ASEAN Journal of Disaster Health Management https://doi.org/10.22146/ajdhm.v2i2.32173
Vol. 2 (2) 2026: 101-117

CHANGES IN COGNITIVE AND PSYCHOMOTOR COMPETENCIES FOLLOWING A PROBLEM-BASED LEARNING INTERVENTION FOR START TRIAGE: A ONE-GROUP PRETEST–POSTTEST STUDY

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Submitted: 02-07-2026 **Revised**: 09-09-2026 **Accepted**: 13-09-2026

List of Abbreviations

ACLS	: Advanced Cardiovascular Life Support
BLS	: Basic Life Support
BTCLS	: Basic Trauma Cardiac Life Support
HREC	: Health Research Ethics Committee
LPPM	: Lembaga Penelitian dan Pengabdian kepada Masyarakat / Institute for Research and Community Service
SPSS	: Statistical Package for the Social Sciences
START	: Simple Triage and Rapid Treatment
TKQ	: Triage Knowledge Questionnaire
TSQ	: Triage Skill Questionnaire
PBL	: Problem-Based Learning

ABSTRACT

Introduction: Disasters often cause mass casualties that require rapid and accurate triage, making effective training essential for nursing students who serve as disaster volunteers. **Objective:** This study examined changes in cognitive and psychomotor competencies following a Problem-Based Learning (PBL) intervention in Simple Triage and Rapid Treatment (START) among nursing student disaster volunteers. **Methods:** A quantitative one-group pre-test–post-test design was used, involving 65 participants. Cognitive competency was assessed using a validated knowledge questionnaire, while psychomotor competency was measured

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using a validated performance checklist. Data were analyzed using the Wilcoxon signed-rank test. **Result:** Before the intervention, most participants had a moderate level of knowledge (56.9%), and 58.5% demonstrated poor psychomotor performance. After the intervention, the proportion of participants with a high level of knowledge increased to 73.8%, while 81.5% demonstrated good psychomotor performance. Statistical analysis showed significant improvements in both cognitive and psychomotor competencies ($p < 0.05$). **Conclusion:** The intervention was associated with significant immediate improvements in cognitive and psychomotor competencies. However, the absence of a control group prevents causal conclusions regarding the effectiveness of PBL. The intervention may have potential as a supplementary learning activity in disaster nursing education and disaster volunteer training.

Keywords: Disaster Volunteers; Nursing Education; Problem-Based Learning; Psychomotor Competency; START Triage

INTRODUCTION

Mass casualty incidents often create highly complex emergency situations that require rapid, accurate, and priority-based medical responses in order to minimize mortality rates and the risk of disability. In the event of a mass-casualty accident or disaster, volunteers commonly work alongside police officers, firefighters, and emergency medical teams to support disaster response efforts (1). Nursing students, in particular, can serve as medical volunteers and play an important role in providing initial emergency care. To perform this role effectively, they must be adequately trained to conduct initial victim assessments, particularly disaster triage. In such conditions, the triage process becomes very important because it helps healthcare workers assess the condition of each victim and determine who should receive treatment first based on the severity of their condition and the urgency of their medical needs (2). Among the various disaster triage systems, the Simple Triage and Rapid Treatment (START) method is one of the most widely used approaches due to its simple procedure, rapid applicability, and suitability for emergency situations with limited resources (3). The effective application of START triage requires not only cognitive competence to understand the triage algorithm, but also psychomotor competence in conducting rapid assessments and providing appropriate interventions in emergency situations (4, 5).

Effective mass-casualty management depends on careful preparedness, coordinated teamwork, clearly defined roles, rapid casualty assessment, and accurate triage procedures (6). The International Council of Nurses also highlights several core areas of disaster nursing

practice, including preparedness and planning, communication, incident management, safety and security, assessment, intervention, recovery, and ethical and legal considerations (7). These competencies can serve as a foundation for disaster-readiness curricula that combine theoretical knowledge with clinical reasoning, teamwork, communication, safety, and practical response skills (7, 8). Integrating these elements into nursing education may help students feel better prepared to respond safely and appropriately during mass-casualty incidents.

