The Pedagogical Competence of Pre-Service PPG Students in Peer Teaching Using the Science, Technology, Engineering, and Mathematics (STEM) Approach is Commendable

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Abstract: The insufficient competence of teachers, resulting in qualifications below standards is one of the current issues within the Indonesian education system. The government has initiated the Pre-Service Teacher Professional Education (PPG) program for education and non-education graduates to fully master teaching competencies. In this context, pedagogical competence refers to the ability to teach and manage classrooms effectively. Therefore, this study aimed to examine the pedagogical competence of Pre-Service PPG students in peer teaching using the Science, Technology, Engineering, and Mathematics (STEM) approach. The instructional materials cover mathematics topics related to spatial structures, scientific concepts regarding earthquakes, technological applications through multimedia resources, and engineering principles in the design of earthquake-resistant structures. Meanwhile, these teaching materials are structured based on the foundational principles of computational thinking. A qualitative descriptive approach is adopted with data collection methods including instructional videos, video transcripts, and observation sheets, as well as subsequent analysis using Atlas.ti. Specifically, this study analyzes 10 instructional videos featuring 10 Pre-Service PPG students majoring in Primary School Teacher Education (PGSD) at Pasundan University, Bandung. The results show that Pre-Service PPG students have good mastery of pedagogical competence, including (1) the ability to start lessons by capturing attention, fostering motivation, providing guidance, and linking old and new materials, (2) engaging in learning activities by using suitable strategies for the subject matter, explaining with relevant examples, being enthusiastic about feedback, and efficiently using time, and (3) wrapping up lessons by reviewing, evaluating, and informing about the next materials.

Keywords: Pedagogical, PPG, Peer Teaching, STEM.

1. Introduction

Pre-Service Teacher Professional Education (PPG) program is designed to cultivate a new generation of Indonesian teachers characterized by a profound dedication to teaching, unwavering professionalism, a commitment to exemplify role models, genuine passion for the vocation, and an enduring dedication to lifelong learning. Pre-Service PPG program is available to graduates of bachelor's or applied bachelor's degrees as well as Diploma IV, regardless of academic background in education or non-education disciplines, to attain a teaching certification (Rinto Alexandro, Misnawati, and Wahidin, 2021). These efforts are conducted by the government to enhance the quality of teachers, focusing on mastering four competencies, namely pedagogical, personality, social, and professional. Pedagogical competence is the ability to manage student learning, while personality competence includes having a strong, virtuous, wise, and authoritative character to serve as a role model for students. Social competence comprises effective communication and interaction with students, fellow teachers, parents, and the surrounding community. Additionally, professional competence relates to the extensive and in-depth mastery of the subject matter (Sholikhudin and Qomariyah, 2016). In the context of pedagogical competence, the average ability of teachers to manage classrooms remains below standard (Mulyati, 2022).

Observations within the educational landscape show a trend among teachers to rely on conventional and monotonous methods, often neglecting to integrate creative and captivating teaching methods to stimulate students' interest and enthusiasm for learning within the classroom (Jumriani et al., 2021). Similarly, the proper sequence of learning activities is often neglected, starting from the introduction, core, and conclusion. A tendency among teachers is the focus on content delivery at the expense of prioritizing the attainment of learning objectives (Hoesny and Darmayanti, 2021). However, an actionable solution is the adoption of the Science, Technology, Engineering, and Mathematics (STEM) approach in classroom instruction.

STEM learning is an instructional method that integrates science, technology, engineering, and mathematics, focusing on problem-solving processes in everyday life. In this context, the use of concepts and principles in mathematics, science, technology, and engineering is integrated to develop beneficial products in real-life situations. The four components are interconnected to create an active, innovative, and applicable learning environment.

Therefore, the approach is centered around students and ignites enthusiasm for learning. STEM learning was initially launched by the National Science Foundation of the United States as an educational reform movement to enhance human resources, motivate, as well as increase competitiveness in scientific and technological innovation (Hanover, 2011). The pattern of integrating the components consists of using silo (separate), embedded, and integration approaches (Roberts and Cantu, 2012). The embedded approach includes imparting knowledge through real-world problems with mathematics as the main subject and embedded materials in science, engineering, and technology. (Winarni, Zubaidah and Koes, 2016). In addition, Pre-Service PPG is offered in Primary School Teacher Education (PGSD) to prepare professional teachers for elementary schools, which serves as the first formal educational institution (Kenedi et al., 2019). Elementary school is the initial platform for instilling knowledge, concepts, and values regarding the environment and life (Maryono, 2017). As facilitators in the learning process, teachers play a crucial role in developing learning methods to achieve maximum objectives.

