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Development of E-Student Worksheet based on Guided Discovery of Membrane Transport Materials to Train Integrated Science Process Skills

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A B S T R A C T

21st century education requires students to have integrated science process (KPST) skills. This research aims to develop *E-student worksheet* based *on guided discovery* on membrane transport materials that are valid, practical, and effective in practicing KPST. This study uses a 4D development model (Define, Design, Develop, and Disseminate) and is tested on a limited basis in grade XI students. Data was collected through validation sheets, student response questionnaires, implementation observation sheets, and pre-test and post-test tests. The E-student worksheet developed has five main features, namely *Bio-Insight, Scilab Explore, Bio-Viz, Veri-Bio,* and *Bio-Conclusion* to train KPST. The results of the study received a score of 97.12% and were included in the very valid category. Observation of activities received a score of 100% with a very practical category and the student response questionnaire obtained a score of 97.64% with a very practical category The learning outcomes of students with *an N-gain score* of 0.80 included in the high category, and the achievement of KPST indicators with an average score of 37% in the *pretest* increased to 87% in *the posttest*, with an *N-gain* score 0.80 which is included in the high category. Thus, guided *discovery-based E-student worksheet* is declared valid, practical, and effective to train students' integrated science process skills.

Keywords: *E-Student Worksheet*, *Guided Discovery*, KPST.

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INTRODUCTION

In this modern era, education must be able to answer the challenges of globalization and support the strengthening of students' character, both in the school environment and outside of school. 21st century education requires students to have various skills to be able to face global challenges, such as critical thinking, problem-solving, creativity, collaboration, and communication. In the context of science education, such skills can be developed through learning that emphasizes not only the mastery of concepts, but also scientific processes that involve investigative and problem-solving activities. Therefore, science learning has an important role in training students' critical, analytical, and creative thinking skills.

One of the skills relevant to the demands of the 21st century is the integrated science process (KPST) skills, which include the ability to formulate problems and hypotheses, identify variables, conduct experiments, analyze data, and draw conclusions. Integrated science process skills are part of scientific practice that emphasizes authentic inquiry activities and contributes to the improvement of science literacy and high-level thinking skills of learners (Bybee, 2020; OECD, 2021). The development of KPST requires interactive and contextual learning so that students can build knowledge through direct experience and meaningful scientific processes.

One of the learning tools that can support these needs is the electronic student worksheet (*E-student worksheet*), which allows students to learn more flexibly and independently through the use of digital media. *E-student worksheet* also has the potential to increase learning motivation because it is equipped with visual features and learning activities that are in

accordance with the characteristics of students. In addition to improving learning outcomes, the use of *E-student worksheet* can also increase students' KPST.

However, the results of observations and interviews with biology teachers at smas ipiems surabaya show that students' integrated science process skills are still relatively low, especially in membrane transport materials. Students have difficulty identifying variables, analyzing data, and conducting experiments appropriately. This condition is influenced by the use of conventional learning methods and print media that do not provide opportunities for students to be actively involved in the concept discovery process. Although various studies have examined the application of *guided discovery* in science learning, most research still focuses on the implementation of learning models without developing digital learning tools explicitly designed to train integrated science process skill indicators. In addition, research on the development of *e-student wsorksheet* based on *guided discovery* on membrane transport materials is still limited, even though this material is abstract and requires visualization and experimental activities to improve students' understanding of concepts.

Membrane transport materials are considered suitable to be developed through a guided discovery approach because they are procedural, applicative, and directly related to daily life. Learning *guided discovery* allows students to discover concepts through a series of investigation activities and practicums with the guidance of teachers, so that they are able to practice kpst optimally. *Guided discovery* is a guided inquiry approach that provides scaffolding for students in the process of exploring concepts, so that it is effective in improving concept understanding, science process skills, and critical thinking skills (alfieri et al., 2021; hmelo-silver & desimone, 2021). The novelty of this research lies in the development of *e-student worksheet* based *guided discovery* that integrates specialized digital features to train each of the integrated science process skill indicators in an explicit and structured manner. Features on *e-student worksheet* i.e. *bio insight, scilab explore, bio-viz, veri-bio,* and *bio-conclusion*. Thus, this study aims to develop e-student worksheet based on guided discovery on membrane transport materials that are valid, practical, and effective in practicing integrated science process skills for grade XI students.

