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Development of Hybrid Problem-Based Learning (HyProBeL) Learning Model on Basic Programming Algorithm Material

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ABSTRACT

Objective: Hybrid learning is environmental learning through the internet used in groups. Hybrid learning activities are expected so that students can actively ask and speak because learning is student-centered. **Method:** The type of research used by researchers is development research, known as Research and Development (R & D), which refers to the Borg and Gall model. **Results:** The research produces a product in the form of a model; the results show that the implementation of the HyProBeL learning model can improve critical thinking and problem-solving skills. Research findings related to the HyProBeL learning model begin with the development of a Hybrid Problem Based Learning model for basic programming algorithm material. **Novelty:** The results of the development of the HyProBeL model obtained a development value of 95.1%, which has a very good category, with the conclusion that the HyProBeL model learning model has a validity level that is valid, effective, and practical to use.

INTRODUCTION

Hybrid learning is a learning environment through the internet that is used in groups, encouraging active student participation and discussions and making learning student-centered. The teacher in hybrid learning acts as both an instructor and a guide, aiming to optimize the teaching and learning system and support independent learning campuses (Mourtzis et al., 2023; Pischetola, 2022; Singh et al., 2021; Singh et al., 2021). Informatics subjects lay a foundation of computational thinking, an essential problem-solving skill crucial in the digital age. Students tackle computational problems that increase in complexity from class X to XII, developing from minor, simple problems to large, complex ones and from concrete to abstract issues. The algorithms and programming material in class X informatics subjects under the independent curriculum focus on creating programs using textual programming languages and applying computational thinking strategies to enhance critical thinking and problem-solving skills.

Preliminary studies at State Senior High School 1 Sidoarjo and 4 Sidoarjo, involving interviews with informatics teachers, revealed that informatics teaching for basic programming algorithm material in class X predominantly employs lecture, discussion, and question-and-answer methods. This approach leaves students struggling with fundamental programming problems, as they are not accustomed to problem-solving due to the traditional teaching methods. Teachers noted that students face difficulties in understanding and solving problems, having been rarely involved in active problem-solving exercises (Dita et al., 2021; Education et al., 2021; Hobri et al., 2020; Mangaroska et al., 2022). Interviews with students indicated that classroom learning fails to adequately convey informatics concepts, as teachers dominate the sessions with

explanations, limiting student participation. Observations confirmed that the current teaching approach does not effectively foster critical thinking Moreover, problem-solving is evidenced by students' low scores. The passive learning environment and underutilization of technology also contribute to students' challenges in mastering programming concepts.

The suboptimal learning outcomes are attributed to several factors: (1) learning remains one-directional, not fostering active knowledge construction; (2) students seldom verify their understanding of problems before attempting solutions; (3) traditional methods lack relevance to real-life and collaborative opportunities, leading to low student engagement and motivation; (4) students struggle with problem analysis, impeding their ability to apply higher-order thinking skills; (5) students underuse technology as a learning resource; (6) the prevalent low-order thinking model hampers the development of critical thinking and problem-solving skills. Developing these skills is crucial for students to discover new facts, concepts, and values.

The Hybrid Problem-Based Learning (HyProBeL) model addresses these issues by leveraging the strengths of both hybrid and problem-based learning approaches. It offers online and face-to-face learning flexibility, promoting interaction among students and with the teacher. HyProBeL enables comprehensive assessment and continuous feedback, helping students correct mistakes and deepen their understanding. The model emphasizes real-life problem-solving, encouraging students to think critically and apply their knowledge to practical situations. By incorporating the HyProBeL model in basic programming algorithms, students can better grasp programming concepts and enhance their critical thinking skills. Teachers facilitate individual or group learning, guiding students through problem-solving processes and coding solutions collaboratively.

Under the independent curriculum phase E, the high school informatics curriculum should focus on developing students as problem solvers who master core concepts, practice skills, and possess a broad, interdisciplinary perspective. Given these insights, the research aims to develop a Hybrid Problem-Based Learning (HyProBeL) model for teaching introductory programming algorithms, addressing the identified challenges and fostering essential 21st-century skills in students. This research introduces the HyProBeL model as an innovative approach to informatics education, aiming to create an effective learning environment that enhances critical thinking and problem-solving skills. Combining online and face-to-face learning with problem-based approaches, the HyProBeL model offers a robust framework for modern education, preparing students to meet the demands of the digital era. This study underscores the need for innovative teaching strategies to improve student engagement, understanding, and skill development in programming and computational thinking. How does the implementation of the Hybrid Problem-Based Learning (HyProBeL) model impact student engagement, understanding, and skill development in basic programming algorithms among high school students, and what specific elements of this model contribute most effectively to enhancing these outcomes?