Although the START triage system has been widely used, errors in determining triage categories remain a significant challenge in disaster management, especially when triage is performed by novice personnel or volunteers involved in emergency situations (9). Previous studies have shown that triage education and simulation-based training can improve healthcare workers' knowledge, decision-making accuracy, and psychomotor skills. However, most existing research has primarily focused on professional healthcare providers. Meanwhile, nursing students who serve as disaster volunteers have received relatively less attention, despite their important role in various disaster response activities (10). In addition, triage education still largely relies on conventional teaching methods that may not effectively develop critical thinking and practical skills to an optimal level, even though both competencies are essential for dealing with complex and dynamic disaster situations (11, 12).

Problem-Based Learning (PBL) is widely recognized as an effective instructional approach for developing higher-order thinking skills, clinical reasoning, decision-making abilities, and psychomotor competencies through contextual, problem-oriented learning experiences (13). According to Barrows, Problem-Based Learning (PBL) is an instructional approach in which learning occurs as students work toward understanding and solving authentic problems (14). Schmidt further explained that PBL promotes learning through the activation of prior knowledge, elaboration of existing knowledge during small-group discussion, and contextual processing of newly acquired information (15).

This approach encourages students to actively analyze problems, determine priorities for action, and integrate theoretical knowledge with its application in practice. Although simulation-based methods, including the use of mannequins and structured clinical scenarios, have shown positive impacts on triage learning among nursing students (16–18). Simulation-based and case-based approaches have shown benefits for triage education. PBL may offer an additional mechanism by emphasizing learner-directed problem identification, information seeking, and collaborative reasoning. In addition, research integrating the START triage method with Problem-Based Learning among nursing students acting as disaster volunteers is still

limited, particularly studies that evaluate both cognitive and psychomotor competencies simultaneously as comprehensive indicators of triage ability (13, 16–18).

Considering the complexity of disaster management, the risk of triage errors among novice responders, and the still limited evidence regarding the application of Problem-Based Learning in START triage education, further research is needed. Therefore, This study aimed to examine changes in cognitive and psychomotor competencies before and after a PBL-based START triage intervention among nursing student disaster volunteers. The findings of this study are expected to contribute to the development of more effective, applicable, and context-appropriate disaster preparedness learning strategies and nursing education.

METHODS

This study employed a quantitative approach using a one-group pretest–posttest design to evaluate changes in participants' cognitive and psychomotor competencies before and after an educational intervention based on Problem-Based Learning (PBL). The intervention was designed to enhance knowledge and practical skills related to the implementation of the Simple Triage and Rapid Treatment (START) triage system.

The study participants were nursing students serving as disaster volunteers. Data collection was conducted between January and February 2026 in Jember Regency, Indonesia. The independent variable in this study is the Problem-Based Learning approach, while the dependent variables include cognitive competence in the form of knowledge and psychomotor competence related to the implementation of Simple Triage and Rapid Treatment (START) triage. The study population consisted of 77 nursing students registered as disaster volunteers. The sample size was determined using the Slovin formula, namely (n = N/(1+Ne2)), with a 5% margin of error, resulting in 65 participants. Stratified random sampling was employed to ensure representation of participants from each academic level. The population distribution included semester 3 (n = 10), semester 5 (n = 7), and semester 7 (n = 60) students. The number of participants selected from each stratum was calculated proportionally using the formula ni = (Ni/N) × n. Based on the sample selection, the participants consisted of 8 third-semester students, 6 fifth-semester students, and 51 seventh-semester students.

Data were collected using the Triage Knowledge Questionnaire and the Triage Skill Questionnaire, which were developed by the researchers based on reference (10). The Triage Knowledge Questionnaire consists of 10 multiple-choice items covering six domains, namely disaster concepts, the definition of Simple Triage and Rapid Treatment (START), triage

principles, assessment indicators, classification, and implementation procedures. Validity testing indicated that all item correlation coefficients exceeded the critical value of 0.195. Meanwhile, reliability testing using the Kuder–Richardson 20 formula demonstrated adequate internal consistency, with coefficients ranging from 0.70 to 0.73. The Triage Skill Questionnaire comprises 12 observational items used to assess participants' psychomotor competence in performing START triage (10).