MHETOD

This research is a development research using a 4d model (*define, design, develop, dan disseminate*) which aims to produce *e-student worksheet* based *guided discovery* on membrane transport materials to train students' integrated science process (kpst) skills. The development model used refers to ibrahim (2010) which includes the *defines*, *design*, *develop*, and *disseminate* limited. The research was carried out at smas ipiems surabaya in the 2024/2025 school year with a limited trial subject of 20 students in class xi.

The definition stage includes the analysis of learning needs, the analysis of the independent curriculum, the analysis of student characteristics, the analysis of membrane transport material concepts, the analysis of learning tasks, and the formulation of learning objectives that refer to the indicators of integrated science process skills. The design stage includes designing the structure and appearance *of e-student worksheet* based on *guided discovery*, the preparation of *the guided discovery* learning syntax in *e-student worksheet*, the design of interactive features, and the development of research instruments in the form of validation sheets, observation sheets, student response questionnaires, and integrated science process skill test questions.

The development stage includes an expert validation process by subject matter expert lecturers, media expert lecturers, and high school biology teachers, product revisions based on validator suggestions, and limited trials to assess the practicality and effectiveness of *e-student worksheet*. The disseminate stage is carried out on a limited basis through the preparation of scientific articles and the dissemination of research results to biology teachers.

The indicators of integrated science process skills measured in this study consist of six aspects, namely: (1) formulating problems and hypotheses, (2) identifying variables, (3) designing and conducting experiments, (4) presenting data in the form of tables or graphs, (5)

analyzing and interpreting data, and (6) drawing conclusions based on the results of experiments. The research instruments used included *e-student worksheet validation sheets* and instruments, observation sheets on learning implementation, student response questionnaires, and google form-based test questions to measure the achievement of integrated science process skill indicators.

The validity of the e-student worksheet was assessed by three independent validators consisting of two expert lecturers (subject matter experts and media experts) and one high school biology teacher. The validity of the e-student worksheet is analyzed using a likert scale converted into a percentage of feasibility to determine the level of product validity. The practicality of *e-student worksheet* is determined based on the results of observation of the implementation of student activities and student response questionnaires after using *e-student worksheet* and then analyzed using the guttman scale. The effectiveness of *e-student worksheet* was analyzed based on student learning outcomes and the achievement of integrated science process skill indicators obtained from pretest and posttest scores. The increase in learning outcomes was calculated using an n-gain score with the categories of low ($g < 0.30$), medium ($0.30 \leq g \leq 0.70$), and high ($g > 0.70$). *E-student worksheet* is declared effective if it shows the completeness of student learning, an increase in *the n-gain* score in the medium to high category, and an increase in the achievement of integrated science process skill indicators.

FINDINGS AND DISCUSSION

The results of the development research produced a product in the form of *e-student worksheet* based on *guided discovery* on membrane transport materials designed to train integrated science process (kpst) skills of students in class xi of smas ipiems surabaya. The developed e-student worksheet is systematically compiled according to the guided discovery syntax, including the stages of stimulation, problem identification, data collection, data processing, proof, and conclusion drawn. Each stage is designed to accommodate kpst indicators, such as formulating problems and hypotheses, identifying variables, designing experiments, interpreting data, and drawing scientific conclusions. The guided discovery approach allows students to build knowledge independently with directed guidance from teachers, in line with the theory of constructivism (bruner, 1957).

