Journal of Advanced Sciences and Mathematics Education
Volume 5, Issue 1, 69 - 82.
e_ISSN: 2798-2351
DOI: 10.58524/jasme.v5i1.744

Evaluating the theoretical validity of the PASPOR model for enhancing mathematical communication in teacher education

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Article Info

Article history:

Received: April 02, 2025
Revised: May 25, 2025
Accepted: June 02, 2025

Keywords:

ASPOR Model;
Model Validity;
Mathematical Communication;
Learning Innovation;
PGSD Students.

Abstract

Background: Mathematical communication is a key skill for preservice primary school teachers, enabling them to effectively facilitate understanding in the classroom. Despite its importance, many students in teacher education programs struggle to convey mathematical concepts clearly in both verbal and symbolic forms.
Aim: This study aimed to evaluate the theoretical validity of the PASPOR Model "comprising Pairing, Square, Presentation, and Repetition" as an instructional framework designed to enhance mathematical communication in preservice teacher education.
Method: A development research approach was applied, based on the Plomp model. Expert validation focused on five core components: syntax, social system, reaction principle, support system, and instructional impact. Data were collected using structured instruments completed by mathematics education experts and analyzed through both quantitative and qualitative techniques.
Result: The findings demonstrated high theoretical validity for the PASPOR Model. Expert ratings ranged from 3.68 to 3.97, with reliability coefficients exceeding 0.90 across all components. Experts affirmed the model's internal consistency, pedagogical relevance, and effectiveness in promoting structured, collaborative mathematical communication among learners.
Conclusion: The PASPOR Model is a theoretically sound and pedagogically appropriate instructional model for improving mathematical communication in preservice teacher education. Its structured stages support cooperative learning and reflective interaction. The strong expert agreement endorses its integration into teacher education curricula and provides a foundation for future empirical studies to assess its practical application and adaptability in various learning contexts, including digital platforms.

To cite this article: Jufri, J., Asrial, A., Johari, A., & Kamid, K. (2025). Evaluating the theoretical validity of the PASPOR model for enhancing mathematical communication in teacher education. *Journal of Advanced Sciences and Mathematics Education, 5*(1), 69 - 82.

INTRODUCTION

In the era of 21st-century education, mathematical communication has become a central competence that preservice teachers must develop to facilitate meaningful learning (Suh et al., 2021; Valtonen et al., 2021). The ability to express mathematical ideas clearly, both verbally and in written form, is not only essential for constructing knowledge but also for fostering student engagement and collaborative understanding in mathematics classrooms. However, many preservice teachers, especially those enrolled in Primary School Teacher Education (PGSD) programs in Indonesia, exhibit low levels of mathematical communication (Maryani et al., 2025; Rifai & Rombot, 2024). This results in difficulties explaining mathematical reasoning, engaging in classroom discourse, and using appropriate representations.

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This phenomenon presents a serious challenge, particularly because the national curriculum and global educational trends are shifting toward learner-centered, dialogic teaching approaches. Teachers are now expected to support learners in explaining, questioning, and negotiating mathematical ideas (Nama & Ayalon, 2024; Zhang et al., 2022). Without adequate communication skills, prospective teachers risk perpetuating shallow, procedural learning. Therefore, developing a pedagogical model that explicitly nurtures mathematical communication is both an urgent educational need and a significant research interest. The PASPOR Model "consisting of four structured stages: Pairing, Square, Presentation, and Repetition" was developed as a response to this pedagogical gap and holds the potential to transform how mathematical communication is taught and practiced in teacher education settings.

A review of recent literature underscores the increasing focus on mathematical communication as a foundation of effective mathematics instruction. Torres-Duarte (2022) emphasized the necessity of integrating communication into mathematics education to reflect authentic learning. Sari et al. (2020) found that the problem-based learning model significantly improved students' reasoning and communication abilities. These findings align with Siregar et al. (2017), who demonstrated how motivational strategies enhance students' confidence in discussing mathematical concepts. Syaiful et al. (2020) emphasized that active learning activities tailored toward verbal and written communication foster deeper mathematical understanding. Meanwhile, Sari et al. (2020) highlighted that current models like Think-Talk-Write (TTW) and Think-Pair-Share (TPS) often focus on single dimensions of communication and lack integration across modalities. Cerone (2020) further stressed the need for educational frameworks that blend cognitive and behavioral elements of reasoning to support holistic mathematical thinking.