Participants received the same educational intervention using a Problem-Based Learning approach focused on START triage. The 65 participants were divided into five small groups, with 13 participants in each group. Each group was supported by two facilitators, resulting in a student-to-facilitator ratio of 13:2. Thus, a total of 10 facilitators were involved in delivering the intervention. The facilitators were generalist registered nurses who had completed Basic Trauma Cardiac Life Support training and had prior experience in disaster simulation activities. Two senior facilitators coordinated and supervised the implementation of the intervention: one held a doctoral degree in nursing, while the other held a master's degree in nursing. These coordinators ensured that the learning process, case discussions, hands-on activities, and assessment procedures were implemented consistently across all five groups.

Each group was given an ill-structured mass-casualty scenario and asked to identify key problems, activate prior knowledge, recognize knowledge gaps, and determine relevant learning issues related to START triage. Participants then engaged in 60 minutes of self-directed learning to explore the identified learning issues independently. After this period, they reconvened in their respective groups to share their findings, discuss their understanding, and apply the acquired information to START triage decision-making and practical exercises.

The intended learning outcomes included the ability to explain the principles and algorithm of START triage, perform rapid assessments of disaster victims, assign appropriate triage categories, determine priority interventions, and correctly demonstrate the START triage procedure. The conceptual framework and detailed intervention protocol are presented in Appendix A and Appendix B. Data collection was conducted using a pretest–posttest procedure carried out on the same day as the intervention. Prior to the learning intervention, participants completed the Triage Knowledge Questionnaire online and underwent psychomotor assessment through direct observation while performing the Simple Triage and Rapid Treatment (START) triage procedure. After the Problem-Based Learning session, both assessments were repeated to evaluate changes in participants' cognitive and psychomotor competencies.

The Triage Knowledge Questionnaire yielded a total score ranging from 0 to 10. Each

correct answer received a score of 1, while each incorrect answer received a score of 0. For descriptive purposes, knowledge levels were classified as low (0–3), moderate (4–6), or high (7–10). The Triage Skill Questionnaire included 12 observational items, with total scores ranging from 12 to 24. Actions performed correctly were scored as 2, whereas actions not performed were scored as 1. For descriptive reporting, psychomotor performance was categorized as poor (12–15), moderate (16–19), or good (20–24).

For the inferential analysis, we used the original total cognitive and psychomotor scores to retain the full range of information provided by the measurements. Pretest and posttest scores were compared using the Wilcoxon signed-rank test because the data were paired and did not meet the assumptions required for parametric testing. The competency categories were used only to describe participants' competency levels.

Statistical significance was determined at $\alpha = 0.05$. The effect size was calculated using the formula $r = |Z|/\sqrt{N}$, where Z represents the Wilcoxon test statistic and N refers to the number of paired observations included in the analysis. All statistical tests were considered significant at a threshold of $\alpha = 0.05$. In addition, the magnitude of the change was assessed using an effect size (r), calculated as $r = |Z|/\sqrt{N}$, where Z is the Wilcoxon test statistic and N is the total number of paired observations. Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) software. Therefore, differences between pretest and posttest scores were analyzed using the Wilcoxon signed-rank test with a significance level of $\alpha = 0.05$.

This study received ethical approval from the Health Research Ethics Committee of Universitas Muhammadiyah Jember under approval number 0033/KEPK/FIKES/XII/2025. Prior to participation, all respondents were provided with an explanation of the study procedures and gave written informed consent after receiving adequate information. The anonymity and confidentiality of participants' data were maintained throughout the study.

RESULTS

A total of 65 nursing students who served as disaster volunteers participated in this study. The results include the respondents' characteristics, changes in cognitive and psychomotor competencies following the implementation of the Problem-Based Learning (PBL) intervention, as well as the statistical analysis of within-group changes following the intervention.

Respondents' Characteristics

Table 1. Respondents Characteristics

Variable	Category	n	%
Gender	Male	15	23.0
	Female	50	77.0
Education level	Undergraduate Nursing	65	100.0
Year of study	Second-year	8	12.0
	Third-year	6	9.0
	Fourth-year	51	78.0
Disaster experience	Simulation	65	100.0
Emergency training	BLS/BTCLS/ACLS	0	0.0

Source: Yoesra et al., 2026

Table 1 presents the characteristics of the respondents. The majority of participants were female (77.0%) and were fourth-year undergraduate nursing students (78.0%). Although all respondents had participated in disaster simulation activities, none had received formal emergency training.