RESEARCH METHOD

The type of research researchers use is development research, also known as Research and Development (R & D). Research and development are a process of developing and validating certain devices that become products, which, from an industrial perspective,

is the development of a product prototype before it is mass-produced (Adnan et al., 2022; Rizki et al., 2023, 2024). The product produced in this development research is the HyProBeL learning model in basic programming algorithm subjects to improve critical thinking and problem-solving skills for class X at 4th Senior High School Sidoarjo. The development model used in this research is a development model, also known as R&D, which refers to the Borg and Gall model (1983). According to Borg and Gall (2007), educational R&D is a process that develops and validates educational products. This means that education and development research is used to produce products based on field tests and then revise them, resulting in valid products that can be used. This development research is intended not to test the theory but to develop products used to support educational activities' success. The research was carried out with research activities, and a model was developed for use in the learning process.

Borg and Gall (1983) mention that in development research or R&D, there are ten steps or ten stages to develop a product, which include (1) Research and information collection, (2) Planning, (3) Dissemination and Implementation, (developing the initial form of the product), (4) Preliminary field testing (limited trial), (5) Main product revision, (6) Mainfield testing (field trial/large-scale test), (7) Operational product revision (operational product revision), (8) Operational field testing (operational field test), (9) Final product revision (final product revision), (10) Dissemination and Implementation. The essence of the Borg and Gall development model procedure can be illustrated in Figure 1.

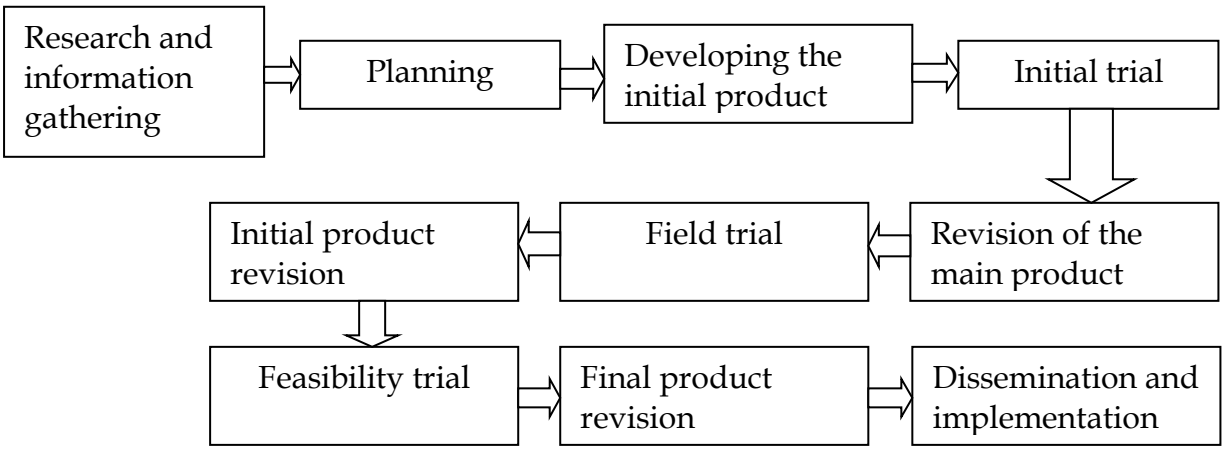

Figure 1. Borg and Gall Development Model (1983).

RESULTS AND DISCUSSION

Results

The discussion is carried out by comparing and/or matching the research results with theory or previous research results and interpretation related to things that are novelty from the research results. An important part of this chapter concerns the feasibility, practicality, and effectiveness of the Hybrid Problem-based Learning (HyProBeL) model on basic programming algorithm material to improve grade X students' thinking and problem-solving skills.

Feasibility of Hybrid Problem-based Learning (HyProBeL) Model and Device

The feasibility of the HyProBeL learning model to improve critical thinking and problem-solving skills is analyzed using assessment data by experts on the HyProBeL model that has been developed.

Learning activities take place according to situations with different needs and must be met effectively and efficiently, so it is necessary to design learning models according to learning needs and objectives by continuously improving learning whose focus is on creating and engineering existing or newly planned learning models, The learning model must create fun learning so that students are active, creative, and innovative during the learning process.