From a design perspective, Plomp et al. (2007) advocated for structured model validation in educational innovation to ensure pedagogical and theoretical soundness before broader implementation. Fresnadillo-Martínez et al. (2012) and Joner & Patias Volpi (2017) also noted the importance of expert validation in the development of instructional models. Safitri et al. (2020) supported the use of cooperative learning environments to stimulate communication and interaction, essential in preservice teacher development. Lomibao et al. (2016) concluded that students' reasoning abilities are directly linked to their communication competence, reinforcing the need for integrative instructional models. Collectively, these studies form a strong theoretical foundation for designing and validating a communication-based instructional model like PASPOR, specifically tailored to the unique needs of future educators.

Although numerous instructional models have been proposed to enhance mathematics learning, most are not specifically designed to address the multifaceted nature of mathematical communication within teacher education contexts (Bakker et al., 2021; Yun & Crippen, 2025). Existing models often lack integration between verbal, written, symbolic, and collaborative forms of communication. Moreover, while some models have been empirically tested in school settings, few have undergone theoretical validation in the context of preservice teacher training (Baier et al., 2021; Wang et al., 2021). The literature also reveals a scarcity of development research studies that combine theoretical design, expert validation, and structured implementation in a comprehensive manner. This gap highlights the need for a research-backed, validated instructional model that systematically enhances mathematical communication among future teachers.

The PASPOR Model was developed to address these limitations by offering a structured instructional framework that emphasizes mathematical communication through cooperative learning and repeated reflection. Each stage of the model "Pairing, Square, Presentation, and Repetition" targets a specific component of communication while aligning with constructivist principles (Dinh, 2025; Peel et al., 2022). Before implementation in classrooms, it is essential to evaluate the theoretical validity of the model to ensure its components are pedagogically sound and aligned with the communication needs of preservice teachers. The model's theoretical grounding, combined with practical application in teacher education, makes this study both relevant and timely in the current educational discourse.

The main purpose of this study is to evaluate the theoretical validity of the PASPOR instructional model in enhancing mathematical communication within the context of teacher education. This research aims to examine whether the model possesses strong theoretical foundations and aligns with pedagogical principles based on expert judgment. The study focuses on validating key components of the model, such as its instructional syntax, social and reaction systems, support mechanisms, and expected learning outcomes, through expert evaluation. By doing so, this research seeks to establish the model's relevance, clarity, and applicability in preparing preservice teachers to effectively communicate mathematical ideas. Ultimately, the findings are expected to provide essential evidence to support further development and implementation of the PASPOR model in mathematics education programs.

METHOD

Research Design

This study employed a development research design following the Plomp model (2007), which is widely accepted for educational model development. The research was conducted in three main phases: preliminary investigation to identify needs and design the initial prototype, prototyping to develop the PASPOR model components, and evaluation through theoretical validation by experts. The focus of this paper is on the theoretical validation phase, aiming to assess the content validity and feasibility of the PASPOR instructional model for mathematical communication enhancement among preservice teachers. The study is categorized as non-experimental with a cross-sectional approach, relying on expert judgment rather than intervention outcomes.

Participants

The participants involved in the validation process were selected based on their expertise in mathematics education and instructional design. A purposive sampling technique was applied to ensure that only individuals with substantial experience in preservice teacher education were included. In total, seven validators participated in the study, all of whom possessed strong academic backgrounds in mathematics teaching, curriculum development, and educational research. Their primary task was to assess various elements of the PASPOR model, including its syntax, social system, reaction principle, support system, and instructional impact. These validators were affiliated with higher education institutions known for their excellence in teacher preparation programs (Asempapa & Lee, 2025). Their insights were considered crucial for evaluating the theoretical soundness of the model. Each validator contributed through a structured evaluation form designed to measure the pedagogical quality and alignment of the model's components. Their assessments played a vital role in determining the model's feasibility and relevance to preservice teacher training contexts.