Pre-Service PPG students engage in teaching practice through peer teaching before advancing to elementary school teachers. In peer teaching, a student takes on the role of the teacher while the others act as the learners. This method of teaching is expected to facilitate students in advancing to become teachers with good pedagogical competence. Therefore, this study aimed to examine the pedagogical competence of students majoring in PGSD using STEM learning. The application of pedagogical competence in classroom teaching is also analyzed with the development of mathematics content learning, as well as the improvement of students' interest and motivation in science, engineering, and technology.

2. Method

2.1. Study Design

The adopted study method is qualitative with descriptive techniques. In this study, there are 10 peer teaching videos involving 10 groups of students majoring in Elementary School Teacher Education (PGSD) at Pasundan University, Bandung. Each group consists of 4-5 individuals. The sample was selected using a purposive sampling technique from final semester students.

This research aims to explore and understand the various dynamics and teaching processes carried out by PGSD students. Through a qualitative approach, the researchers can deeply observe how students develop and apply their teaching strategies. The analyzed teaching videos provide insights into teaching skills, interactions with students, and the application of educational theories in practice.

Moreover, the purposive sampling technique was chosen because it allows the researchers to focus on groups of students with more experience and understanding of teaching. Therefore, the research results are expected to provide a comprehensive overview of the effectiveness of the teaching methods implemented by PGSD students at Pasundan University. Through descriptive analysis, the researchers can provide a detailed depiction of the observed phenomena and offer recommendations for improving teaching quality in the future.

2.2. Data Collection Procedures

Data collection was carried out through instructional videos. The learning carried out by each group in peer teaching is based on the design of learning tools that have been prepared previously and practiced in class. These learning practices are documented in video form.

The instructional videos serve as the primary data source for this research, providing a visual and auditory record of the teaching sessions. Each group developed a detailed lesson plan that included objectives, teaching strategies, and assessment methods. These lesson plans were then implemented in a classroom setting, allowing for a practical demonstration of the theoretical concepts learned during their studies.

By documenting these sessions, the researchers were able to capture not only the content and structure of the lessons but also the interactions between the student-teachers and their peers. This documentation process ensured that every aspect of the teaching practice, from the delivery of content to the management of the classroom environment, was meticulously recorded.

The videos were then analyzed to assess the effectiveness of the teaching methods, the engagement of the students, and the overall execution of the lesson plans. This analysis provided valuable insights into the strengths and weaknesses of the teaching strategies employed by the student-teachers. Additionally, the videos allowed for a comprehensive review and feedback process, where student-teachers could reflect on their performance and identify areas for improvement.

Overall, the use of instructional videos in this study provided a rich, detailed dataset that enabled an in-depth examination of peer teaching practices. This approach not only facilitated the evaluation of individual teaching performances but also contributed to the broader understanding of effective teaching methodologies in the context of elementary education.

2.3. Data Analysis

Learning video recordings are collected and transcribed into three activity sections: preliminary activities, core activities, and closing activities. Each section of activity is analyzed based on the learning implementation plan. Next, coding was carried out using ATLAS.ti version 24. The codes were categorized into themes that were developed a priori based on the similarity of activities in each peer teaching group.

The transcription process involves converting the spoken content of the video recordings into written form, ensuring that every detail of the teaching sessions is accurately captured. This detailed transcription allows for a thorough examination of the different phases of the lesson, providing a clear structure for analysis.

Preliminary activities typically include the initial interactions between the student-teachers and their peers, the introduction of the lesson topic, and the setting of learning objectives. Core activities encompass the main instructional content, including teaching strategies, student engagement, and the delivery of educational materials. Closing activities involve summarizing the lesson, assessing student understanding, and providing feedback.

After transcription, the data is systematically coded using ATLAS.ti, a qualitative data analysis software. Coding involves assigning labels to specific segments of the text, which helps in identifying patterns and themes within the data. The initial set of codes is developed a priori, based on the expected activities and behaviors observed in the peer teaching sessions.

Overall, the process of transcribing, coding, and thematically analyzing the learning video recordings allows for a detailed and nuanced examination of peer teaching practices. This methodological approach not only enhances the validity and reliability of the research findings but also contributes valuable insights into the pedagogical strategies used in elementary education.

