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Journal of General Education and Humanities Vol. 5, No. 1, February 2026, pp. 177 – 190, https://doi.org/10.58421/gehu.v5i1.863 ISSN 2963-7147 177 Journal homepage: https://journal-gehu.com/index.php/gehu Designing GeoGebra-Supported Instruction on Systems of TwoVariable Inequalities in Vocational High Schools under the Kurikulum Merdeka Framework Desvi Astutiana1, Erviani Fajri2, Geby Fitrya Adrian3, Desi Engriani4, Lichia Rahmat5, Zelhendri Zen6 1,2,3,4,5,6Program Studi Teknologi Pendidikan, Sekolah Pascasarjana , Universitas Negeri Padang Article Info ABSTRACT Article history: Received 2025-11-09 Revised 2025-12-14 Accepted 2025-12-16 The Merdeka Curriculum emphasises student-centred, contextual, and problem-based mathematics learning, including in Vocational High Schools (SMKs). One of the key competencies in phase E is the ability to represent and interpret Two-Variable Linear Inequality systems, which requires mastery of both algebraic and graphical representations in an integrated manner. Recent studies indicate that integrating GeoGebra can enhance students' conceptual understanding, motivation, and mathematical literacy across various algebra and geometry topics. However, instructional designs that specifically guide the use of GeoGebra for the Two-Variable Linear Inequality systems in SMK within the Merdeka Curriculum context remain limited. This article aims to develop a framework for designing GeoGebra-assisted learning of Two-Variable Linear Inequality systems for Grade X SMK students. The approach employed is a targeted literature review of the implementation of GeoGebra 4 in mathematics learning from 2017–2025, combined with an analysis of the Merdeka Curriculum Learning Outcomes and Learning Objectives, and a study of student worksheets (LKS) featuring a series of GeoGebra activities designed by the authors. The review results in a set of design principles, including: the use of dynamic visuals to bridge symbolic and graphical representations, sequencing worksheets from guided exploration to vocational problem-solving, and integrating formative assessments based on screenshots and student reflections in GeoGebra. This framework is expected to serve as a reference for SMK teachers in designing more meaningful TwoVariable Linear Inequality system lessons aligned with the Merdeka Curriculum, while also opening avenues for further

empirical research on the effectiveness of the proposed design. Keywords: Geogebra Kurikulum Merdeka Systems Of Two-Variable Inequalities Vocational High Schools Corresponding Author: Desvi Astutiana Universitas Negeri Padang Email: desvyastutiana72@guru.smk.belajar.id

https://doi.org/10.58421/gehu.v5i1.863 1. INTRODUCTION Strengthening literacy and numeracy has become one of the main focuses of education reform in Indonesia [1]. The Merdeka Curriculum and National Assessment place problemsolving, reasoning, and mathematical modelling as key competencies, measured through the Minimum Competency Assessment (AKM) in numeracy [2]. AKM no longer evaluates rote memorisation but assesses students' ability to apply mathematical concepts to analyse situations and make decisions [3]. At the same time, international studies indicate that Indonesian students' mathematical literacy achievements still need improvement. The PISA 2022 study reported Indonesia's average mathematics literacy score at 366, ranking the country between 63rd and 70th out of 81 countries, well below the OECD average [4]. These findings emphasise the importance of more meaningful, contextual, and problem-oriented mathematics learning, in line with the spirit of the Merdeka Curriculum [5]. The context of Vocational High Schools (SMK) presents both unique challenges and opportunities. In 2023, there were approximately 14,252 SMKs in Indonesia, with more than 5 million students [6]. Most SMK graduates are expected to be job-ready, making the ability to model production constraints, budgeting, scheduling, and capacity highly relevant. TwoVariable Linear Inequality systems (2VLI) play a crucial role in representing solution regions for various constraints, such as in production planning, optimising raw material usage, or determining profitable service combinations [7]. According to the Phase E Mathematics Learning Outcomes of the Merdeka Curriculum, students are expected to represent, analyse, and interpret functional relationships and linear models in real-life contexts [8]. The topic of two-variable linear equations and inequalities is a key prerequisite for achieving these competencies, including supporting elements of modelling and decision-making. However, various studies indicate that many students still encounter difficulties with this topic [9]. Several studies in Indonesia have found that students often make conceptual and procedural errors when solving 2VLI problems. These errors include misinterpreting inequality symbols, incorrectly drawing boundary lines, and misidentifying solution regions. Such difficulties appear across students of high, medium, and low ability levels, affecting their capacity to solve contextual problems involving multiple constraints simultaneously [10]. This indicates the need for instructional approaches that help students better connect symbolic and graphical representations, rather than simply memorising algorithmic steps [11]. Advances in digital technology offer opportunities to address these challenges. GeoGebra, a dynamic mathematics software, is widely used to visualise functions, geometry, and algebra interactively. Numerous studies show that using GeoGebra positively impacts conceptual understanding, procedural knowledge, and student engagement 1 in mathematics learning [12]. A recent meta-analysis confirms that GeoGebra effectively enhances conceptual understanding and various learning outcome indicators across different educational levels [13]. Specifically, in the topic of two-variable linear inequalities, several studies have integrated GeoGebra to support problem-solving and visualise solution regions.