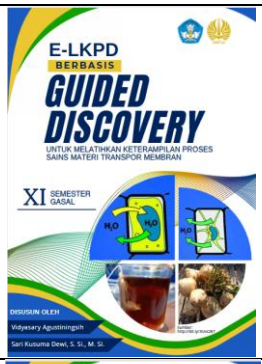
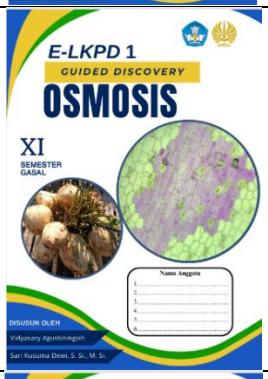
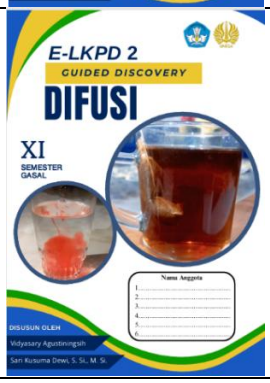
Theoretically, the integration of guided discovery syntax with kpst indicators strengthens the guided discovery-based learning process, because students not only receive information, but are directly involved in the scientific process from problem formulation to concept generalization. This shows that *the developed e-student worksheet* not only serves as a medium, but also as a cognitive scaffolding to develop high-level science process skills.

The definition stage begins with observation and interviews that reveal the low skills of integrated science processes on three main indicators, namely identifying variables, conducting experiments, and analyzing data. This condition is affected by the limited laboratory facilities and the difficulty of visualizing the osmosis and diffusion process. Results based on the needs analysis, the *guided discovery* model was chosen because it allows learners to discover concepts gradually through structured guidance and effectively practice the skills of the integrated science process thoroughly. The selection of this model is based on the assumption that the active involvement of learners in the scientific process can improve higher-level thinking skills and reduce the dominance of lecture-based passive learning.

The design stage begins by designing *e-student worksheet* using *the canva* application with a4 size and using two types of fonts, namely *times new roman* and arimo. After the design is completed, *the e-student worksheet* is uploaded to the topworksheet platform so that it appears more interactive and attractive. *E-student worksheet* is developed as an interactive electronic media that is easily accessible through gadgets, equipped with attractive visual displays, videos, and autofill features. This product has five main features that are integrated with the guided discovery syntax, namely *bio-insight, scilab-explore, bio-viz, veri-bio*, and *bio-conclusion*. The integration of these features supports all indicators of systematically integrated science process skills. The integration of features with learning syntax is designed

to ensure that each stage of guided discovery explicitly trains specific kpst indicators, so that learning is not only product-oriented but also scientifically process-oriented. The appearance of *the e-student worksheet* design can be seen in table 1 below.

Table 1. E-Student Worksheet Design Display

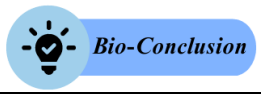
E-STUDENT WORKSHEET *Display*	**Remarks**
	The main cover *of the e-student worksheet* contains the title of the general material, the learning model, and the author. The page after the cover is a preface, table of contents, definition of kpst and guided discovery, instructions for using *e-student worksheet,* mapping, features of *e-student worksheet*, cp and tp, and concept map
	The cover *of e-student worksheet* 1 contains the learning model, the topic of the material studied, namely "osmosis", and the names of the group members
	The cover *of E-student worksheet* 1 contains the learning model, the topic of the material studied, namely "Diffusion", and the names of the group members

The development stage is carried out through three stages of revision based on the input of experts and biology teachers. Revision i focused on improving the appearance by improving the cover image and adding the difference columns to the mass and volume tables. Revision ii includes the improvement of the content and structure *of the e-student worksheet*, including the addition of an explanation of the advantages of *e-student worksheet, guided discovery*, and integrated science process skills, the completion of abcd elements in learning objectives, the layout of feature layouts, the replacement of concept maps, the inclusion of video sources and temperature descriptions on the diffusion practicum table, and the preparation of answer keys. Revision iii focuses on the final refinement in the form of the inclusion of image sources and thanks, improvement of the drafting of the concept from general to specific, the layout of the feature layout, the preparation of guided discovery syntax relationship mapping, kpst indicators and features in the form of tables, and the affirmation of introductory sentences at each step of the activity.