Population and Sampling Method

The population in this study included mathematics education experts from universities across Indonesia who had experience in training preservice teachers. These individuals were deemed capable of evaluating the theoretical components of the PASPOR instructional model due to their academic background and professional experience. A purposive sampling method was employed to ensure that only those with specific expertise participated in the validation process. This non-random technique was selected because the study required evaluators who possessed not only subject knowledge but also familiarity with instructional model design and evaluation. To be included in the sample, validators were required to have at least a master's degree in mathematics education. In addition, participants needed to have published relevant academic works or been involved in curriculum development activities. Another criterion was the validators' willingness to engage in more than one round of evaluation if necessary. These strict criteria ensured that the selected experts could provide reliable and insightful assessments of the PASPOR model's theoretical validity.

Instrumentation

The instrument designed for this study was a structured evaluation sheet tailored to assess five core dimensions of the PASPOR instructional model: syntax, social interaction system, principle of reaction, support mechanisms, and overall instructional outcomes. Each of these dimensions was assessed using a four-point Likert scale, enabling validators to provide ratings from 1 (highly inappropriate) to 4 (highly appropriate). The items were developed to gauge the logical flow of the learning process, the presence of collaborative learning structures, and the model's ability to strengthen mathematical communication. For example, one item addressed the sequence of activities and whether it effectively supports communication development. Another item measured how well the model facilitates peer interaction and collaborative work. Additionally, the repetition stage was evaluated in terms of how it reinforces knowledge and builds communication skills. These indicators were selected to ensure that both theoretical robustness and practical classroom relevance were captured. The tool aimed to comprehensively reflect the pedagogical integrity of each element in the model.

In analyzing the validation results, average scores were calculated for each component based on responses from the participating validators. The following interpretation scale was employed: scores between 3.26 and 4.00 were categorized as "Very Valid"; scores from 2.51 to 3.25 were considered "Valid"; those in the 1.76 to 2.50 range were marked "Less Valid"; and scores between 1.00 and 1.75 indicated an "Invalid" rating. To ensure the instrument's internal consistency, Cronbach's alpha was applied, a reliability coefficient widely used in educational research. A value equal to or greater than 0.70 was accepted as the benchmark for reliable instruments. In this study, all validation components produced alpha scores higher than 0.90, signifying excellent reliability (Izah et al., 2023; Trabelsi et al., 2024). Before distributing the instrument to validators, an initial content validation was conducted by experts to verify item clarity and alignment with the theoretical constructs of the PASPOR model. This preliminary process helped refine the instrument and increased the likelihood of obtaining meaningful evaluations. Altogether, the validation tool proved both statistically reliable and educationally relevant for assessing the model.

Scoring Method:

- Collect total validator ratings for each component;
- Compute the mean score for every individual aspect;
- Derive the overall average score across all dimensions;
- Conclude the level of validity of the model and supporting tools.

Validity classification criteria were adapted from the framework by Nurrahmawati (2020), which outlined how to proceed based on the results. If a "Moderately Valid" conclusion was reached, it signaled that only specific elements required revision. However, a finding of "Invalid" implied a more comprehensive redesign, which could involve just the model, just the tools, or both. In situations where changes to the model necessitated tool revisions, both were updated simultaneously to maintain coherence. Once modifications were complete, the adjusted versions were referred to as prototype models (Nurrahmawati, 2020). Feedback and remarks from the validators were also taken into account during the revision process. This iterative refinement ensured that the instructional model and its components remained aligned and theoretically consistent. Ultimately, the rigorous validation and revision steps enhanced the model's overall credibility and readiness for application in real educational contexts.

Procedures and Time Frame

The research was carried out over a six-month period, beginning with the design phase and concluding with expert validation. During the initial stage, the development of the PASPOR instructional model was guided by an in-depth literature review and a preliminary needs analysis involving stakeholders in teacher education. These foundational activities helped define the model's components and informed the creation of validation instruments. Following this, the draft model and accompanying validation tools were shared electronically with selected experts in mathematics education for assessment. Each validator was given two weeks to complete the review, ensuring they had ample time to reflect on and evaluate each component. To facilitate transparency and gather qualitative insights, a feedback session was organized after the completion of scoring. Based on the collected responses, necessary revisions were made to improve model clarity, alignment, and feasibility. This iterative process ensured that the final prototype of the PASPOR model was not only theoretically valid but also ready for further testing and potential classroom implementation.