https://doi.org/10.58421/gehu.v5i1.863 GeoGebra, when used in problem-based learning models, contributes to improved mathematical problem-solving skills [14]. GeoGebra for visualising two-variable linear inequality graphs and reported an increase in SMK students' mathematical communication skills [15]. Other studies have developed linear inequality learning designs with GeoGebra Classroom using a discovery learning model to strengthen student engagement [16]. Nevertheless, most of these studies focus on testing the effectiveness of developed learning models or media rather than on presenting a systematic, detailed, and replicable instructional design framework for teachers across various SMK contexts. Moreover, few studies explicitly refer to the Phase E Mathematics Learning Outcomes and Objectives of the Merdeka Curriculum or link them to the specific vocational needs of SMK students, such as production, service, and business planning contexts. In other words, there remains a gap in providing comprehensive guidance for designing 2VLI learning with GeoGebra that integrates the demands of the Merdeka Curriculum, SMK student characteristics, and authentic vocational student needs. Based on this situation, the research problem addressed in this article is: how to design a GeoGebra-assisted instructional design framework for two-variable linear inequality systems for Grade X SMK that aligns with the Phase E Mathematics Learning Outcomes of the Merdeka Curriculum and supports [6] the development of students' vocational competencies. To address this problem, the article aims to develop an instructional design framework encompassing learning objectives, principles for context selection, worksheet sequencing, utilisation of GeoGebra features, and integrated formative assessment design. The contribution of this article is both theoretical and practical. Theoretically, it enriches the literature on integrating dynamic technology into mathematics learning by emphasising instructional design as the primary focus rather than merely evaluating outcomes. The design framework combines research findings on GeoGebra with the perspective of the Merdeka Curriculum and SMK learning needs. In practice, the article provides a reference for teachers to design more meaningful, contextually aligned 2VLI lessons aligned with the Merdeka Curriculum Learning Outcomes, while also opening avenues for further empirical research to examine the effectiveness of the proposed design framework across various vocational school contexts in Indonesia. 2. METHOD This study employs a qualitative descriptive approach focused on developing a learning design framework for teaching systems of linear inequalities in two variables (SLITV) using GeoGebra for Grade X vocational high school students. The research is conceptual in nature and does not include classroom trials. The article presents findings derived from a directed literature review, curriculum document analysis, and examination of student worksheets (LKS) designed to integrate GeoGebra-based activities. The data sources are not student participants, but rather documents and instructional design products. Primary data include curriculum documents from the Merdeka Curriculum, especially the Mathematics Learning Outcomes (CP) and Learning Objectives (TP) for Phase E along with supplementary official documents; national and international research articles related to GeoGebra, student difficulties in learning SLITV, and worksheet design; as well as a set of

planned GeoGebra learning activities constructed by the researcher based on vocational contexts relevant to vocational schools. The researcher serves as the main instrument responsible for planning, collecting, and analysing data. The research process is supported by several analytical tools, including a literature review sheet to record essential information from selected articles, a CP–TP mapping matrix to align curriculum requirements with learning design needs, a worksheet analysis sheet to identify cognitive structure and potential misconceptions, and a design framework template to organise analytical results into learning principles, activity sequences, and formative assessment plans. The research procedure follows several stages, beginning with defining the study's focus, emphasising the use of GeoGebra as the primary instructional medium, and highlighting its relevance to curriculum requirements and vocational contexts. The researcher then searches for, selects, and documents relevant literature based on predefined eligibility and relevance criteria. Curriculum documents are reviewed to identify competency demands in mathematical reasoning, representation, problem-solving, and modelling. Based on this analysis, the researcher develops initial drafts of GeoGebra learning activities, analyses each worksheet that has been designed, and identifies cognitive steps, prerequisite knowledge, and potential areas of misconception. Findings from these analyses are subsequently synthesised into a comprehensive learning design framework that includes overarching principles, structured learning sequences, and formative assessment strategies aligned with GeoGebra features. Data analysis in this study uses qualitative content analysis and thematic analysis. Each literature source is categorised according to the purpose of GeoGebra use, the types of activities, the reported research outcomes, and the implications for SLITV learning design.