Changes in Knowledge Competency

Table 2. Distribution of Knowledge Levels Before and After the Intervention

Knowledge Level	Pre-test n (%)	Post-test n (%)
Low	11 (16.9)	1 (1.5)
Moderate	37 (56.9)	16 (24.6)
High	17 (26.2)	48 (73.8)
Total	65 (100.0)	65 (100.0)

Source: Yoesra et al., 2026

Table 2 shows the distribution of respondents' knowledge levels before and after the PBL intervention. The proportion of participants with a high level of knowledge increased from 26.2% to 73.8%, while the proportion of participants with a low level of knowledge decreased from 16.9% to 1.5%.

Changes in Psychomotor Competency

Table 3. Distribution of Psychomotor Levels Before and After the Intervention

Psychomotor Level	Pre-test n (%)	Post-test n (%)
Poor	38 (58.5)	0 (0.0)
Moderate	27 (41.5)	12 (18.5)
Good	0 (0.0)	53 (81.5)
Total	65 (100.0)	65 (100.0)

Source: Yoesra et al., 2026

Table 3 presents the changes in participants' psychomotor competence after the intervention. Before the intervention, most participants demonstrated poor psychomotor performance (58.5%). After the intervention, the majority of participants (81.5%) achieved a good level of psychomotor competence.

Pretest–Posttest Changes in Cognitive and Psychomotor

Table 4. Pretest–Posttest Changes in Cognitive and Psychomotor Scores Following the PBL Intervention

Variable	Median Pre (IQR)	Median Post (IQR)	Positive ranks, n (%)	Ties, n (%)	Negative ranks, n (%)	Z	p-value	Effect Size (r)
Knowledge competency	5.00 (3.00)	8.00 (3.00)	51 (78.5)	6 (9.2)	8 (12.3)	-5.159	<0.001	0.64
Psychomotor competency	17.00 (2.00)	21.00 (2.00)	65 (100.0)	0 (0.0)	0 (0.0)	-8.004	<0.001	0.99

Note: Cognitive competency was analyzed using the original total knowledge score ranging from 0 to 10. Psychomotor competency was analyzed using the original total psychomotor score ranging from 12 to 24. Positive differences indicate higher posttest scores than pretest scores, ties indicate identical pretest and posttest scores, and negative differences indicate lower posttest scores. Effect size was calculated as $r = |Z|/\sqrt{N}$

Source: Yoesra et al., 2026

The Wilcoxon signed-rank test applied directly to the original continuous total scores revealed statistically significant pretest–posttest improvements in both cognitive and psychomotor competencies ($p < 0.001$). For knowledge competency, the median score increased from 5.00 (IQR = 3.00) at pretest to 8.00 (IQR = 3.00) at posttest, with 51 participants (78.5%) showing an increase in raw scores, 6 (9.2%) remaining tied, and 8 (12.3%) showing a lower score ($Z = -5.159$, $p < 0.001$, $r = 0.64$). For psychomotor competency, the median score

rose from 17.00 (IQR = 2.00) to 21.00 (IQR = 2.00). Notably, all 65 participants (100.0%) demonstrated an increase in their raw psychomotor scores, with no ties or negative ranks observed ($Z = -8.004$, $p < 0.001$, $r = 0.99$). These updated findings offer a highly sensitive representation of the positive changes following the PBL intervention.

DISCUSSION

Participant characteristics may have influenced the magnitude of the observed pretest–posttest changes. Most participants in this study were final-year nursing students and had previous experience in disaster simulation activities, although none had received formal emergency training. Previous studies indicate that higher educational levels and structured training experiences are associated with improved triage knowledge and preparedness because they facilitate the understanding of complex triage concepts and clinical decision-making processes (19, 20). Furthermore, students with greater academic and clinical exposure tend to demonstrate stronger critical thinking and problem-solving abilities, which are essential components of PBL-based learning. Meta-analytic evidence also suggests that active learning approaches are more effective than conventional methods in improving triage competencies (21). Therefore, the predominance of final-year students in this study may explain the substantial improvement observed following the PBL intervention.