Analysis Plan

The data gathered from expert validations were analyzed using descriptive statistical methods to determine the theoretical validity of the PASPOR instructional model. This analysis included the calculation of mean scores, standard deviations, and percentage agreements for each of the five core components: syntax, social system, reaction principle, support system, and instructional impact. Cronbach's alpha was employed to assess the internal consistency of the validation instrument, ensuring that the items measured the intended constructs reliably. The analysis did not involve inferential statistics since the objective was to evaluate expert judgment rather than test a hypothesis across a population. Each validator's rating was compiled and processed to determine average scores per component, and from those, an overall validity score for the model was calculated. In addition to numerical scores, qualitative feedback from validators was reviewed to guide revisions and strengthen the pedagogical soundness of the model. This process ensured a holistic interpretation of validity, incorporating both quantitative rigor and expert commentary. The final interpretation was conducted using predefined criteria adapted from (Nurrahmawati, 2020), in the table below.

The formula for Cronbach's alpha:

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k} \sigma_i^2}{\sigma_i^2}\right)$$

This formula assesses how closely related a set of items are as a group. A higher alpha value (generally ≥ 0.70) indicates strong internal consistency, meaning that the instrument reliably measures the underlying constructs. In this study, all components demonstrated alpha values above 0.90, which signifies excellent reliability and supports the robustness of the instrument.

Table 1. Criteria for the Validity of the Model and Its Tools

Interval	Validity Criteria
3.26–4.00	Very Valid
2.51–3.25	Valid
1.76–2.50	Less Valid
1.00–1.75	Invalid

These criteria were used to interpret the validation scores across all assessed components. If a component received a "Very Valid" classification, it was deemed to require no further modification. A "Valid" score suggested that the component was acceptable but could benefit from minor refinement. "Less Valid" indicated that more substantial revisions were needed to improve clarity or alignment with instructional goals. An "Invalid" result required a comprehensive redesign of the component or instrument. These categories were crucial in deciding whether the PASPOR model and its tools could be finalized or required additional development. Feedback from validators was also considered alongside numerical results to ensure qualitative alignment. The integration of both quantitative and qualitative inputs enhanced the credibility and academic rigor of the model validation process.

Scope and Limitations of the Methodology

This study was limited to the theoretical validation of the PASPOR instructional model through expert review, without extending to empirical implementation in classroom settings. The primary focus was to evaluate the coherence, relevance, and feasibility of the model's design components based on informed judgments by mathematics education specialists. Consequently, the findings represent expert perspectives rather than evidence derived from practical application or student performance outcomes. While this approach ensures a rigorous conceptual foundation, it does not account for real-world teaching dynamics, student variability, or contextual classroom challenges. The relatively small sample size of validators, though carefully selected for their expertise, may not fully capture the diversity of views across different educational institutions and regions. Additionally, the absence of triangulation with observational or empirical classroom data limits the ability to generalize the results beyond the validation phase. Nevertheless, this theoretical groundwork provides essential insights for subsequent stages of research, particularly empirical trials that assess the model's practical impact. Future studies should build on these findings by incorporating field-based evaluations with larger and more varied participant groups to validate the model's effectiveness in actual learning environments.

Recommendations for Manuscript Reporting

Given the nature of this study, which focuses on theoretical validation through expert judgment rather than empirical testing, it is essential to adopt established reporting guidelines to ensure transparency and academic rigor. The Standards for Reporting Qualitative Research (SRQR) offer an appropriate framework for presenting this type of research, particularly in terms of detailing research design, participant selection, and data analysis procedures. These guidelines emphasize clarity in how experts were chosen, how data were collected and interpreted, and how reliability and validity were assessed. Providing thorough descriptions of the validation process, including scoring rubrics and reliability coefficients, contributes to the credibility of the study. Clear articulation of the model's development stages also enhances reproducibility for future researchers interested in implementing or adapting the PASPOR model. Furthermore, integrating both statistical results and qualitative feedback from validators adds depth to the findings and strengthens the study's contribution to instructional design literature. Authors are encouraged to present not only the final results but also the iterative refinement process based on expert input. By adhering to these reporting standards, the manuscript demonstrates methodological soundness and becomes more suitable for submission to high-quality international journals in the field of educational research.