3. Finding and Discussion

The pedagogical abilities of students in conducting peer teaching are divided into three parts. The first part concerns the ability to open lessons, which consists of indicators such as capturing attention, improving motivation, providing lesson guidance, and connecting old and new materials. The second part is related to learning activities, which include indicators such as using strategies relevant to the subject matter, providing explanations with pertinent examples, being enthusiastic about feedback, and effectively managing time. Meanwhile, the third part is the ability to close lessons, including indicators such as reviewing, evaluating, and informing about the materials.

3.1. The Ability to Start Lessons

The skill of opening a lesson is the teacher's effort to provide an introduction or direction regarding the material taught to students (Marno & Idris, 2008: 86). Meanwhile, the opening activities are intended to increase the focus on learning. This can be carried out by stating the objectives to be achieved, capturing students' attention, providing guidance, and making connections between the material (Suwarna, 2006: 66). The ability to open a lesson by Pre-Service PPG students majoring in PGSD at Pasundan University can be seen in Figure 1.

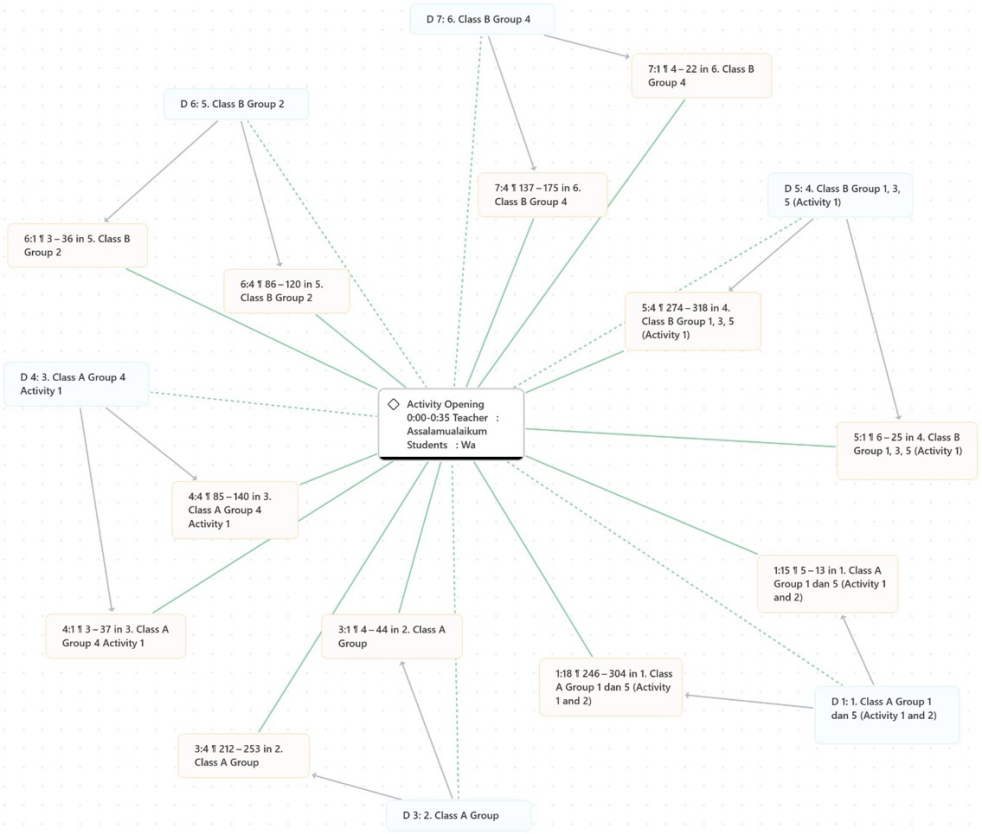

Figure 1. The Ability to Start Lessons

In the field of educational pedagogy, the Opening Activity is a meticulously crafted blueprint for improving a positive and engaging learning atmosphere. Each lesson plan unfolds with a purposeful greeting and prayer, setting the tone for a respectful and uplifting environment. The intentional initiation transcends mere routine, becoming a cornerstone for increased student engagement and motivation (Lee, Song, and Hong, 2019). In addition, the teacher's conscientious attendance-taking serves as a subtle and significant gesture, ensuring the preparedness of every student for active participation. In this context, the educational landscape is subjected to a transformative phase as the teacher delves into a comprehensive review of the preceding lesson. The strategic revisiting of key concepts serves as a foundational bridge, reinforcing students' understanding and seamlessly paving the way for the introduction of novel material.