The features in *the e-student worksheet* are arranged in line with the integrated science process skill indicators (kpst) and *guided discovery* syntax. The *bio-insight* feature supports the stimulation and problem identification stages by practicing problem-formulating and hypothesis skills. The *scilab-explore* feature is used at the data collection stage to train variable determining skills, designing work steps, and conducting experiments, both directly and

through a virtual lab. The *bio-viz feature* supports the data processing stage by trainisng students to present the results of the experiment in the form of a table. The *veri-bio* feature supports the verification stage by training data analysis skills and linking experimental results to theory. Meanwhile, *the bio-conclusion feature* supports the generalization stage by training students to draw conclusions based on problem formulations, hypotheses, and experimental results. The display of features on *the e-student worksheet* along with its description can be seen in table 2.

Table 2. E-Student Worksheet Feature Display

Feature Display	Remarks
	Observation of videos or pictures of osmosis and diffusion events in daily life.
	The implementation of practicum on the process of osmosis and diffusion using the materials that have been provided.
	The activity organizes the results of the experiment in the form of tables or graphs.
	Analyze the results of experiments based on theories in books or scientific journals by answering questions.
	Conclusions based on the formulation of the problem and the results of the parktikum carried out.

Then the limited disseminate stage was carried out in one meeting with 20 students of grade XI and ran without technical problems. Students are able to use all *E-STUDENT WORKSHEET features*, fill in data on the results of direct and virtual practicums, and draw conclusions based on the results of the experiment. *The E-student worksheet* presented in electronic form contains concise texts, illustrative images, observation tables, and questions that direct students to carry out the scientific process. The development of *E-STUDENT WORKSHEET* aims to overcome the limitations of conventional LKPD which tends to focus on memorizing concepts and is not optimal in practicing science process skills. The use of digital media in biology learning has been proven to increase student engagement and learning activities (Nurdiana & Prasetyo, 2021).

Validity Test

The validation of the E-STUDENT WORKSHEET was carried out by three validators consisting of two expert lecturers and one high school biology teacher. The validation instrument includes aspects of presentation, content, compatibility of features with integrated science process skills, and linguistics with a likert scale of 1-4. The recapitulation of the validity of the E-STUDENT WORKSHEET is presented in Table 3.

Table 3. Recapitulation of the Validity of E-STUDENT WORKSHEET

Yes	Aspects	Presentase (%)	Criteria
1.	Presentation Eligibility.	100	Highly Valid
2.	Content Eligibility.	97,2	Highly Valid
3.	Eligibility of Feature compatibility with KPST.	91,6	Highly Valid
4.	Language proficiency.	100	Highly Valid
	Average	**97,12**	**Highly Valid**

The validation results showed an overall average score of 97.12% with a very valid category based on the likert scale (riduwan, 2016), which indicates that *e-student worksheet* has met the feasibility standards as a learning medium for biology of membrane transport materials. The presentation aspect includes display design, systematic, and accessibility. The presentation aspect obtained a score of 100%, which indicates that *e-student worksheet* it has easy access via direct link or qr code, good color contrast between the background and text, a combination of appropriate font types and sizes, and an easy-to-operate filling field without

the need for a special account. Multimedia in the form of videos of osmosis and diffusion phenomena can be opened smoothly on laptop and mobile devices.

The high validity score indicates that the media design, material structure, and feature integration are in accordance with the principles of effective digital learning design. These findings are in line with the development of guided inquiry-based biology teaching materials that emphasize the accessibility and consistency aspects of layout as determinants of the feasibility of learning media (artayasa et al., 2021; utami et al., 2024).

The content aspect obtained a score of 97.2% with a very valid category, which shows that osmosis and diffusion materials are in accordance with scientific concepts and support the application of guided discovery syntax. The presentation of contextual phenomena, material flows from general to specific, and structured learning objectives support students' involvement in the concept discovery process. The objectives of the study include analyzing the phenomenon of membrane transport in daily life, identifying problems to formulate problems, conducting simple experiments, analyzing experimental data, verifying experimental results with relevant theories, and drawing conclusions from experimental results. Compatibility of osmosis and diffusion materials with syntax *guided discovery* it is also reported as the main factor in the high validity of teaching materials based on scientific approaches (darwis et al., 2023).

The aspect of feature compatibility with kpst obtained a score of 91.6% with a very valid category. Features *scilab-explore* it is considered effective in practicing the skills of identifying variables and conducting experiments through interactive experiment activities, both in person and virtually. In addition, *features of bio-viz, veri-bio,* and *bio-conclusion* supporting data presentation, analysis of experimental results, and drawing hypothesis-based conclusions. Integration of features aligned with science process skill indicators is proven to improve quality and validity *e-student worksheet* (manurung & anazifa, 2024).