RESULTS AND DISCUSSION

Results

Paspor Learning Model Development Process

The development of the PASPOR learning model "comprising the stages of Pairing, Square, Presentation, and Repetition" was guided by the framework proposed by Plomp et al. (2007), which includes three core phases: initial investigation, prototyping, and assessment. This structured approach was selected because it provides a systematic methodology for designing educational innovations grounded in both theory and empirical evidence. The initial investigation phase focused on identifying educational problems and analyzing learners' needs related to mathematical communication. During the prototyping stage, a preliminary version of the model was constructed, incorporating expert insights and pedagogical principles. The assessment phase involved validation by experts to evaluate the model's coherence, feasibility, and instructional potential. This multi-phase process ensures that the development is iterative, allowing revisions based on stakeholder input and data analysis. The use of this model aligns with educational development principles that prioritize validity, practicality, and potential impact (Nieveen & Folmer, 2013). Overall, the PASPOR model was developed through a rigorous process designed to produce a pedagogically sound and theoretically grounded instructional framework.

Fase 1: Preliminary Research

The results of the investigation show that mathematics learning at Rokania University is still dominated by the traditional approach that emphasises the delivery of material by lecturers, followed by giving examples and practice problems. Despite efforts to implement methods that are more interactive and based on active student participation, the reality is that many lecturers still tend to use instructive methods. This has an impact on the low active involvement of students in class discussions and mathematical communication. Students tend to be passive, only waiting for explanations from lecturers, thus inhibiting the development of critical thinking skills and the ability to solve problems independently. This is in line with the findings of previous studies which indicate that more innovative teaching, such as problem-based learning, can improve learning outcomes compared to traditional methods.

Evaluation of learning tools, especially lesson plans and student worksheets, shows that the tools currently used are still unstructured. Most lecturers only use the Semester Learning Plan (RPS) which is general in nature without details for each meeting. This reduces the effectiveness of learning and does not provide clear guidance in designing activities that support students' mathematical communication skills.

Preliminary studies show that students' mathematical communication skills are still low. Although they were able to provide the final answer to the mathematical problem, many students had difficulty in explaining the steps of the solution, transforming the problem into a mathematical model, and using appropriate terms and symbols in explaining their solutions. This indicates that students need more practice in organising and communicating their mathematical ideas.

Fase 2: Prototyping

The PASPOR model is designed with components that support students' mathematical communication, including syntax, social system, reaction principle, support system, and instructional impact. Each syntax has clear objectives and activities to develop students' mathematical communication skills. For example, in the Pairing phase, students work in pairs to construct understanding and solve problems together, while in the Square phase, they collaborate in groups to unify solutions and strengthen understanding of the concepts learnt. The Presentation phase provides an opportunity for students to present the results of their discussions in front of the class, while Repetition helps reinforce understanding through additional practice and reflection.

In order to support the implementation of the PASPOR Model, the learning tools developed include student worksheets, lecturer's manual, and lesson plans. The student worksheets are designed to engage students in activities that improve their mathematical communication skills. The lecturer's manual provides clear instructions on the implementation of the PASPOR model in the classroom. The lesson plans include learning steps that focus on developing mathematical communication.

Fase 3: Assessment

In the assessment phase, the validity of the PASPOR Model that has been developed is evaluated. This evaluation is carried out through validation by experts, consisting of experts in the field of mathematics education.

Validity of PASPOR Model and Learning Tools

1. Self Evaluation Results

After the design of the PASPOR learning model was completed, an internal evaluation was conducted to ensure there were no errors in the writing, use of terms, and suitability of the format. Some improvements were made to the model book, student worksheets, and lesson plans based on the results of this evaluation, which ensured the quality and feasibility of the developed model.