The lesson plans within the Opening Activity represent a skillful fusion of creativity and pedagogical expertise. The spectrum of engaging activities, ranging from the melodic cadence of song to the interactive dynamism of discussions, caters to diverse learning styles. This approach is a deliberate strategy to infuse enjoyment and interactivity into the learning process, in line with contemporary educational study focused on the importance of the methods (Lavoué et al., 2019).

As the instructional tapestry begins to weave the narrative towards closure, the teacher summarizes the key points as a ritualistic conclusion and purposeful strategy to solidify comprehension and distill key takeaways. This moment of recapitulation serves as a reflective pause, ensuring that the mosaic of knowledge is firmly etched in the students' minds. To further fortify the understanding, homework assignments are thoughtfully assigned, providing an avenue to practice and reinforce newfound knowledge. This strategic approach is consistent with contemporary educational practices that recognize the significance of extending learning beyond the classroom (Lee, Song, and Hong, 2019).

The lesson plans in the Opening Activity are not a one-size-fits-all solution considering the dynamic diversity within education. However, this is carefully tailored to accommodate the unique intricacies of varied grade levels and subjects. The adaptive approach, finely attuned to the age and developmental requirements of the students, ensures that the structure and fundamental concepts remain consistent, improving a cohesive and effective learning experience across diverse educational settings (Brandišauskienė et al., 2021).

In the context of educational practices, deliberate greeting, prayer, engaging activities, and adaptive tailoring

create pedagogical masterpiece. Considering contemporary study insights, these practices facilitate the transmission of knowledge and actively contribute to the creation of a dynamic, motivating, and inclusive learning environment.

3.2. The Core Lesson Activities

The learning activities consist of indicators such as appropriate strategies for the subject matter, explanations with relevant examples, enthusiasm for feedback, and careful time management. The ability to conduct learning activities by students majoring in PGSD at Pasundan University can be seen in Figure 2.