Curriculum documents are coded to extract statements on mathematical representation, modelling, problem-solving, and communication skills. Worksheet analysis examines alignment between learning goals, task sequences, and mathematical representations activated through GeoGebra. All analytical results are integrated to formulate a complete set of design principles, instructional components, and sample activity scenarios, which serve as the core output of the study and provide a foundation for future empirical implementation in classroom settings. 3. RESULTS AND DISCUSSION 3.1. Result Mapping of Learning Outcomes and Learning Objectives An 1 analysis of the Learning Outcomes (CP) and Learning Objectives (TP) for Mathematics Phase E in vocational high schools (SMK) yielded four competency clusters relevant to designing GeoGebra-assisted learning on systems of linear inequalities in two variables. First, 3 conceptual understanding of linear algebra. Students are expected to understand the general form of linear equations and inequalities in two variables, the meaning of coefficients and constants, and the relationship between symbolic expressions and the slope or position of a line on the coordinate plane. The mapping results indicate that this aspect is a crucial prerequisite before students engage with systems involving multiple

https://doi.org/10.58421/gehu.v5i1.863 inequalities simultaneously. Second, competencies in representation and graphical interpretation. The CP and TP documents emphasise students' ability to read, construct, and interpret graphs of linear functions and models in real-world contexts. In the context of SLITV, this is understood as the ability to connect inequalities to boundary lines, determine the appropriate type of line to use, and identify the region that satisfies one or more constraints. Third, competencies in modelling and contextual problem-solving. The CP–TP mapping matrix indicates a strong need for students to use linear models to analyse real-life situations and workplace problems. For vocational schools, this relates to the ability to translate vocational problems into systems of inequalities—such as constraints involving raw materials, working hours, machine capacity, or production targets—and then use these models to make reasonable decisions.

Fourth, competencies in mathematical communication and reflection. Explicitly and implicitly, the CP and TP encourage students to explain their reasoning, steps, and interpretations, both orally and in writing. The mapping indicates that SLITV learning in vocational settings must provide opportunities for students to articulate why a certain region is considered a solution set, why a particular point is feasible or not, and what the solution means in terms of vocational decision-making. These four clusters of competencies serve as the primary reference for formulating specific learning objectives and for analysing the suitability of the GeoGebra worksheets developed in this study. Synthesis of Literature on GeoGebra, SLITV, and Student Worksheet (LKS) Design An analysis of the collected literature reveals several strong thematic patterns. First, almost all the reviewed articles highlight GeoGebra's role as a bridge between symbolic and visual representations. GeoGebra is used to demonstrate graphical changes when coefficients or constants are modified, to emphasise the relationship between the algebraic form and the slope or intercept of a line, and to visualise solution regions arising from one or more linear inequalities. The synthesis indicates that the success of GeoGebra-based learning depends largely on how the activities compel students to connect multiple representations, rather than merely follow teacher-directed procedures. Second, the literature identifies three dominant patterns of GeoGebra use in classroom activities: interactive teacher demonstrations, guided student explorations, and project-based or contextual problem-solving. In demonstration-oriented activities, GeoGebra primarily functions as a presentation tool. In guided explorations, students directly manipulate objects and infer patterns from their observations. In problem-solving activities, GeoGebra is used as a tool to construct and analyse mathematical models derived from real-world contexts. Third, in topics closely associated with SLITV, several studies report a reduction in procedural errors when students employ GeoGebra to draw boundary lines and identify solution regions. Students make fewer mistakes in placing lines or shading regions because they can immediately observe the graphical consequences of altering an equation. However, the literature also warns that without well-designed student worksheets, learners tend to follow technical instructions mechanically and fail to develop a deeper conceptual understanding.