Informatics subjects provide a foundation for computational thinking, problem-solving ability, an important generic skill, and the rapid development of digital technology. Learners are challenged to solve computational problems that develop from class X to class XII, from little data to many data, from small and simple problems to large, complex, and complicated problems, and from concrete to abstract and vague or ambiguous things. Informatics subjects also improve learners' abilities in logic, analysis, and interpretation of data needed in literacy, numeracy, and science literacy and equip learners with programming skills that support modeling and simulation in computational science using ICT.

The Informatics learning process is student-centered learning with the principles of inquiry-based learning, problem-based learning, and project-based learning. Teachers can determine themes or cases according to local conditions, especially themes or cases about data analysis. Informatics learning supports students' ability to express structured thinking and understanding of syntactic and semantic aspects of language, forming the habit of logical thinking in mathematics, and the ability to analyze and interpret data in science.

Since the 2021/2022 academic year, the Independent Curriculum has been implemented in nearly 2500 schools participating in the Driving School Program and 901 Vocational Centers of Excellence as part of learning with a new paradigm. 4th SHS Sidoarjo is one of the first driving schools to implement an independent curriculum. The implementation of an independent curriculum enables teachers to implement fun learning. Fun learning with stages that learners can do. In addition, fun learning must prepare 4 21st century competencies, namely (1) critical, logical thinking, and problem-solving, namely the ability to think critically and solve problems; (2) communication and collaboration, which means the ability or skills of communication and collaboration or good cooperation, (3) creativity, and innovation skills, namely the ability to be creative and have innovative ideas, (4) information, and communications technology literacy, namely the ability to use and create technology in all fields, (5) contextual learning skills, namely the ability to develop their knowledge through contextual learning, (6) information, and media literacy skills, skill to utilize existing communication media.

The informatics learning element of programming algorithms expects students to be able to apply computational thinking with standard algorithmic strategies to develop computer programs structured in a textual procedural programming language as a solution to problems in various fields that contain discrete data in small volumes, work together to solve a complex problem by developing (designing, implementing, improving, testing) computational artifacts that are in contact with other fields according to the rules of the engineering process, and communicate orally and in

writing the product design, product and process. This element has been proven effective in enhancing students' creativity and independence while providing them with practical skills relevant to the needs of today's workforce. The HyProBeL learning model, applied to students, can improve students' understanding and learning creativity and help learners be active and independent in developing thinking skills and solving algorithmic problems. Learning Outcomes of informatics subjects must effectively increase students' creativity and independence while providing them with practical skills relevant to the needs of today's workforce, so students need to be equipped with knowledge in preparing learning activities that support 21st-century competencies.

Learning activities in informatics subjects still use one-way learning methods, so students feel bored with the informatics learning process with programming algorithm material. In learning informatics subjects, the emphasis is still on general knowledge, not yet directing students to have the ability to think critically and solve hybrid problems. Analysis of preliminary research results revealed that learning is still emphasized on low-level cognitive abilities. So far, the teacher has not assessed the ability to think critically and solve problems. Informatics subject elements of programming algorithms is a subject that studies procedural programming concepts in one of the procedural programming languages and can develop programs structured in algorithm notation or other notations based on appropriate algorithmic strategies. This subject requires thinking and solving problems by exploring knowledge from several learning sources. It involves students having varied abilities in applying learning and learning strategies according to student needs and improving the quality of learning. The initial research results became the basis for developing a learning model that combines hybrid learning and problem-based learning.

The HyProBeL learning model was developed in accordance with the stages of Borg and Gall (2003), resulting in a draft of the HyProBeL model. The draft HyProBeL model is in the form of a HyProBeL model book with supporting components, namely learning tools, including Teaching Modules, Teaching Materials, and student worksheets, as well as critical thinking and problem-solving skills assessment instruments. The model book and learning tools that support it are tested by learning design experts and material experts. In developing the HyProBeL model, three things must be met to ensure the learning model's quality: feasibility, practicality, and effectiveness. The feasibility of the model is carried out to test the accuracy of the variables in estimating the actual value (. The model feasibility test is used to determine the feasibility level of a model.

The results of the feasibility review show that the HyProBeL model is feasible according to learning needs. The feasibility test on the HyProBeL model was carried out with a validity test following the development stages of Borg and Gall (2003). The draft I was tested at the initial field trial stage and produced at the initial product development stage. Content and learning design expert validators conducted field trials. This stage aims to obtain suggestions for improvement from several experts. The initial design in the draft was validated by learning design experts and material experts. The results of validation that have been carried out by learning device experts designed valid and obtained suggestions for improvement to be used as a basis for improving learning devices. In the limited trial, the model book and supporting devices were revised according to the suggestions of experts and practitioners. The results of the expert validation test at the initial field trial stage obtained the results of the validator's

assessment of the HyProBeL model book of 3.93 with the criteria for the feasibility level can be used without revision.