Cognitive competency appeared higher immediately after the intervention compared with the pretest, as shown by the greater proportion of participants categorized as having a high level of knowledge. This change may suggest that the intervention helped participants strengthen their conceptual understanding and acquire new knowledge by linking theoretical principles with real-world disaster triage scenarios. These results are in line with previous studies indicating that PBL-based learning can enhance learning outcomes by supporting the integration of theory with clinical practice (22). In nursing education, similar approaches have been reported to improve patient safety knowledge and contribute to better knowledge retention over time (23). In addition, PBL-based triage training has been associated with improvements in triage accuracy, self-confidence, and clinical decision-making abilities (24). Taken together, these findings imply that PBL-based educational strategies may provide meaningful cognitive benefits and could help reduce knowledge gaps in disaster triage among nursing students. Nevertheless, since this study did not include a control group, the improvement observed cannot be attributed solely to the intervention.

Psychomotor competency was higher immediately after the intervention compared with the pretest, and all participants shifted to a higher competency category. This improvement may be linked to the combination of contextual problem analysis, hands-on practice, and immediate feedback, which helped participants connect theory with actual START triage procedures more directly. These findings align with previous studies showing that problem-based and simulation-based learning can support clinical performance and improve problem-solving skills among nursing students (25). In addition, other comparative studies have reported that simulation and active learning approaches tend to improve triage decision-making accuracy and practical skills when compared with traditional teaching methods (26). While simulation-based training is often highlighted for its ability to quickly build procedural skills, especially in areas like Basic Life Support (27), other approaches that blend problem-solving with practical exercises have also been shown to produce positive learning outcomes and better clinical performance (28). Similar results have been reported in disaster triage training, where such interventions help strengthen clinical response and mass-casualty management abilities (9). However, since this study did not include a control or comparison group, the results should be interpreted cautiously. It cannot be concluded that PBL is more effective than other teaching methods, nor that the observed improvements were caused solely by the intervention.

A larger effect size was found for changes in psychomotor competency compared to cognitive competency. However, this should not be taken to mean that PBL had a stronger direct effect on psychomotor skills. At baseline, most participants were in the poor psychomotor category, and none had reached a good level. In contrast, many participants already had moderate to high cognitive competency before the intervention. This difference suggests that the psychomotor domain simply had more room for improvement, which may have contributed to the larger observed change after the intervention. The design of the learning activities may also help explain this finding. Participants were actively involved in disaster-based scenarios, hands-on practice, victim assessment, prioritization, and START triage decision-making. These activities closely matched the skills measured in the psychomotor checklist, allowing participants to immediately apply what they had learned in a practical setting. Consistent with previous research, learning approaches that combine problem-solving with direct practice tend to enhance clinical performance and skill acquisition (25, 28). It is also important to consider that the posttest was administered immediately after the intervention. As a result, the improvement observed in psychomotor competency may reflect short-term learning effects, such as recent practice, task familiarity, and initial skill acquisition, rather than long-term

retention. Moreover, because cognitive and psychomotor competencies were assessed using different instruments and classification criteria, comparisons of their effect sizes should be made with caution. Future studies with longer follow-up periods and more controlled designs are needed to determine whether these improvements persist over time and how they compare with other teaching approaches (25, 28).

These findings offer several practical considerations for disaster nursing education and volunteer training, where a structured PBL-based START triage module could be used as an additional learning activity in disaster nursing courses, skills laboratories, and disaster preparedness programs for volunteers, involving small-group discussions, realistic mass-casualty scenarios, guidance from trained facilitators, self-directed learning, hands-on triage exercises, structured feedback, and competency-based evaluation; such a learning format may help students connect theoretical knowledge with clinical reasoning and real-time decision-making in situations that resemble mass-casualty events, and because this study only measured competency immediately after a single learning session without assessing long-term retention, repeated practice and periodic refresher training are also important to reinforce skills over time, so this approach should be considered a complementary method rather than a replacement for existing teaching strategies, with future implementation benefiting from further studies comparing different educational methods and examining whether improvements in competency are sustained in the long term.