https://doi.org/10.58421/gehu.v5i1.863 182 Fourth, research on worksheet design within dynamic mathematics software environments emphasises the need for planned variation and for question sequences that prompt student explanations. The analysis shows that effective worksheets typically follow a structure that progresses from exploring a single simple situation, to comparing several variations, and finally to generalising and applying the ideas in new contexts. This pattern serves as the foundation for structuring GeoGebra-assisted SLITV worksheets in this study. Overall, the synthesis suggests that GeoGebra offers significant potential to address difficulties in representation and visualisation related to SLITV. However, this potential can only be realised if worksheet design actively engages students in explaining, connecting ideas, and reflecting on their mathematical reasoning. 1 Analysis of the Developed GeoGebra Student Activities An analysis of the series of GeoGebra activities developed by the author reveals both strengths and areas for improvement in the initial design. In the initial stage, students focus on exploring the relationship between linear equations and line graphs. They are asked to modify coefficients and constants in GeoGebra and then observe changes in line position and slope. The analysis shows that this stage aligns well with competencies in conceptual understanding and graphical representation, as students must record observed patterns and conclude the relationship between algebraic form and graphical behaviour. However, the analysis also indicates the need for additional questions that prompt students to connect their exploration results to real contexts, such as production capacity or time constraints. The following stage shifts to representing a single inequality. Students are instructed to convert boundary equations into inequalities, determine the appropriate type of line, and use GeoGebra's shading feature to mark solution regions. The worksheet analysis shows that this activity explicitly targets skills in identifying boundary lines and shading directions. A critical issue identified is the potential misconception regarding inclusive versus exclusive boundary lines; therefore, the design was improved by adding examples contrasting the use of “greater than or equal to” and “greater than” symbols. The third stage involves combining two inequalities to form a system. Students are tasked with constructing two inequality models from a situational description and visualising each solution region. They then use GeoGebra to identify the intersection area that satisfies both constraints. The analysis indicates that this activity closely aligns with modelling [3] and problem-solving competencies, as students must translate contextual descriptions into mathematical models, assess model accuracy, and interpret the intersection region. However, there is a need to strengthen the reflection component, for example, by adding prompts that ask students to explain the meaning of boundary points in the intersection and distinguish them from points outside the solution region. The fourth stage focuses on more complex vocational contexts, such as planning product or service combinations with multiple resource constraints. Students work with systems involving more than two inequalities and use GeoGebra to determine feasible solution regions. The analysis shows that worksheets at this stage can activate all competency clusters: conceptual understanding, representation, modelling, and communication. However, the analysis also highlights the need for additional scaffolding

for lower-ability students, particularly in the initial step of translating contextual narratives into algebraic models. The final stage consists of a reflective component that requires students to explain, in writing, the relationships among equations, inequalities, lines, and solution regions, as well as how GeoGebra assisted their understanding. Analysis shows that this reflection stage is essential for strengthening mathematical communication and metacognition. The initial design was therefore revised by adding more structured reflective prompts, such as asking students to identify a common error and explain how GeoGebra helped correct it. Overall, the worksheet analysis indicates that the design of GeoGebra activities already follows a cognitive progression from exploration and formalisation to contextual modelling.

Nonetheless, the analysis also underscores the need to strengthen vocational context integration explicitly and to establish more systematic formative assessment mechanisms. Identified Instructional Design Principles A synthesis of the literature analysis, curriculum documents, and worksheet evaluations resulted in several instructional design principles for GeoGebra-assisted learning of systems of linear inequalities in two variables (SLITV) for Grade X vocational school students. This section remains within the domain of research findings, as it presents the main products of the analysis process. First, the design must explicitly bridge symbolic and graphical representations. Each GeoGebra activity should include questions that prompt students to connect algebraic expressions with their corresponding graphs and solution regions, rather than simply following technical procedures. Second, the sequence of worksheets should progress from structured exploration of a single constraint to systems involving multiple constraints, and finally to modelling vocational contexts. This sequence enables students to gradually build conceptual understanding before engaging with the complexity of real workplace situations. Third, worksheet contexts should reflect vocational realities in SMK. Problems presented should portray realistic scenarios of production, service operations, or resource management encountered by vocational school graduates, so that students perceive the direct function of SLITV concepts in decision-making. Fourth, GeoGebra should be used not merely as a drawing tool, but as a thinking tool. Activities must encourage students to manipulate objects, predict outcomes, test their conjectures, and reinterpret solutions within the problem context. Fifth, formative assessment must be integrated throughout the learning sequence. Teachers should utilise screenshots, student exploration notes, and brief written reflections to provide rapid and specific feedback on students' 3 conceptual understanding of SLITV and their use of GeoGebra. These principles form the foundation for presenting the instructional design framework in the discussion section, which will elaborate on how these principles can be operationalised in concrete lesson scenarios for Grade X vocational mathematics classrooms.