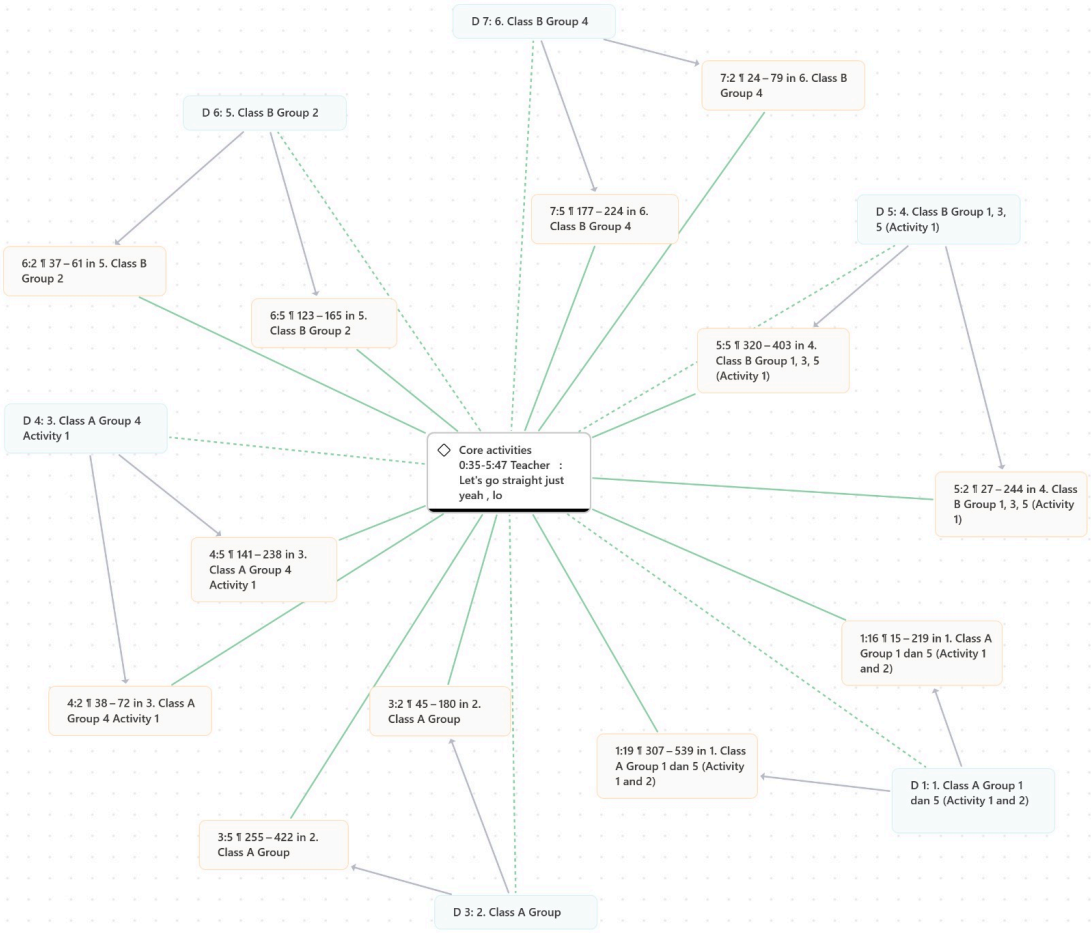

Figure 2. The Ability to Conduct Core Learning Activities

In the tapestry of educational engagement, the core activities serve as a canvas for dynamic discussions on earthquakes, infusing the learning environment with a vibrancy that transcends traditional boundaries. The teacher orchestrates these discussions with finesse, enabling students to articulate an understanding of earthquakes as geological events and powerful phenomena marked by shocks, vibrations, and earth movements. This interactive exchange lays the groundwork for a journey into the complexities of seismic activity.

Considering the geographical context, the teacher navigates the discourse toward the predisposition of Indonesia to earthquakes. This question is met with insightful responses from students attributing the concept to the country's location on three tectonic plates. The practical considerations extend beyond the theoretical, including safety measures crucial in earthquake-prone regions. The discussions echo the resonance of real-world applications, allowing students to ponder on finding secure places and evacuating buildings during seismic events.

The introduction of a video presentation elevates the learning experience, providing a multi-sensory dimension to the understanding of earthquakes. This multimedia approach is consistent with contemporary educational study and serves as a conduit for enhanced comprehension. Additionally, the visual narrative unfolds the potential aftermaths of earthquakes, unveiling the cascading impact on landscapes in the form of floods, tsunamis, and landslides. The merging of visual and verbal inputs deepens students' understanding of the subject matter, enhancing a holistic understanding.

Transitioning seamlessly to the vulnerabilities of man-made structures, the teacher steers the discussion toward houses and challenges during earthquakes. Students engage in analytical thinking, attributing collapses to fundamental issues with materials and foundations. The narrative concludes with a forward-looking perspective since the teacher introduces the notion of constructing earthquake-resistant houses. The affirmative response from students shows the comprehension and willingness to embrace innovative solutions in the face of challenges.

As the educational journey progresses through subsequent core activities, the focus shifts towards exploring the shape of the earth and the design of houses. The facilitation of the teacher guides students through an exploration of the earth's spherical or circular form. This evolves into an imaginative journey, prompting students to identify round objects in the environment. The shift to the geometric configurations of houses adds a creative layer to the learning experience since students recognize and classify shapes such as triangles, rectangles, squares, and pentagons. Additionally, the teacher skillfully weaves in discussions on construction materials, inviting students to contemplate the diverse elements in building an environment.

Considering the foundational topic of earthquakes, the teacher embarks on a review of the previous lesson. Students reiterate the understanding as vibrations caused by the movement of the earth's plates. The strategic emphasis on reinforcing prior knowledge is consistent with pedagogical practices, ensuring a solid understanding before progressing. The teacher skillfully explores strategies to mitigate earthquake risks, with a particular focus on the construction of earthquake-resistant houses.

In another core activity, the abstract and crucial concept of the center point of a circle is introduced. The journey from unfamiliarity to comprehension unfolds since students understand the term "epicenter" and delve into the subtleties of the point, known as "hypocenter." The conceptual exploration is concluded with the aid of a video, enriching students' understanding through visual reinforcement.