The linguistic aspect obtained a perfect score of 100%, which shows that the language used in *e-student worksheet is* easy to understand, does not cause double interpretation, is in accordance with the level of development of grade xi students, and meets the rules of good and correct indonesian language. Clarity of sentences in activity instructions and practicum supports the implementation of learning effectively, in line with the results of the development of e-student worksheet based on argument driven inquiry which emphasizes the accuracy and suitability of language as a condition for the construction of teaching materials (utami et al., 2024).

Overall, the validation results confirm that guided *discovery-based e-student worksheet* has a very high level of feasibility and is suitable for use as a biology learning medium for class xi m-2 smas ipiems surabaya to train fully integrated science process skills.

Practicality Test

The practicality of guided *discovery-based e-student worksheet* is determined from the results of observation of students' activities in using e-student worksheet and student response questionnaires after using *e-student worksheet*. the results of the recapitulation of the practicality *of e-student worksheet* can be seen in table 4.

Table 4. Results of the Recapitulation of the Practicality of *E-Student Worksheet*

Yes	Practicality test	Presentase (%)	Criteria
1.	Results of implementation observations	100	Very Practical
2.	The Results of the Student Response Survey	97,64	Very Practical

The results of the observation showed that the implementation of student activities reached 100% with the category of very practical, which indicates that all indicators of integrated science process skills can be implemented properly. Students are able to operate *e-student worksheet* independently, read readings at the problem orientation stage, formulate problems and hypotheses, identify variables, conduct osmosis and diffusion practicums, present data in tables, analyze data through discussions, and draw conclusions.

The practicality of *e-student worksheet* is evident at the data collection stage through the *scilab-explore* feature, where students actively identify temperature variables in diffusion practicum and concentration variables in osmosis, both through direct experiments and virtual labs. The implementation of the *guided discovery syntax* runs smoothly without technical obstacles, so that students are actively involved in data analysis discussions and conclusions drawn.

This finding is in line with the research of permatasari and laksono (2019) which states that guided discovery is effective in actively and meaningfully involving students, and is supported by the research of rosalinur and isnawati (2025) who reported that the use of e-student worksheet based on guided discovery with phet simulation shows high practicality with 100% activity implementation.

The response questionnaire was distributed to 20 students of class xi of smas ipiems surabaya. This questionnaire was used to measure the practicality of the e-student worksheet that had been developed with 17 questions. The response questionnaire sheet uses the guttman scale, where a score of 1 is for the answer "yes" and a score of 0 is for the answer "no". The following is a recapitulation of the student response questionnaire seen in table 5.

Table 5. A Recap of the Students' Responses

Yes	Aspects	Presentase (%)	Criteria
1.	Presentation.	98,3	Very Practical
2.	Contents.	98,12	Very Practical
3.	Language	95	Very Practical
Average		**97,64**	**Very Practical**

The student response questionnaire provided an overall average of 97.64% with a very practical category according to table 4.7. The presentation aspect obtained 98.3% because of the attractive cover design, time allocation according to osmosis and diffusion learning activities, easy to understand instructions for use, precise font size, activities arranged sequentially, and complete bibliography. The content aspect of 98.12% is due to *e-student worksheet* according to membrane transport materials, facilitating the understanding of the concept of osmosis and diffusion, interesting and easy to carry out activities, practicing problem formulation and hypothesis, identification of freely bound variables and controls, design and implementation of practicum, presentation and analysis of practicum data results, and drawing conclusions based on problem formulation. The linguistic aspect is 95% because the language is clear, does not cause double interpretation, and is in accordance with eyd. The development of an interactive e-student worksheet based on creative thinking also received a very high response from students in terms of content and presentation so that the category is very practical (ardiansah & zulfiani, 2023).