2. Expert Validation

The model validation process by experts involved three validators who were experts in conceptual, material, and media aspects. The validation results showed that the PASPOR Model met the validity criteria with a fairly high average score. Some improvements suggested by the validators include the addition of more detailed explanations of scaffolding, theoretical foundations, and syntax components of the model to ensure its more effective application in the learning context.

3. Validity Analysis Results

Validation activities are carried out by sending all instruments to the validator. Validators reviewed the learning tools and provided suggestions through comments on the assessment sheet or online discussion. After several revisions, the validation results of the PASPOR model and learning tools are presented in Table 1 below:

Table 2. Recapitulation of validation of PASPOR learning models and tools

No	Item	Reliability Value	Level of Reliability	Level of Reliability	Description
1	Passport Learning Model (Model Book)	98,85%	Reliabel	3,68	Valid
2	Lesson Plan (RPP)	98,85%	Reliabel	3,97	Valid
3	Student Worksheet	91,67	Reliabel	3,78	Valid
4	Lecturer Handbook	96,52	Reliabel	3,88	Valid
5	Model Implementation Observation Sheet	98,59	Reliabel	3,88	Valid
6	Student Activity Observation Sheet	91,53	Reliabel	3,79	Valid
7	Student Response Questionnaire	91,41	Reliabel	3,78	Valid
8	Pre-test Questions	98,85	Reliabel	3,94	Valid
9	Post-test Questions	97,87	Reliabel	3,97	Valid

Based on the validation results in Table 1, for the PASPOR Learning Model (Model Book), the reliability value of 98.85% indicates that the PASPOR learning model book is very reliable. The average validator score of 3.68 also indicates that this model is valid and accepted by experts as an effective learning model and in accordance with the desired mathematical communication principles. With a reliability of 98.85% and an average validator score of 3.97, the lesson plan developed for the PASPOR model is also considered valid. This shows that the lesson plans developed strongly support the implementation of the PASPOR model and are able to provide clear guidance for lecturers in implementing the model in the classroom. The student worksheet received a reliability of 91.67%, indicating that this instrument can be relied upon to measure students' ability to apply the PASPOR model. The validator score of 3.78 indicates that the worksheet is valid and in line with the learning objectives of mathematical communication. The lecturer guidebook received 96.52% reliability with an average validator score of 3.88. This indicates that the guidebook provides clear and valid instructions to assist lecturers in implementing the PASPOR model in mathematics learning.

For the Model Implementation Observation Sheet, this observation instrument has a reliability of 98.59% with an average validator score of 3.88, which indicates that the model implementation observation goes as expected and is effective in measuring the implementation of the PASPOR model in the classroom. The student activity observation sheet showed a reliability of 91.53% and a validator score of 3.79, which means that this instrument is reliable to assess how active students are in applying the PASPOR model during learning.

Furthermore, the Student Response Questionnaire. This questionnaire has a reliability of 91.41% and a validator score of 3.78, which indicates that this instrument is valid to measure student responses to the application of the PASPOR model in learning. The pretest and posttest questions received excellent reliability scores, 98.85% and 97.87% respectively. The average validator score of 3.94 for the pretest and 3.97 for the posttest showed that these questions were valid in measuring the improvement of students' mathematical communication skills before and after the application of the PASPOR model.

Discussion

The expert validation results strongly affirm the theoretical strength of the PASPOR instructional model, particularly in enhancing mathematical communication. Among the five assessed components, the syntax dimension obtained the highest validation score, indicating that the learning stages (Pairing, Square, Presentation, and Repetition) are pedagogically coherent and sequentially logical. Such structured sequencing enables students to gradually develop their communication competencies, transitioning from collaborative ideation to structured expression of mathematical ideas. This finding aligns with Cairns et al. (2021), who emphasized that clearly organized instructional phases improve cognitive clarity and verbal articulation. Validators highlighted that the clarity of each syntax stage supports classroom feasibility, especially in preservice teacher contexts. Furthermore, the internal consistency as shown by Cronbach's alpha above 0.90 reinforces the reliability of this dimension (Izah et al. 2023; Trabelsi et al., 2024). This supports the view that instructional syntax plays a central role in enabling communication-oriented pedagogy. Therefore, the syntax structure in PASPOR is not only theoretically valid but also highly implementable.