The final core activities elevate the discourse to a broader perspective, initiating a discussion on the broader impact of earthquakes. Meanwhile, students delve into critical reflections on the consequences, showing the destruction of buildings and the loss of life. The teacher adeptly shifts towards a proactive stance, directing the focus towards the characteristics of earthquake-resistant houses. In a crescendo of collaborative engagement, students are tasked with the creative efforts of designing structures resilient to seismic forces, integrating theoretical knowledge with practical application. This narrative consists of educational study that provides support for the pedagogical decisions implemented. The incorporation of video presentations is consistent with studies focusing on the efficacy of multimedia tools to enhance learning outcomes (Hefter et al., 2019). Beyond visual aids, the presence of co-learners during video-based learning is developed as a crucial element, reducing cognitive load and promoting self-regulation and monitoring behaviors (Pi et al., 2022). According to (Altersberger et al., 2019), the perceived helpfulness of instructional videos mirrors the observed engagement and understanding enhancement in the described learning activities.

The core activities unfold as a transmission of knowledge as well as an orchestration of creative, analytical, and critical thinking skills. The teacher navigates the educational landscape promoting students to understand the concepts as well as question, discuss, and apply learning. The synthesis of theoretical understanding with real-world implications and innovative problem-solving sets the stage for a holistic and impactful educational experience.

3.3. The Ability to Conclude Lessons

The ability to conclude lessons by Pre-Service PPG students consists of indicators such as reviewing, evaluating, and informing about the next materials, as seen in Figure 3.

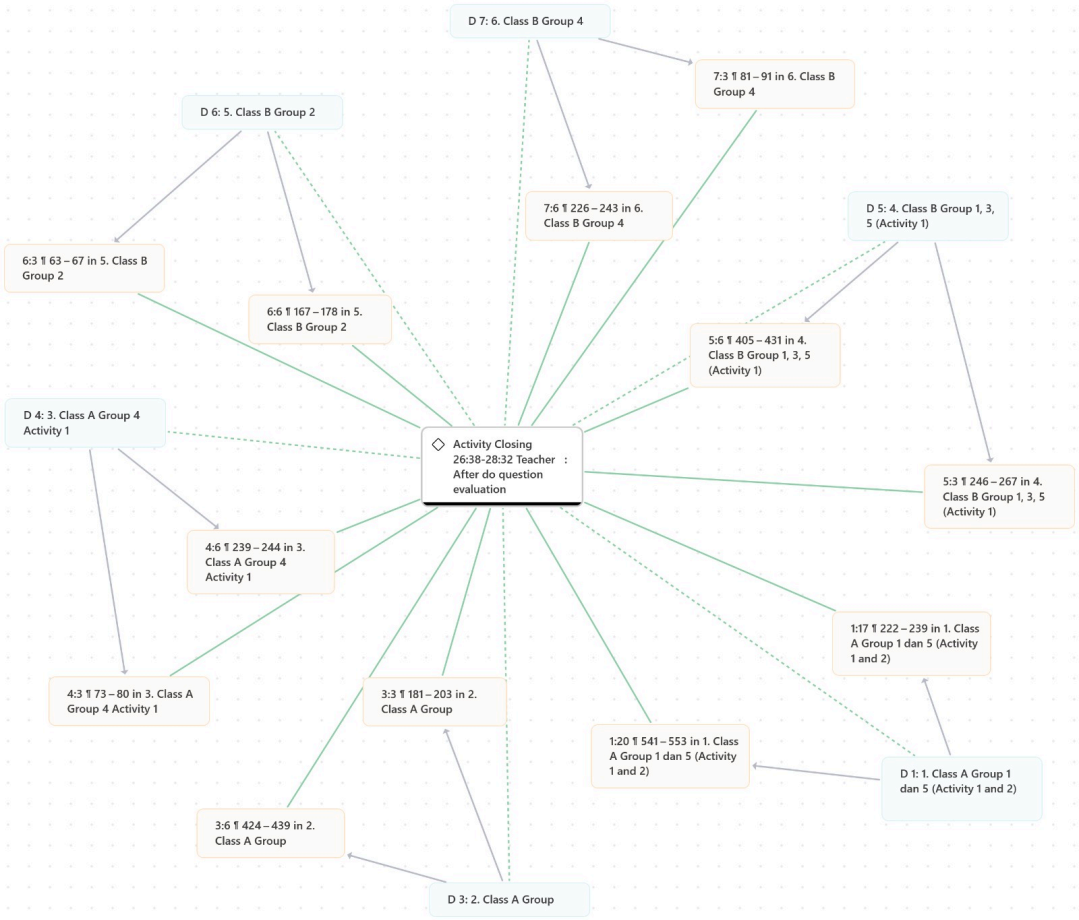

Figure 3. The ability to conclude lessons.