https://doi.org/10.58421/gehu.v5i1.863 3.2. Discussion Alignment of the Design with the Orientation of the Kurikulum Merdeka The 1 analysis of the Learning Outcomes (Capaian Pembelajaran/CP) and Learning Objectives (Tujuan Pembelajaran/TP) for Mathematics in Phase E indicates that instructional design for systems of linear inequalities in two variables (SLITV) must move beyond procedural drills. The design should guide students to engage with representations, reasoning, and modelling in real-world contexts rather than merely executing algebraic steps. The design framework developed in this study reflects this orientation. The sequence of learning from exploring linear functions, single inequalities, and systems of inequalities to vocational contexts represents a shift from focusing on mathematical objects to applying concepts for decision-making. In other words, learning does not stop at drawing lines and shading solution regions; students are encouraged to interpret feasibility, evaluate resource constraints, and consider practical implications of given conditions. The explicit connection to vocational contexts is a crucial element often missing in mathematics instruction at vocational schools (SMK). Many algebra topics are still taught through abstract exercises disconnected from students' future work environments. The design framework presented in this study aims to bridge this gap by positioning SLITV as a language for describing real workplace constraints, such as limited machinery capacity, production time, staffing, material use, or service limits. This supports the competencies promoted in the Kurikulum Merdeka, which emphasise meaningful problem-solving, datadriven decision-making, and the application of mathematical models in authentic situations. Recent studies on Kurikulum Merdeka demonstrate that mathematics learning becomes more relevant and comprehensible when instructional models emphasise exploration, representation, and real-life problem solving. Instructional models such as problem-based learning, project-based learning, and discovery learning, when tailored to student characteristics, align well with the goals of the Kurikulum Merdeka and increase students' understanding of mathematical concepts through relevant, contextual activities [17]. Implementation of the Kurikulum Merdeka supports the development of students' mathematical representation skills, especially when digital tools and contextual learning media are integrated [18]. The use of GeoGebra in this design demonstrates these principles. GeoGebra is not merely a drawing tool but a reasoning tool that supports visualisation, parameter manipulation, hypothesis testing, and reflection on solution meanings in real contexts. Such digital integration is aligned with contemporary mathematics education research, which highlights the importance of dynamic visualisation tools in supporting conceptual understanding and model-based reasoning. Overall, the design framework aligns with the principles of the Kurikulum Merdeka by ensuring that mathematics learning for vocational school students is meaningful, contextual, and directed toward critical thinking and mathematical decision-making. Students are not only learning how to solve SLITV problems, but why they need them and how the concepts can be used to model real constraints and optimise decisions in authentic vocational situations.