The HyProBeL learning model integrates hybrid and problem-based learning models to improve critical thinking and problem-solving skills. The HyProBeL learning model was developed in accordance with six development components, namely l) theoretical rationale, 2) reaction principles, 3) syntax, 4) social system, 5) learning management support system, and 6) instructional and accompanying impacts. The HyProBeL model was developed by following the stages of Borg and Gall (2003) until a draft of the HyProBeL model was obtained, which was presented in the form of a model book and its supporting devices, including Teaching Modules, Teaching Materials, and student worksheet as well as instruments of critical thinking and problem-solving skills. Then, the model book and HyProBeL model tools are tested for feasibility by learning design and material experts.

The quality of learning model development must fulfill four elements: relevance, consistency, practicability, and effectiveness. Relevance means that strong and up-to-date theoretical studies must support a model. Consistency means that the model can be guaranteed its validity, constructively valid, which refers to the relevant stages between the components of the learning model starting from the rationale, syntax, social system, reaction principles, support system, instructional, and accompanying impacts. Practicability means the learning model must be practical and easily implemented in learning activities. While effectiveness is based on the achievement of the goals and results expected by the model,

The feasibility test of the HyProBeL model was carried out with validity and practicality tests in accordance with the Borg and Gall (2003) stage. The model was an initial field trial with expert validation of the model book and supporting devices, and empirical validity tests were carried out in limited trials and operational fields. Practicality test by testing the readability of the model book and its supporting devices in the limited field test. In this process, continuous improvements are made so that the final draft of the HyProBeL model is obtained.

The results of the expert assessment of the HyProBeL learning model book are very valid. This reflects that the components of content validity, which include development needs, current knowledge, learning model theory support, planning and implementing the HyProBeL model, HyProBeL model learning environment, and using evaluation techniques, are in the very valid category. This model book is content valid showing that the components of the HyProBeL model development needs are based on 1) the E phase independent curriculum which states that the curriculum must be able to encourage student curiosity, motivate lifelong learning, facilitate student learning, encourage students to think critically and do higher order thinking, 2) 21st-century skills foster HOTS (high order thinking skills), including communication, collaboration, critical thinking, creative thinking, computational logic, compassion and civic responsibility. Content validity means that there are elements of novelty and necessity. In contrast, constructively valid means consistency between parts of the model, the model developed, and the theory underlying it. The HyProBeL model can be tested in limited class and field trials.

The need for the HyProBeL learning model is related to the implementation of the independent curriculum in phase E. The HyProBeL learning model can be applied in the Informatics learning subject of the Programming Algorithm element and supports the implementation of the independent curriculum so as to achieve the competencies

expected by the curriculum. Applying the HyProBeL learning model includes activities to identify problems, formulate problems, collect information, process information, convey problem-solving, collaborate, and discuss in a hybrid manner so that students can master critical thinking and problem-solving skills. Critical thinking and problem-solving skills are 21st-century skills. The HyProBeL model is feasible to use in Informatics subjects of programming algorithm elements to improve critical thinking and problem-solving skills.

The construct validation of the HyProBeL model is determined by the consistency between stages in the syntax of the model, the ability of one component with another component, and the consistency between the model and the underlying theory. The HyProBeL learning model integrates hybrid and problem-based learning models to improve critical thinking and problem-solving skills. The HyProBeL learning model was developed by six development components, namely l) theoretical rationale, 2) reaction principles, 3) syntax, 4) social system, 5) learning management support system, and 6) instructional and accompanying impacts.

The HyProBeL learning model has shown consistency between parts of the model, which includes model syntax, social system, reaction principles, support system, and instructional and accompanying impacts. This consistency can be seen from the role of students and teachers, interactions between students, and interactions between teachers and students shown in each hybrid phase; student-centered hybrid learning activities make the teacher act as a facilitator, guide, and mediator. The HyProBeL learning model has shown consistency between phases in the model syntax. The HyProBeL model consists of 5 interrelated phases. The HyProBeL model syntax is highly valid and reliable. In problem orientation, structured problems are presented at the beginning of learning with everyday problems. In problem orientation, organization, and hybrid problem solving, the teacher acts as a facilitator and assists students in formulating problems operationally to take a problem-solving approach. The results of expert validation in the initial field trial obtained an average value of 3.93 for the model book component. This means that the model book can be used in the learning process to improve critical thinking and problem-solving skills.