LIMITATION

This study has several limitations. First, the use of a one-group pre-test–post-test design without a control group limits the study's ability to establish causal relationships between the intervention and the observed outcomes. Second, the study was conducted among nursing students serving as disaster volunteers in a single geographic area, which restricts the generalizability of the findings to other populations and contexts. Third, the post-intervention assessment was carried out immediately after the learning activity, thus only reflecting short-term learning outcomes and not capturing the long-term retention of cognitive and psychomotor competencies. Future research is recommended to employ a controlled experimental design, involve larger and more diverse samples, and include follow-up assessments to evaluate the sustainability of learning outcomes.

CONCLUSION

This study showed that students experienced noticeable improvements in both cognitive and psychomotor competency categories after participating in a PBL-based START triage intervention as disaster volunteers. In general, the results indicate that students demonstrated a better understanding of triage concepts and improved practical skills immediately after the learning activities. The increase in psychomotor competency appeared more pronounced than in cognitive competency. This may be related to the lower initial skill level in psychomotor aspects, the greater room for improvement, and the strong emphasis on hands-on practice during the intervention.

Overall, these findings suggest that a structured PBL approach could be a useful additional method in disaster nursing education and volunteer training to support the development of START triage competencies. However, since this study used a one-group pretest–posttest design without a comparison group, the improvements observed cannot be fully attributed to the intervention alone, and it cannot be concluded that PBL is more effective than other teaching methods. Future research is encouraged to use controlled study designs, involve larger and more varied samples, and include follow-up assessments to better understand causal relationships, compare different instructional approaches, and see whether the improvements are maintained over time.

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ACKNOWLEDGMENTS

The author expresses sincere gratitude to all nursing students who served as disaster volunteers and participated in this study for their time, commitment, and contributions throughout the research process. The author also extends appreciation to the Institute for Research and Community Service (LPPM) of Universitas Muhammadiyah Jember for its support during the implementation of the study. In addition, the author would like to thank all members of the research team for their dedication, collaboration, and assistance in the data collection process, intervention implementation, and data analysis. Their contributions were highly significant to the successful completion of this research.

FUNDING

This research was funded by the Institute for Research and Community Service (LPPM), Universitas Muhammadiyah Jember, through the Internal Research Grant Program of Universitas Muhammadiyah Jember, Indonesia. The funding body had no involvement in the study design, data collection, data analysis, interpretation of results, or manuscript preparation.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest in this study. The funding body had no role in the study design, data collection, analysis, or interpretation of data, manuscript preparation, or the decision to publish the results of the research.

ETHICAL APPROVAL

This study received ethical approval from the Health Research Ethics Committee of Universitas Muhammadiyah Jember, Indonesia (Approval No. 0033/KEPK/FIKES/XII/2025; approved on December 29, 2025). Written informed consent was obtained from all participants prior to data collection. Participant anonymity and confidentiality were maintained throughout the study.