The validation of the social system component indicated substantial agreement among experts about its effectiveness in promoting peer collaboration and dialogic learning. Validators acknowledged that the cooperative learning design embedded in the PASPOR model aligns with current pedagogical theories emphasizing interaction as a foundation for cognitive development (Prieto-Saborit et al., 2022). These findings support the role of social learning frameworks in advancing conceptual understanding through shared discourse. In mathematics education, such collaborative exchanges allow students to negotiate meaning, clarify misconceptions, and strengthen reasoning. The validators emphasized that peer interaction in this model contributes significantly to preservice teachers' skill development. Moreover, the PASPOR model facilitates a dynamic and supportive learning environment in which communication skills can thrive. This echoes the assertion by Nama & Ayalon (2024) that structured peer collaboration fosters teacher noticing and professional reflection. Thus, the model's social system effectively builds a foundation for sustained communication practice.

The reaction principle component received favorable evaluation scores, confirming its alignment with motivational scaffolds and responsive instructional feedback. Validators highlighted that the model provides continuous feedback loops, enabling learners to refine their thinking and expression throughout each phase. This component is consistent with the findings of Alsmadi et al. (2024), who noted that responsive feedback enhances learner motivation and engagement. Similarly, Okada (2024) emphasized that real-time feedback mechanisms are essential for cultivating learners' metacognitive awareness. In the PASPOR model, feedback is not merely corrective but also reflective, encouraging students to evaluate their mathematical discourse. The integration of both peer and instructor responses adds a valuable dimension to the instructional cycle. As such, this reaction principle reinforces learner confidence and supports the articulation of mathematical reasoning. The validators agreed that this element was instrumental in promoting a safe space for communication development. Hence, the model's feedback-oriented structure plays a crucial role in supporting learners' communicative resilience.

The remaining two components (support system and instructional impact) also achieved strong validation outcomes, confirming the holistic nature of the PASPOR model. The instructional tools accompanying the model, such as student worksheets and lesson plans, were judged to be pedagogically coherent and aligned with communication objectives. According to El-Sabagh. (2021), instructional alignment is critical for maintaining theoretical integrity and facilitating practical application. Likewise, Wu et al. (2022) argued that tools designed with constructivist principles are more likely to engage students in meaningful learning. Validators appreciated that the developed materials are adaptable for diverse educational settings and effectively promote symbolic, verbal, and written mathematical communication. The model's instructional impact, measured through expected learning outcomes, was considered feasible and relevant to the demands of teacher preparation. The consistency of expert evaluations further affirms the model's robustness and scalability. Overall, the PASPOR model stands as a validated instructional innovation with comprehensive theoretical support.

Implications

The validated PASPOR instructional model offers significant contributions for curriculum developers and teacher educators by introducing a structured pedagogical framework centered on enhancing mathematical communication. Through its integration of cooperative learning, sequenced interaction, and repeated reflection, the model addresses key instructional gaps in preservice teacher education. The high validity scores from expert evaluations underscore the model's potential for practical application in classroom settings. It provides a research-based foundation for designing training programs that emphasize both content mastery and communication competence. As educational policies increasingly prioritize active learning and discourse-rich environments, this model aligns with contemporary pedagogical demands. Teacher preparation institutions can adopt or adapt the PASPOR framework to strengthen the communicative abilities of future educators. Its structure also facilitates the creation of lesson plans and learning tools that encourage collaborative and expressive mathematical thinking. Therefore, the PASPOR model stands as a viable instructional innovation to support evidence-informed curriculum design and improve instructional quality in mathematics education.