https://doi.org/10.58421/gehu.v5i1.863 GeoGebra as a Representational Bridge and Thinking Tool The literature indicates that one of the most persistent barriers students face when learning systems of linear inequalities in two variables (SLITV) is the transition between symbolic and graphical forms. Many students perceive equations and inequalities merely as strings of symbols rather than as representations of lines, regions, and constraints in a coordinate plane. This representational disconnect significantly hinders their ability to understand feasible solution sets and interpret mathematical models in real contexts. The instructional design developed in this study positions GeoGebra as a representational bridge rather than simply a drawing instrument. Each activity not only guides students through technical procedures but also incorporates prompting questions that require them to explain the relationship between algebraic parameters and visual outcomes. Students are pushed to articulate how changes in coefficients affect line slopes, or how different inequality symbols determine the position and shading of solution regions. Through this approach, GeoGebra becomes a thinking tool that helps students visualise, test, and revise their ideas concerning relationships among mathematical objects. Shifting the learning process from example-following to exploratory reasoning is a key outcome of this integration. Rather than merely repeating a set of procedural steps, students observe patterns, pose conjectures, and test them by modifying objects on the screen. When a line shifts due to a coefficient change, students can immediately associate that shift with the coefficient's numerical meaning in the algebraic model. This immediacy is a central advantage of dynamic mathematics software: ideas that were previously abstract or imagined become visible, manipulable, and testable. Several studies support this cognitive benefit of using GeoGebra as a dynamic environment for representation, reasoning, and model construction. GeoGebra enhances students' ability to "see" structural relationships in algebraic expressions because it enables direct manipulation of parameters and constants [19]. The Integration of GeoGebra in lessons on linear systems reduced representational errors and supported conceptual understanding by making visible the impact of symbolic changes on graphical outcomes [20]. When activities are well-designed with reflective questions, students develop mathematical reasoning skills by predicting graphical changes, testing hypotheses, and interpreting solution sets [21]. Thus, in this instructional design, GeoGebra is not employed merely as a visualisation tool but as a cognitive scaffold that supports representational fluency and encourages students to think mathematically. The goal is not simply accurate graphing but developing the ability to reason about algebraic relationships, evaluate contextual constraints, and justify solution strategies based on visual and symbolic evidence. Through such design, GeoGebra functions as an environment for exploration, inquiry, and meaningful conceptual understanding in learning SLITV. Strengths of the Worksheet Design in the SMK Vocational Context One of the most significant contributions of this instructional design is the systematic integration of vocational contexts specific to SMK (Indonesian vocational high schools). Many studies on the use of GeoGebra remain limited to general contexts, such as mixture problems or comparisons of different ticket prices. In contrast, this study intentionally brings mathematical applications closer to real workplace situations encountered by SMK graduates. At intermediate and advanced stages, students work with situations such as planning product combinations, scheduling services, and determining machine capacity constraints. They are required to translate contextual narratives into systems of linear inequalities, then use GeoGebra to identify feasible solution regions and interpret the mathematical meaning of available options. In doing so, GeoGebra becomes not only a visualisation tool but also a modelling environment in which vocational decision-making can be simulated and evaluated mathematically. This approach strengthens two pedagogical dimensions. First, relevance. Students can clearly see why understanding systems of linear inequalities matters. Concepts are no longer confined to test-paper exercises but are tied to production efficiency, operational scheduling, and resource allocation. Research shows that when mathematical activities are situated in relatable contexts, students display greater motivation, persistence, and conceptual engagement [22]. Second, conceptual depth. When students are asked to explain the meaning of the intersection region in terms of limited raw materials or working hours, they are compelled to connect each point on the graph with real decision consequences. The contextualised GeoGebra tasks support deeper reasoning, particularly in distinguishing feasible and non-feasible solutions [23]. However, the worksheet (LKS) analysis also revealed that integrating vocational contexts requires appropriate scaffolding, especially for students with limited foundational algebra skills. The translation from narrative context to an algebraic model is often the most challenging step. Many vocational students struggle not with graphing inequalities but with formalising constraints from textual descriptions. The results of this study, therefore, suggest the need for additional step-by-step examples, guided questioning, and structured classroom discussions during the early stages of mathematical modelling [24]. From an instructional design perspective, this implies that successful vocational integration is not merely a matter of inserting industry-based narratives into worksheets. Instead, it requires intentional scaffolding, opportunities for student reflection, and explicit modelling of how professionals use mathematics to make decisions in practical work environments. When these supports are in place, integrating vocational contexts strengthens mathematical understanding and helps students view systems of inequalities as meaningful tools for problem-solving in real-world industries. The Role of Formative Assessment and Reflection in GeoGebra-Supported Learning The proposed instructional framework positions formative assessment as an integral component rather than an add-on at the end of learning activities. Teachers are encouraged to use student screenshots, GeoGebra exploration notes, and short written reflections as a basis for providing feedback. In line with current research on classroom assessment practices 3 in mathematics education, this design treats student work not simply as evidence of performance but as evidence of thinking processes [25], [26]. This approach yields at least three key benefits. First, teachers gain richer insight into students' reasoning. Errors are not limited to final answers, but surface throughout