The teacher prepares Learning tools so that the implementation and evaluation of learning can be carried out systematically and expectations can obtain results. Learning tools that support the HyProBeL learning model are 1) Teaching Module, 2) Teaching Materials, 3) student Worksheets, and 4) Instruments of critical thinking and problem-solving skills.

Teaching Module

A teaching module is one teaching tool that contains lesson plans to help direct the learning process to achieve Learning Outcomes. The development of teaching modules aims to provide teaching tools that can guide teachers in learning. The teaching module implements learning objectives developed from the Learning Outcomes with the Pancasila Learner Profile as the target. Teaching modules are arranged according to the phase or stage of learner development, considering what will be learned with learning objectives and based on long-term development. Teachers need to understand the concept of teaching modules to make the learning process more enjoyable and meaningful. The HyProBeL model Teaching Module is adapted to the syntax of the HyProBeL model and aims to improve critical thinking and problem-solving skills. The

teaching module's average validation score is 3.80, a very valid category. This means that the teaching module can be used without revision.

Teaching Materials

The aspect that concerns media experts is the ease of accessing and using online learning applications as a learning resource. From the perspective of learning resources, the hybrid learning model with a PBL approach for basic programming algorithm material is a planned learning resource (by design) in the form of printed materials. Related to this, AECT (1986: 9) explains that learning resources can be grouped into two parts, namely: (1) learning resources that are planned (by design), namely all learning resources that have been specifically developed as components of the instructional system to provide directed and formal learning facilities; and (2) learning resources because they are utilized (by utilization), namely sources that are not specifically designed for learning purposes but can be found, applied and used for learning purposes.

Furthermore, it can be explained that the provision of stimulus in the form of examples, selection of type, shape, and size of letters for the graphical component of the presentation contained in printed teaching materials (modules) and online learning is also related to efforts in creating learning conditions, namely providing learning stimulus. In other words, the design contained in printed teaching materials (modules) and online learning is expected to foster learning motivation for students and can obtain effective learning outcomes. The average validation score of the teaching materials developed is 3.88, which is a very valid category. This means that teaching materials can be used without revision.

Student worksheets

Student worksheets are a means to assist and facilitate teaching and learning activities so that effective interactions between students and educators can increase student learning activities and achievements. Student worksheets make students more active in learning activities. In contrast, student worksheets help students understand and practice the material that will be or is being learned. The developed Student worksheet must be valid, practical, and effective. The student worksheet in the HyProBeL model uses the syntax of the HyProBeL model, which refers to critical thinking and problem-solving skills. The average validation score of the developed Student worksheet is 3.90, with a very valid category, which means that this Student worksheet can be used without revision.

Critical Thinking Skills Instrument

The feasibility of the research instrument includes an assessment of the critical thinking ability instrument. The critical thinking skills test instrument was validated by experts who teach informatics. The validation results were used as the basis for revising the critical thinking skills assessment instrument, which showed the average of all aspects assessed on the critical thinking skills instrument assessment instrument of 3.9 with very valid criteria. So, the critical thinking ability assessment instrument can be feasible without revision. Validation was carried out on the critical thinking skills instrument after a limited trial, and the validity calculation result was 0.63 with high criteria and a reliability of 0.91. In the operational field trial, the results of the validity of the critical thinking ability instrument were calculated. The validity calculation result is 0.63 with

high criteria and reliability of 0.811. This means the critical thinking skills instrument is valid and feasible without revision.

Problem-Solving Skills Instrument

The feasibility of the research instrument includes the assessment of the problem-solving instrument. The problem-solving ability test instrument was validated by experts who teach informatics. The validation results were used as the basis for revising the problem-solving ability assessment instrument, showing the average of all aspects assessed on the problem-solving ability instrument of 3.87 with very valid criteria. So, it is concluded that the problem-solving assessment instrument can be feasible without revision. Validation was carried out on the problem-solving instrument after a limited trial; the results of calculating the validity of the problem-solving ability instrument were 0.63 with high criteria and instrument reliability of 0.93.

The results of calculating the validity of the problem-solving instrument in the operational field trial were obtained. The validity of the problem-solving ability instrument amounted to 0.63, with high criteria and instrument reliability of 0.78. This means that the problem-solving instrument can be valid and feasible without revision.