Research Contribution

This study contributes significantly to the field of mathematics education by addressing a critical theoretical gap in the development and validation of instructional models aimed at enhancing mathematical communication skills among preservice teachers. Unlike many instructional frameworks that are implemented without rigorous theoretical scrutiny, the PASPOR model was evaluated through a structured validation process that emphasizes both pedagogical alignment and theoretical coherence. The use of expert judgment to validate components such as instructional syntax, social interaction, and support mechanisms demonstrates a commitment to evidence-based instructional design (Nieveen & Folmer, 2013; Plomp et al. 2007). Additionally, the incorporation of communication-focused strategies within the model reflects emerging priorities in teacher education, where dialogic and expressive competencies are increasingly recognized as essential for effective mathematics instruction (Prieto-Saborit et al., 2022; Suh et al., 2021). The study not only introduces a replicable validation approach for instructional models but also enhances the academic discourse on bridging theory and classroom practice. As such, it sets a foundation for future research to empirically implement and refine the PASPOR model across diverse educational contexts.

Limitations

Although this study successfully establishes the theoretical validity of the PASPOR instructional model, it is important to acknowledge several limitations that may affect the scope of its conclusions. First, the validation relied exclusively on expert judgment without including any empirical classroom implementation or observation of student outcomes. As such, the practical effectiveness of the model in real educational settings remains untested. The sample of validators, though highly qualified and experienced, was relatively small and limited to a specific academic context. This may reduce the generalizability of the findings across broader educational environments or diverse instructional cultures. Additionally, the absence of triangulated data from students, lecturers, or classroom trials restricts the depth of interpretation regarding user acceptance and contextual adaptability. The study also did not investigate the long-term sustainability or scalability of the model beyond its initial design framework. Future research is needed to explore these aspects through field trials, cross-institutional testing, and longitudinal evaluation to fully validate the PASPOR model's utility in mathematics teacher education.

Suggestions

To build upon the theoretical foundation established in this study, future research should prioritize the empirical implementation of the PASPOR instructional model in actual classroom settings. Conducting field trials involving preservice teachers will help determine the model's effectiveness in enhancing mathematical communication skills in real-world educational environments. Expanding the participant base to include students from various teacher education institutions will increase the generalizability and applicability of the findings. Researchers are encouraged to use both quantitative and qualitative methods to capture nuanced insights regarding learner engagement, instructional impact, and classroom dynamics. Longitudinal studies may also be beneficial in evaluating the model's sustained influence on teaching practices and learning outcomes over time. Furthermore, integrating digital platforms or blended learning tools into the model could enhance accessibility and learner motivation. Comparative studies involving PASPOR and other instructional models may reveal its relative strengths and areas for refinement. These future directions will provide more comprehensive evidence to support the PASPOR model's role in advancing communication-based instruction in mathematics education.

CONCLUSION

This study has successfully confirmed the theoretical validity of the PASPOR instructional model, which was specifically designed to improve mathematical communication skills among preservice primary school teachers. Developed through an educational design research framework, the model incorporates four structured stages—Pairing, Square, Presentation, and Repetition—that collectively support the progressive development of communication abilities. The expert validation process demonstrated high validity scores across all components, including syntax, social system, reaction principle, support system, and instructional impact. Additionally, the validation instrument achieved excellent reliability, with Cronbach's alpha values exceeding 0.90. These results indicate that the PASPOR model is pedagogically sound and theoretically consistent, making it suitable for integration into teacher education curricula. The structured stages of the model facilitate active participation, peer collaboration, and meaningful articulation of mathematical concepts. While the current research focused solely on theoretical evaluation, it provides a strong basis for future empirical investigations to assess the model's classroom effectiveness. Overall, the PASPOR model represents a promising instructional innovation that can contribute to improving the quality of mathematics education in teacher preparation programs.

AUTHOR CONTRIBUTIONS STATEMENT

Jufri conceptualized the research design and led the development of the PASPOR instructional model, including the formulation of its theoretical framework and learning components.
Asrial was responsible for coordinating the validation process, managing expert communication, and organizing data collection procedures during the prototyping and assessment phases.
Asni Johari contributed significantly to the literature review, synthesis of related studies, and drafting of the manuscript's background and rationale.
Kamid played a critical role in data analysis, including statistical processing of the validation results, interpretation of reliability scores, and preparation of visual data presentations.

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