The high level of practicality shows that *e-student worksheet* is easy for students to use and does not cause technical obstacles, so that it can support the implementation of guided discovery learning optimally. These findings are consistent with the research of rosalinur and isnawati (2025) and muthalib et al. (2024) who reported that discovery *learning-based e-student worksheet* has high practicality due to its interactive design and easy-to-use navigation. The positive responses given by students were written in the advice and comment column.

> "*the way ms. Vidya teaches is very good and not boring, the e-student worksheet is also easy to understand and the use of sentences is very good*".

Effectiveness test

The effectiveness of *e-student worksheet* is measured through student learning outcomes and the achievement of integrated science process skill indicators using pretest and posttest results. The pretest and posttest questions each amounted to 10 questions that were in accordance with the integrated science process skill indicators. Pretest questions were given before the use of e-student worksheet and posttest was given after the use *of e-student worksheet* to 20 students in grade xi m-2 of smas ipiems surabaya. The kktp at the school is with a score of 76. The following *pretest* and *posttest recapitulation* is presented in table 6.

Table 6. Pretest and Posttest Recapitulation

Yes	Aspects	*Pretest*	*posttest*

1.	Lowest value	20	80
2.	Highest score	70	100
3.	Average	37	87
4.	*Lowest N-gain*	0,60	
5.	*Highest N-gain*	1,00	
6.	**Average *N-gain***	**0,80**	

The effectiveness of *guided discovery-based e-student worksheet* is shown by a significant increase in student learning outcomes on membrane transport materials. The average pretest score of 37 with 0% completeness increased to an average posttest of 87 with 100% completeness. The results of the *n-gain* calculation showed an average value of 0.80 with the high category, where 14 students were in the high category and 6 in the medium category, and no low n-gain was found. This data shows that *e-student worksheet* is effective in practicing integrated science process skills and improving students' understanding of concepts.

The low pretest results indicate the limitations of students' initial mastery of abstract membrane transport concepts, especially osmosis and diffusion, due to conventional learning that tends to be oriented towards memorization and minimal practicum activities. Through *guided discovery-based* e-student worksheet, students are actively involved in formulating problems related to the osmosis phenomenon, namely the effect of differences in solution concentrations (ordinary water, sugar water, and brine) on changes in mass and volume in jicama. And diffusion phenomena, namely the effect of differences in normal, cold, and heat temperatures on the speed of color change or the diffusion process of substances in water, identifying variables, conducting osmosis and diffusion experiments, analyzing data, and drawing conclusions based on problem formulations, hypotheses, and experimental results, so that learning becomes more meaningful and student-centered.

The increase in learning outcomes with the high n-gain category is in line with previous research showing that the application of *guided discovery-based* e-student worksheet with a structured syntax is able to significantly improve students' understanding of concepts and science process skills, as reported in the development of e-student worksheet photosynthesis material which also produces high n-gain (rahayu & rahayu, 2025).

The effectiveness of the *developed e-student worksheet* can also be analyzed through the achievement of integrated science process skill indicators obtained from the results of the pretest and posttest. There are six indicators of students' integrated science process skills, namely, formulating problems and hypotheses, identifying variables, conducting experiments, presenting data, analyzing data, and drawing conclusions. The following are the results of the achievement of the indicators of integrated science process skills of students contained in figure 2.