APPENDIX A

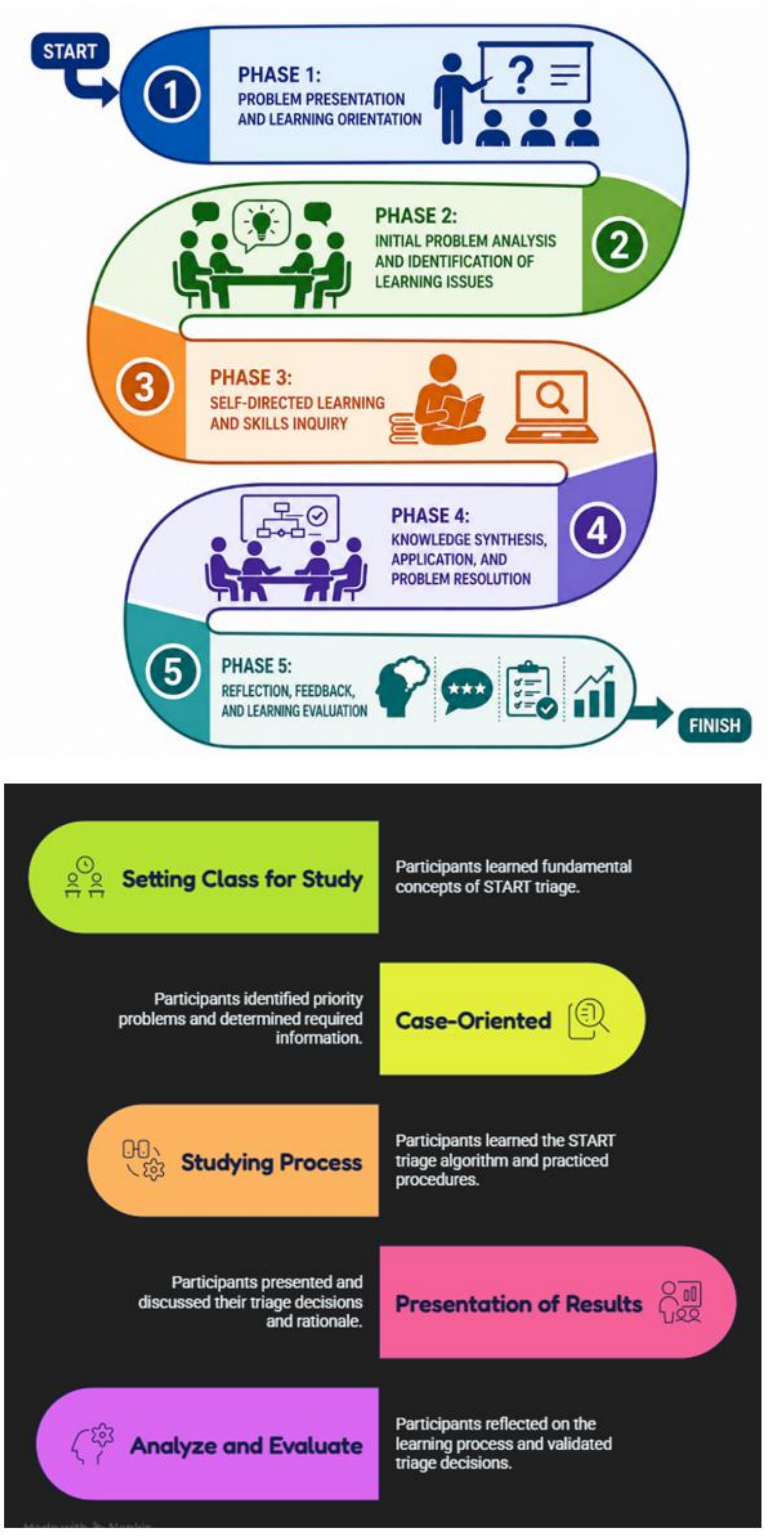


Figure A1. Framework of Problem-Based Learning Implementation in START Triage Training

Source: Yoesra et al., 2026

Figure A1. Framework of the Problem-Based Learning implementation for START triage, adapted from the principles described by Barrows and Tamblyn. The learning process began with an ill-structured mass-casualty problem, followed by initial problem analysis, identification of learning issues, self-directed learning, synthesis and application of newly acquired information, and reflection and evaluation. The facilitator acted primarily as a process guide, while participants assumed active responsibility for identifying their learning needs and resolving the presented problem.

APPENDIX B

Table B1. Protocol of Problem-Based Learning Intervention in START Triage Training

Phase	Learning Activities	Facilitator Activities	Student Activities	Duration
Problem Presentation & Orientation	Introduction to objectives, roles, and learning flow. Students are given a mass-casualty scenario as the trigger case.	Explain the process, clarify roles, present the scenario, and prompt questions without giving answers.	Read and understand the scenario, clarify terms, and identify key information.	20 minutes
Problem Analysis & Learning Issues	Group discussion to explore the scenario, activate prior knowledge, and define key learning gaps related to START triage.	Guide discussion with probing questions and help students identify what they know and need to learn.	Identify triage problems, share prior knowledge, and formulate learning issues.	30 minutes
Self-Directed Learning	Independent and group study of START triage, including assessment steps and classification criteria.	Monitor progress, suggest resources, and clarify misconceptions when needed.	Study materials, review START algorithm, and practice basic triage skills.	60 minutes
Synthesis & Application	Integration of new knowledge and application of START triage to the scenario.	Facilitate discussion, ask for justification, and provide feedback on reasoning and skills.	Apply START triage, assign categories, and explain decisions.	30 minutes

Reflection & Evaluation	Reflection on learning process, decisions, and performance.	Lead reflection and summarize key feedback points.	Reflect on performance, identify strengths and gaps, and summarize learning.	20 minutes
Total Duration				160 minutes

Source: Yoesra et al., 2026

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