The practicality of the HYPROBEL Model that has been developed to improve critical thinking and problem-solving skills of E-phase students

Learning device development research and testing the quality of the results or development products includes testing the validity, practicality, and effectiveness of the products developed. In addition, the resulting product can then be applied to a broader area. The practicality aspect of learning devices refers to, (l) practitioners or experts stating that a learning device developed benefits users and (2) learning devices are easily implemented in the field. Learning devices are practical if there is a good response from students and teachers on the benefits and convenience of learning devices. The practicality of the HyProBeL model and the HyProBeL model device was measured using the HyProBeL model implementation instrument and the teacher's ability to manage the learning process according to the lesson plan/teaching module. The measurement of practicability was measured by observing the implementation of the model and the teacher's skills in managing learning activities, which two informatics subject teachers carried out. Observations were conducted in six meetings.

Informatics subject teachers will test the readability of instruments used to observe the implementation of the model and learning tools. The results of the two practitioners' readability test of the model book showed that overall, informatics subject teachers declared the HyProBeL model book very easy to understand, with an average value of 3.87. Based on the criteria for determining the level of practicality in chapter III, the HyProBeL model book is declared very good and can be used without revision.

The practicality test of the HyProBeL model in implementing the HyProBeL model resulted in an average of 94.80% with a very good category. From practicality based on the criteria for determining the level of practicality in Chapter III, the HyProBeL model book is declared usable without revision. The average of each aspect of observation, which includes: l) HyProBeL model syntax obtained an average of 98.00%, 2) HyProBeL model social system obtained an average of 98.00%, 3) HyProBeL model reaction principle obtained an average of 86.00%, 4) HyProBeL model support system obtained an average of 91.00%, meaning the model is very good.

Implementing the HyProBeL learning model in informatics subjects of programming algorithm elements has advantages, including 1) implementing hybrid learning. This learning method combines or combines online learning with face-to-face learning. So, in its implementation, there are times when students and educators meet face-to-face in class. Other times, they do distance learning. The concept of hybrid learning is active learning centered on students being able to understand the concepts that have been explained. This learning model combines various technological media to solve problems in the learning process. The hybrid learning method makes it easier for students to study the material freely to understand the basic theory better.

This is to the 21st Century Partnership Learning Framework, which states that students must have the following competencies: (l) critical logical thinking and problem solving, which is the ability to think critically and solve problems; (2) communication and collaboration, which means the ability or skills of communication and collaboration or working together effectively, (3) creativity and innovation skills, which is the ability to be creative and have innovative ideas, (4) information, and communications technology literacy, which is the ability to use and develop technology in all fields, (5) contextual learning skills, which is the ability to develop knowledge through contextual learning, (6) information, and media literacy skills, which are skills to utilize existing communication media.

The HyProBeL learning model is a learning model that can answer the challenges of the 21st century by fostering HOTS (high-order thinking skills), including communication, collaboration, critical thinking, creative thinking, computational logic, compassion, and civic responsibility. Applying the HyProBeL Learning model can develop critical thinking and problem-solving skills. This can be seen in the phases of the HyProBeL learning model. In hybrid problem solving, students can interact with other students to discuss different ideas in solving problems. Working together between individuals can result in interaction between individuals, providing mutual support and providing facilities between individuals to solve problems. As supported by research by Fan Ray Kuo et al. (2012), a learning model is needed that can provide feedback to students when solving problems and also to solve time problems. Learning with hybrid learning models can be an alternative learning model for understanding concepts and finding the best solution to solving problems. This model gives students more time to solve problems because learning can be done anywhere and anytime.

Educational technology is a study and practical ethics to facilitate learning and improve performance through creating, utilizing, and managing technological processes and resources. The development of the HyProBeL model is an implementation of educational technology. The development of the HyProBeL model is a study of ethics regarding systematic learning patterns that contain learning steps that aim to facilitate students' learning and achievement of the learning objectives set.

The practicality test of the HyProBeL model learning management observation results in the range of 96.86% in terms of the criteria for determining the level of ability in managing learning with the model in Chapter III stated that all aspects of the learning management observation showed very good results and were feasible to use without revision. The average of each aspect of observation of preliminary activities is 93.40%, problem orientation is 96.70%, organizing 92.70%, hybrid problem solving 90.50%, discussion and presentation 95.00%, and closing 94.50%, each with very good criteria. The results of the practicality test of learning devices, from the initial field trial stage to the operational field trial, stated that the learning device model was very good

and feasible to use without revision. Learning development is a way to develop, evaluate learning tools. Learning development is part of the instructional system, which includes messages, people, materials, equipment, techniques, and settings in learning devices. The learning model device is part of the planning that guides the implementation of learning. Learning tools are designed to facilitate learners in learning.

