science Concepts, with an overall mean score of 4.07. Among the

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three dimensions, Strength obtained the highest mean score (4.20), followed by Generality (4.02) and Magnitude (4.00). These findings suggest that students generally possess strong confidence in their ability to persist when facing learning challenges. This result is consistent with previous studies emphasizing that self-efficacy plays a crucial role in students' engagement, persistence, and academic achievement (Frank et al., 2025; Jayanti & Wulandari, 2024; Nomin et al., 2025; von Knebel et al., 2023). High self-efficacy enables students to perceive academic challenges as manageable rather than threatening, thereby encouraging greater effort and perseverance in learning activities.

The relatively high scores across all dimensions may also be associated with students' prior learning experiences and exposure to technology-enhanced learning environments. Previous studies have shown that meaningful learning experiences, active participation, and technology-supported instruction contribute positively to the development of self-efficacy (Escobar et al., 2023; Kumar, 2025; Natsir, 2025; Natsir et al., 2022). Therefore, the positive self-efficacy profile observed in this study may reflect the interaction between students' personal beliefs and the learning environments in which they engage.

The Anxiety–Self-Efficacy Paradox Among Generation Z Learners

One of the most interesting findings of this study is the apparent contradiction between the psychological characteristics commonly associated with Generation Z and the high level of self-efficacy reported by participants. Previous literature characterizes Gen-Z learners as being more vulnerable to academic anxiety, overthinking, low stress tolerance, and self-doubt when confronted with demanding academic tasks (Aghata, 2024; Budiman et al., 2025; Tahir & Prabowo, 2026; Tanim-Ul-islam & Ashrafuzzaman, 2025). However, despite these tendencies, participants in the present study reported high confidence in their ability to learn science concepts and complete academic tasks successfully.

This finding suggests that anxiety and self-efficacy may not necessarily function as opposing constructs in contemporary learning environments. Although students acknowledged experiencing confusion, anxiety, and lack of confidence when dealing with abstract concepts and calculation-based problems, many of them continued to engage actively in learning activities. Their persistence indicates that the presence of anxiety does not automatically reduce self-efficacy. Instead, students may develop adaptive mechanisms that enable them to manage learning difficulties while maintaining positive beliefs about their capabilities. This finding expands current understanding of self-efficacy among Gen-Z learners by demonstrating that psychological vulnerability can coexist with strong academic confidence.

Digital Technology, AI Tools, and the Strength Dimension of Self-Efficacy

The qualitative findings revealed that students frequently utilized digital resources such as online learning materials, educational videos, and AI-based platforms when encountering difficulties in science learning. This finding provides an important explanation for the high score observed in the Strength dimension. According to Bandura's framework, the Strength

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dimension reflects persistence, resilience, and the ability to maintain effort when facing obstacles. Students in this study rarely reported abandoning difficult tasks. Instead, they actively searched for alternative explanations, additional examples, and learning support through digital technologies.

A possible interpretation is that digital technology functions as a cognitive and emotional safety net for Gen-Z learners. The availability of online resources and AI-assisted learning tools may reduce feelings of helplessness because students perceive that assistance is always accessible whenever difficulties arise. Rather than viewing challenges as barriers, students may perceive them as problems that can be solved through available technological support. This perception strengthens their sense of control over the learning process and increases their willingness to persist when encountering obstacles.

This interpretation is supported by previous studies demonstrating that digital learning technologies facilitate self-regulated learning and strengthen students' confidence in their academic abilities (Kumar, 2025; Natsir, 2025). Consequently, technology contributes not only to cognitive learning outcomes but also to affective dimensions of learning, particularly persistence and resilience. The present findings suggest that the high Strength score among Gen-Z students may be partially explained by their confidence in accessing technological resources whenever learning difficulties occur.

Social Support and Learning Confidence

Another important finding concerns the role of peer interaction in supporting students' self-efficacy. Participants frequently reported discussing difficult concepts with classmates, exchanging ideas, and seeking clarification from peers. These findings align with previous studies identifying social support as an important contributor to self-efficacy development (Santos et al., 2025). Through collaborative interactions, students gain opportunities to validate their understanding, receive feedback, and reduce uncertainty regarding difficult concepts.

Peer discussions may be particularly important in science learning because many concepts require conceptual reasoning and multiple perspectives. Collaborative learning environments therefore provide not only academic assistance but also emotional support, which can enhance students' confidence in their abilities. This finding reinforces the importance of creating interactive and supportive learning environments for pre-service teachers.

Implications for Science Education

The findings indicate that self-efficacy in science learning is influenced by the interaction of cognitive, social, technological, and emotional factors. While students continue to experience difficulties in understanding abstract concepts such as energy, force, and waves, they employ various adaptive strategies to overcome these challenges. The combination of digital learning resources, AI-assisted tools, peer support, and self-directed learning appears to strengthen students' confidence and persistence in learning science.

These findings suggest that science instruction in higher education should move beyond content delivery and provide opportunities for

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technology-enhanced learning, collaborative learning, and emotional support. Such learning environments may help students maintain confidence while navigating the conceptual complexity of science subjects. More importantly, the study highlights that technological support may play a significant role in explaining why Gen-Z learners can simultaneously experience anxiety-related tendencies and maintain high levels of self-efficacy in science learning.

CONCLUSION

This study found that Gen-Z pre-service elementary school teachers demonstrated a high level of self-efficacy in learning Basic Science Concepts, with the Strength dimension showing the highest score. Despite experiencing difficulties in understanding abstract science concepts and solving calculation-based problems, students employed various adaptive strategies, including peer collaboration, independent learning, and the use of digital resources and AI-based tools. An important finding is the paradox that, although Generation Z is often associated with anxiety, overthinking, and self-doubt, the participants maintained high levels of confidence and persistence in science learning. This suggests that self-efficacy is shaped not only by cognitive abilities but also by students' capacity to access support systems and utilize available learning resources.

Several limitations should be acknowledged. The qualitative data were collected only through open-ended questions in Google Forms, which may not fully capture the depth of students' experiences and perceptions. In addition, the participants were limited to students from a single study program at Universitas Negeri Makassar, which may restrict the generalizability of the findings. Future studies are recommended to involve participants from multiple institutions and employ in-depth qualitative methods, such as interviews or focus group discussions, to obtain a more comprehensive understanding of self-efficacy among Generation Z learners.

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