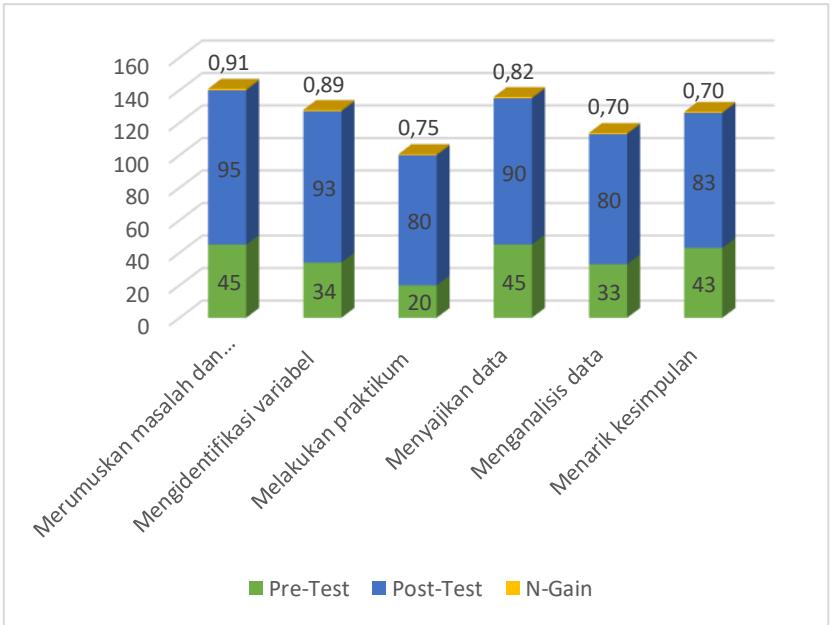


Figure 1. Graph of Achievement Indicators of Students' Science Process Skills

Figure 1. shows that all indicators have increased in the high category, with the indicator formulating problems and hypotheses obtaining the highest *N-gain* of 0.91, while the indicator draws conclusions and analyzes the data obtaining the lowest N-gain of 0.70.

The highest increase in the indicators of formulating problems and hypotheses was influenced by the *Bio-Insight* feature which presented videos of osmosis and diffusion phenomena accompanied by open-ended questions, thus stimulating students to formulate problems and hypotheses collaboratively. These findings are in line with research that shows that guided discovery is effective in practicing problem-solving skills and hypotheses in biology learning (Kibirige & Maake, 2021). The indicator of identifying variables and conducting experiments has also experienced a high increase through *the SciLab-Explore* feature, which allows the manipulation of one variable by keeping other variables constant and the implementation of virtual experiments repeatedly, as supported by Chengere et al. (2025) and Rosalinur and Rosalinur & Isnawati (2025).

The indicator presents data significantly improved through the support of *the Bio-Viz* feature, which provides an automated table for the results of osmosis and diffusion practicum data, namely mass, volume, and color change speed observations, so that students can present the data neatly. This feature helps students compile data systematically and neatly, making it easier to process and interpret data. This increase is in line with the research of Lestari et al., (2025) which reported that the use of automated tables in *E-student worksheet* is able to improve the ability to present student data.

The indicator analyzes the data increased through the *Veri-Bio feature*, which guides students to compare the results of the experiment with the hypothesis and describe the relationships between variables in a structured manner. Although the increase is in the lowest category, these results still show the effectiveness of guided discovery in training data analysis skills on biological materials (Ratnasari et al., 2021). Meanwhile, the indicator of drawing conclusions remains in the high category thanks to *the Bio-Conclusion feature* which provides a framework for drawing conclusions based on the formulation of the problem, hypotheses, and analysis results, in line with the findings of Utami et al. (2024). Overall, *Guided Discovery-based* E-student worksheet has proven to be effective in training all indicators of integrated science process skills.

This improvement shows that guided discovery-based learning through *E-student worksheet* is able to significantly improve students' understanding of concepts as well as science process skills. This indicates that learning that involves investigative activities is more effective than conventional lecture-based learning. These results are in line with Rahayu & Rahayu (2025) research which reports that guided *discovery-based E-student worksheet* produces high *N-gain* in photosynthetic materials, as well as Chengere & al., (2025) research which shows guided discovery significantly improves understanding of science concepts.

CONCLUSIONS

E-student worksheet based on *guided discovery* on membrane transport materials was successfully developed using a 4D model with six guided discovery syntax integrated with integrated science process skill indicators and supported by five main features, namely *Bio-Insight, SciLab-Explore, Bio-Viz, Veri-Bio,* and *Bio-Conclusion. The E-student worksheet* developed was declared to be very valid (97.12%), very practical based on student activity observation (100%) and student response questionnaire (97.64%), and effective based on increasing learning outcomes from 37% in the pretest to 87% in the posttest with *an N-gain* of 0.80 (high category). The implications of this study show that guided *discovery-based E-student worksheet* can be used by teachers as an interactive digital learning medium to increase student involvement and practice science process skills systematically. Further research is recommended to conduct large-scale trials, development on other biological materials, and application at different levels of education to obtain a more comprehensive picture of effectiveness.

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