In the tapestry of educational closure, the Closing Activity shows an array of methods that transcend conventional boundaries, weaving a narrative of thoughtful design and engagement. Beyond the perfunctory conclusion of classroom sessions, the closures serve as dynamic platforms for reinforcing comprehension, promoting reflective practices, as well as nurturing a positive and respectful classroom environment. At the core of the closures lies a systematic review and reflection process, connecting students' reflections on learning experiences. This dual-layered approach solidifies comprehension and catalyzes the intricate process of forging connections between newfound knowledge and the existing cognitive landscape. The intentional reflection becomes a bridge, allowing students to traverse the field of understanding and application.

A recurring motif within the closures is the harmonious blend of tradition and innovation. Student-led prayers transcend mere rituals, evolving into threads intricately woven into the communal and spiritual fabric of the classroom. The exchange of greetings goes beyond formality, establishing an opportunity for the cultivation of a positive and respectful ambiance. These rituals transform the classroom into a haven to nurture intellectual and emotional growth. Similarly, the teacher introduces a symphony of supplementary elements that elevate the closing activities to a crescendo of enriched learning experiences. Demonstrations and simulations unfold, transforming abstract concepts into tangible experiences lingering in the students' minds. The classroom becomes a stage, where complex ideas are brought to life, ensuring a depth of understanding that transcends the theoretical. In the fluidity of closure, homework assignments exceed tasks, serving as stepping stones to ensure clarity.

A closing session featured a musical interlude, introducing an element of vibrancy that extends beyond the auditory senses. This deviation shows a comprehension of the multifaceted nature of student engagement. By orchestrating the musical coda, the teacher captures attention and embeds the lesson into memory with a melodic cadence.

The deliberate diversity in closing methods echoes a profound understanding of the kaleidoscope of learning styles and preferences within the classroom. The teacher also orchestrates a spectrum of activities, providing a tailored opportunity to engage meaningfully with the material. It is an acknowledgment that each mind is a unique canvas, and the brushstrokes of comprehension need to be varied and vibrant.

In the context of educational study, the methodologies are consistent with contemporary insights that show the efficacy of multifaceted closure practices. The established strategies for solidifying understanding and preparing students for future lessons are reviewing fundamental lesson points, engaging in reflective practices, and offering a preview of upcoming content (Jeynes, 2020). Meanwhile, the incorporation of prayer and greetings is consistent with the study stating the role of positive classroom environments in improving student well-being (Mingo, 2021). The intentional diversity in closing methods resonates with studies recognizing the importance of accommodating various learning styles and preferences (Yonker et al., 2019). The incorporation of supplementary elements, such as demonstrations and simulations, is also in line with the study focusing on the value of experiential learning in consolidating comprehension (Lingefjärd and Ghosh, 2022). This thoughtful design, rooted in pedagogical insights is a strategic engagement, ensuring that each student leaves the classroom with knowledge and a tapestry of experiences (Sahib et al., 2021). In addition, the Closing Activity is a carefully orchestrated finale that sets the stage for the next educational act. The pedagogical symphony leaves an indelible mark in shaping the canvas of student learning due to the connection of tradition and innovation, as well as reflection and engagement.

4. Conclusion

In conclusion, this study was carried out to analyze Pre-Service PPG students majoring in PGSD at Pasundan University, focusing on pedagogical abilities in peer teaching. The result showed a tripartite division of skills, including the ability to open lessons, conduct core learning activities, and effectively close lessons. Additionally, the opening activities, marked by intentional greetings, prayers, and a strategic review of previous lessons, formed a pedagogical masterpiece to enhance a positive and engaging learning atmosphere. The core learning activities unfolded as an orchestration of creative, analytical, and critical thinking skills, in line with contemporary educational studies on multimedia tools and experiential learning. The closing activities, characterized by a blend of tradition and innovation, offered a dynamic platform for reinforcing comprehension and nurturing a positive classroom environment. In this context, the deliberate diversity in closing methods stated the varied learning styles within the classroom in line with current studies on improving student well-being and accommodating preferences. Meanwhile, effective peer teaching included the transmission of knowledge and strategic engagement, leaving students with a tapestry of experiences woven into education. To enhance this method of teaching, teachers, and institutions might consider incorporating diverse and innovative methods, leveraging multimedia tools, and enhancing a positive classroom environment through intentional rituals and activities. Additionally, ongoing studies and professional development could refine and adapt the pedagogical strategies in response to the evolving landscape of education.

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