Effectiveness of HyProBeL Model

Learning tools will be effective if students understand them and can affect the results of formative evaluations according to plan. Learning tools are also effective if teachers understand them and make it easier to implement learning.

Effectiveness is intended to determine the theory or model's implementation level. The effectiveness of the HyProBeL learning model is measured by testing the effectiveness of the HyProBeL model to improve critical thinking and problem-solving skills carried out at the operational field test stage to determine whether or not there is an increase in students' critical thinking and problem-solving skills. The data collected to test the effectiveness of the HyProBeL model includes 1) pretest and post-test data on critical thinking skills and 2) pretest and post-test data on problem-solving skills. The effectiveness of the HyProBeL model was carried out by analyzing student learning outcomes data on basic programming algorithm material with significance using the t-independent sample test.

Effectiveness of HyProBeL Model to Improve Critical Thinking Skills

Based on the mean calculation, it is known that the average score of HyProBeL model learning to improve critical thinking is 79.67, and learning with a problem-based learning model on critical thinking skills is 58.17. Furthermore, from the t-test analysis, the calculation of the control and experimental classes on learning is 0.00 or significance <0.05 (0.00 <0.005). Because one differentiator in the learning process is the treatment of the HyProBeL model, the treatment causes the difference in value between the control and experimental groups. From the analysis of critical thinking test results in the experimental class using HyProBeL model learning and the control class using HyProBeL model learning in general, it can be concluded that HyProBeL can improve critical thinking of learning materials has an important role in the learning process.

Effectiveness of HyProBeL Model to Improve Problem-Solving Skills

Based on the calculation of the mean, it is known that the average score of HyProBeL model learning to improve problem-solving is 81.83, and learning with a problem-based learning model on critical thinking skills is 73.83. Furthermore, from the t-test analysis, the calculation of the control and experimental classes on learning is 0.00 or significance <0.05 (0.002 <0.005). Because one differentiator in the learning process is the treatment of the HyProBeL model, the treatment causes the difference in value between the control and experimental groups. From the analysis of critical thinking test results in the experimental class using HyProBeL model learning and the control class using HyProBeL model learning in general, it can be concluded that HyProBeL can improve critical thinking of learning materials has an important role in the learning process.

Discussion

Quality of Learning

The development of information and technology in the era of revolution 4.0 provides enormous challenges for the nation in various fields. The government has made concrete steps in facing the challenges of the 21st century by making a new policy on curriculum (Ashton & Ashton, 2023; Bunyamin et al., 2022; Dilekçi & Karatay, 2023; Erwin Akib et al., 2020; Pranajaya et al., 2022). The Merdeka Belajar curriculum answers the intense competition for human resources globally in the 21st century (Dayusman, 2023; Mansur & Sukirman, 2024; Wirawan et al., 2024). The competencies that students must have towards the 21st Century Partnership Learning Framework are as follows: (1) critical thinking and problem solving, namely the ability to think critically and solve problems; (2) communication and collaboration, which means the ability or skills to communicate and collaborate or cooperate effectively, (3) creativity and innovation skills, namely the ability to be creative and have innovative ideas, (4) information and communications technology literacy, namely the ability to use and develop technology in all fields, (5) contextual learning skills, namely the ability to develop their knowledge through contextual learning, (6) information and media literacy skills, which are skills to use existing communication media. In preparing human resources who have 21st-century competencies, the quality of learning needs to be improved by using strategies and learning models that meet the needs. The HyProBeL learning model seeks to improve quality learning to 21st-century needs.

The hyProBeL learning model has a product in the form of a HyProBeL learning model that improves critical thinking and problem-solving skills. The resulting HyProBeL model can be seen from the phases of each HyProBeL syntax and learning tools used in the HyProBeL model. The HyProBeL model is measured through classroom trials. At the same time, the test results state that in terms of feasibility and practicality, the learning model is feasible and very good.

The improvement in critical thinking and problem-solving skills resulting from the development of the HyProBeL model is indicated by an increase in these skills when learning with the HyProBeL learning model is implemented.