https://doi.org/10.58421/gehu.v5i1.863 exploratory steps. For example, teachers can identify patterns such as repeated shading of the wrong region or arbitrary changes to coefficients without conceptual understanding. Research shows that capturing student actions during dynamic software use enhances diagnostic accuracy because teachers can see how misconceptions develop rather than merely identifying their end products [27]. Second, students are encouraged to value learning processes rather than only results. When students are asked to reflect on how GeoGebra helped them understand linear inequality systems, they examine their own strategies, assumptions, and problem-solving choices. This reinforces students' metacognition by helping them understand how they learn and make decisions. Studies in technologyenhanced mathematics learning consistently find that reflection tasks improve conceptual transfer and self-regulated learning [28]. Third, formative assessment integrated with GeoGebra aligns strongly with the spirit of the Kurikulum Merdeka. Teachers do not wait until summative exams to evaluate student understanding. Instead, they provide fast, specific feedback that students can immediately apply in the next activity. This is especially crucial in conceptual topics such as systems of linear inequalities, where small misconceptions can easily crystallise into persistent patterns of reasoning. Rapid, ongoing feedback allows teachers to correct misunderstandings while student ideas remain flexible and modifiable. Moreover, integrating formative assessment with technology supports the principle of "assessment as learning," where students become active participants in monitoring their own progress [29]. In this design, saving GeoGebra screenshots, annotating reasoning, and writing micro-reflections transform assessment from a passive evaluation process into an active learning strategy. Rather than merely being judged, students become observers of their own thinking, able to identify strengths, weaknesses, and areas requiring further exploration. These findings suggest that the success of GeoGebra-assisted instruction depends not only on the quality of worksheet design but also on how assessment is embedded throughout the learning sequence. Formative assessment practices facilitate a feedback loop that makes conceptual growth visible, supports teacher decision-making, and fosters student agency in mathematical thinking. 4. CONCLUSION This article develops a design framework for teaching systems of linear inequalities in two variables (SLITV) using GeoGebra for Grade X vocational high school (SMK) students within the Merdeka Curriculum. Based on an analysis of Curriculum Achievement Indicators, Learning Objectives, literature synthesis, and student characteristics, several key findings emerge. First, mapping the curriculum documents highlights four essential competency clusters that must become the focus of instructional design: 3 conceptual understanding of linear algebra, representation and interpretation of graphs, contextual problem modelling and solving, and mathematical communication and reflection. These clusters require instructional approaches that integrate symbolic, visual, and vocational representations rather than relying solely on procedural practice. Second, the literature synthesis indicates that GeoGebra is effective as a bridge between symbolic and graphical representations, helping students observe relationships among coefficients, equations, line graphs, and solution regions. However, this effectiveness

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is evident only when teachers design worksheets (LKS) that encourage exploration, explanation, and reflection, not merely technical demonstration. Third, the analysis of the developed GeoGebra worksheets yields a sequence of learning activities ranging from exploring linear graphs, single inequalities, and systems of inequalities to vocational modelling tasks. This sequence provides a progressive conceptual structure that prepares students to apply their understanding in work-related contexts. The findings also reveal the need for additional scaffolding at the stage of translating contextual narratives into algebraic models, as well as reinforcement of reflective components. Fourth, synthesising all findings produces a set of design principles: instruction must explicitly connect symbolic and graphical representations; student activities should progress from exploration to vocational modeling; worksheet contexts must be relevant to SMK work environments; GeoGebra should be positioned as a thinking tool rather than merely a drawing tool; and formative assessment must be integrated through screenshots, exploration notes, and student reflections. Theoretically, this study affirms that integrating dynamic mathematical technology in learning requires close attention to curriculum demands, an understanding of student learning difficulties, and clearly articulated design principles. Practically, the resulting framework can serve as a starting point for SMK mathematics teachers to design GeoGebraassisted lessons on SLITV. Schools and teacher education programs can also use this framework to develop training initiatives that emphasise task design, integration of vocational context, and formative assessment in digital environments. This study has several limitations. It remains conceptual, without empirical classroom implementation data; the vocational contexts used are still limited; and the literature review, although directed, may not cover all relevant studies. Therefore, future research is recommended to test this design framework in real classrooms using mixed-methods approaches, broaden the diversity of SMK vocational contexts, apply the framework to other mathematics topics relevant to vocational education, and explore teacher professional development strategies for designing and facilitating GeoGebra-assisted learning

sustainably. ACKNOWLEDGEMENTS The researcher would like to express sincere gratitude to all parties who have contributed to the completion of this study. Special appreciation is extended to the mathematics teachers and curriculum developers whose insights into the Merdeka Curriculum provided valuable guidance for developing the instructional design framework. The contributions of colleagues and peers who shared constructive feedback on integrating GeoGebra into vocational contexts have also been instrumental in improving the clarity and relevance of this work. Deep thanks are also extended to the academic community and the authors of prior studies on dynamic mathematical software, representational understanding, and technologyenhanced learning, whose research provided an essential foundation for this article. Finally, the researcher hopes that this study will support the further development of innovative mathematics learning in vocational schools and contribute to improving instructional

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