The novelty of HyProBeL Model Development

The learning model is a plan used in learning so that learners gain knowledge, ideas, skills, values, and ways of thinking; the learning model will help direct learners to design learning that involves learner experience; the learning model has a significant role in the process of learning activities so that learning can be maximized. Maximum learning is effective and efficient learning according to the planned objectives by involving learner experience (Firaina & Sulisworo, 2023; Hardiansyah & Mulyadi, 2022; Lee et al., 2021; Shemshack et al., 2021; Surani & Hamidah, 2020). The HyProBeL learning model implemented in phase E of the independent curriculum is a learning model that has the novelty of improving the quality of current learning to improve critical thinking and problem-solving skills. The HyProBeL model is a learning model that integrates the face-to-face process of PBL in the classroom with online learning into one cohesive experience. Hybrid learning in a PBL environment can provide opportunities to improve learners' problem-solving, critical thinking, creative thinking, and communication abilities.

In applying the HyProBeL model, students are faced with unstructured problems that are then formulated in groups. The teacher facilitates students in learning,

organizes learning tasks, mediates problem formulation, and formulates hypotheses (Slavin, 2009). Over time, students will begin to get used to facing problems and feel challenged to solve a problem that exists in everyday life (real world) (Chen, 2024; Dwivedi et al., 2022; Ng et al., 2023; Rahmatullah et al., 2022; Rizvi & Nabi, 2021). So that students can learn to think critically in solving a problem that is shown to have essential knowledge and concepts from the subject matter.

Pros and Cons of the HyProBeL Model

The HyProBeL learning model is a learning model that can prepare secondary students, in particular, to have 21st-century competencies, namely critical thinking and problem-solving, communication, and collaboration. In the implementation of this HyProBeL model, students are faced with unstructured problems, which are then formulated into groups. The teacher facilitates students in learning, organizes learning tasks, mediates problem formulation, and formulates hypotheses. Over time, students will get used to facing problems and feel challenged to solve problems in everyday life (Chen, 2024; Inganah et al., 2023; Li, 2022; Mangaroska et al., 2021). So that students can learn to think critically in solving a problem that is shown to have essential knowledge and concepts from the subject matter.

The weakness of this HyProBeL model is its use for the Informatics subject's essential programming algorithm elements and the possibility of being developed in other informatics elements or other subjects. In addition, the weaknesses of the HyProBeL learning model are that students' questions and opinions can widen out of the subject matter, so it requires a long time. Therefore, it can be applied to other subjects and needs modification.

Research Findings

The research produces a product as a model, showing that implementing the HyProBeL learning model can improve critical thinking and problem-solving skills. Research findings related to the HyProBeL learning model begin with developing a Hybrid Problem Based Learning model for basic programming algorithm material. The results of the development of the HyProBeL model obtained a development value of 95.10%, which is a very good category, with the conclusion that the HyProBeL model learning model has a level of validity that is quite valid, quite effective, reasonably complete, and feasible to use. This means that the entire syntax of the model can be implemented as a whole as expected. Other findings from the study related to students' ability and good interaction in learning activities of the HyProBeL learning model proved to improve critical thinking and problem-solving skills. Teaching Modules, Teaching Materials, and Student worksheets using the syntax of the HyProBeL learning model proved to be practical and effective to apply in the classroom.

CONCLUSION

Fundamental Finding: The analysis and discussion of the HyProBeL (Hybrid Problem-Based Learning) model for programming algorithm material indicate its strong alignment with feasibility, practicality, and effectiveness criteria. The model's feasibility is validated by high average scores across several dimensions, including validator assessments, teaching materials, teaching modules, Student worksheets (3.92), critical thinking assessments, and problem-solving assessments. Practicality is evidenced by an average readability from two practitioners and a 95.1% success rate in implementing the

model's syntax. Effectiveness is demonstrated through significant improvements in critical thinking and problem-solving skills, as shown by statistical tests that reveal substantial differences in post-test scores between control and experimental groups. **Implication:** The findings suggest that the HyProBeL model is a viable framework for enhancing students' critical thinking and problem-solving abilities, particularly in programming algorithm courses. Its successful implementation could lead to a deeper understanding of programming concepts and the development of essential skills required in modern education. **Limitation:** The development of the HyProBeL model was constrained by its reliance on integrating steps from existing learning models and merging two distinct learning approaches, which may limit its originality and adaptability to other educational contexts. **Future Research:** Further research should focus on refining the HyProBeL model, promoting its use by high school informatics teachers, and developing programming materials that are aligned with the latest educational advancements. Additionally, efforts should be made to disseminate the model through educational forums such as MGMPS, MGMP, and MKKS to encourage broader application across various subjects and contribute to advancing 21st-century educational practices.

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