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HOTS-BASED STUDENT WORKSHEET DEVELOPMENT TO IMPROVE STUDENTS' VISUAL THINKING SKILLS IN SOLVING CALCULUS PROBLEMS

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Abstrak

Salah satu alternatif bahan ajar yang dapat menunjang mengoptimalkan pembelajaran yaitu lembar kerja mahasiswa (LKM). Riset pengembangan dengan tahapan ADDIE (*Analysis*, *Design*, *Development*, *Implementation*, dan *Evaluation*) ini bertujuan untuk mendeskripsikan proses pengembangan LKM materi kalkulus berbasis HOTS dalam rangka meningkatkan kemampuan berpikir visual mahasiswa dalam menyelesaikan masalah kalkulus yang valid, praktis, serta efektif. Subjek penelitian ini yakni 2 kelas mahasiswa Program Studi Tadris Matematika UIN Sayyid Ali Rahmatullah Tulungagung semester V. Data dikumpulkan menggunakan angket dan tes kemampuan pemecahan masalah, serta analisis data menggunakan uji Manova. Hasil penelitian menunjukkan bahwa: 1) LKM berbasis HOTS yang dikembangkan berada pada kategori "valid" sehingga dapat digunakan pada matakuliah kalkulus; 2) Kepraktisan LKM berbasis HOTS bisa dilihat dari hasil respon mahasiswa pada respon positif dan berada pada kategori "sangat baik"; dan 3) Daya guna atau efektivitas LKM berbasis HOTS dilihat dari hasil posttest yang menunjukkan ada perbedaan kemampuan berpikir visual mahasiswa dalam menyelesaikan masalah kalkulus antara kelas eksperimen dan kelas kontrol.

Kata kunci: Berpikir Visual; HOTS; LKM; *Problem Solving*

Abstract

One alternative teaching subject that can support optimizing learning is student worksheets (SW). This development research with the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) stages aims to describe the process of developing HOTS-based calculus subject SW to improve students' visual thinking skills in solving valid, practical, and effective calculus problems. The subjects of this research were 2 classes of students from the Mathematics Education Study Program at UIN Sayyid Ali Rahmatullah Tulungagung fifth semester. Data was collected using questionnaires and problem-solving ability tests, and data analysis using MANOVA tests. The research results show that: 1) the HOTS-based SW developed is in the "valid" category so it can be used in calculus courses; 2) The practicality of HOTS-based SW can be seen from the results of student responses which are positive and in the "very good" category; and 3) The usability or effectiveness of HOTS-based SW is seen from the posttest results which show that there are differences in students' visual thinking abilities in solving calculus problems between the experimental class and the control class.

Keywords: HOTS; Problem Solving; SW; Visual Thinking

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INTRODUCTION

Mathematics education in the era of the Industrial Revolution 4.0 is focused on developing mathematical abilities that are by the demands of the 21st century. According to research by Ariyana et al. (2018), learning in the 21st century refers to the concept of 4Cs, that is critical thinking, communication, collaboration, and creativity. These four skills are recognized as essential aspects of 21st-century education. These four elements are part of higher-order thinking skills (HOTS). López and Whittington (2021) suggest that thinking at a higher level than mere cognition is an essential skill in the learning process. Furthermore, Ramos et al. (2013) explain that high-level thinking refers to the thinking process that occurs at a higher level than the cognitive processing stage. HOTS covers various aspects of knowledge, such as understanding, application, analysis, and evaluation (Anderson & Krathwohl, 2001; Arum et al., 2022; Brookhart, 2010; Kusaeri et al., 2018; Tonra et al., 2019).

HOTS or high-level thinking skills are cognitive aspects (Faiqoh et al., 2019; Masitoh & Aedi, 2020) which emphasizes the use of questions that require high-level thinking skills (HOTS) in the context of collaborative learning. Therefore, teaching subjects are needed, including student worksheets (SW), which are specifically designed based on HOTS characteristics including in the preparation of assessment instruments (Purnasari et al., 2021). Based on observations, students' ability to solve HOTS problems is still low, in line with the results of previous research which stated that students' ability to solve HOTS problems is generally still in the problem analysis category (Dosinaeng et al., 2019).

In addition to learning models that can be used to develop or improve thinking skills (Aisyah et al., 2024; Aprilia & Diana, 2023; Asria & Nurhayati, 2024; Asyhar, 2023; Hermansyah et al., 2024; Khoirunnisa et al., 2024), SW is also one of the learning aids designed to help educators develop students' thinking skills and skills in finding concepts through the work steps and problem-solving provided, accompanied by appropriate assessment techniques. Its function as a learning aid in the classroom is very significant because it presents subject that summarizes various relevant book sources, making the learning process efficient and effective. SW also includes learning subjects, practice questions, and learning activity instructions (Purwasi & Fitriyana, 2020). Developing HOTS-based SW is expected to create a learning atmosphere that promotes HOTS and helps students train their high-level thinking skills, especially in the context of calculus. Calculus is considered an important topic of mathematics because of its application in everyday life (Sulistyorini & Napfiah, 2019; Takaendengan et al., 2022). Alzaber et al. (2021) revealed that the challenge in the learning process in higher education is the lack of educators who prepare learning subjects optimally. One of the steps that educators can take to improve their professional abilities is to develop teaching subjects. Based on this explanation, an educator should involve themselves in writing activities, including the preparation of teaching subjects. Teaching subjects are recognized as a crucial element in the learning process (Fitriani & Susanti, 2022). This can also be considered a concrete manifestation of innovation done by an educator. Maharani (2022) stated that innovation in learning needs to be done by educators to achieve the desired goals. Not only for educators but also for students, it is very important to have teaching subjects to increase their involvement and skills in the learning process (Siregar et al., 2022).

Research by Fitriani and Susanti (2022) stated that the calculus teaching subject is not optimal, while students need the subject. Another finding from the research by Siregar et al. (2022) shows that students need SW that can be used independently in learning calculus. In addition, from the results of Sholihah and Asyhar's research (2023), it can be seen that the visual reasoning ability of male and female students in solving integral problems is different, whereas in solving integral problems there is a visual thinking process. According Wahyuni et al.

(2022), visual thinking plays a role in developing students' ways of thinking, understanding mathematics, and serving as a bridge in the transition from concrete to abstract thinking in solving mathematical problems. To bridge the concrete to the abstract, guidance and special assistance are needed in the form of visual representations of what students are thinking. This allows them to visualize the structure of their ideas in the form of symbols or images that can assist students in the learning process and in solving mathematical problems. Visual thinking skills are essential in learning calculus as they help students understand abstract concepts such as limits, derivatives, and integrals through graphical representations and diagrams. These skills align with 21st-century needs by enhancing spatial reasoning, creativity, and problem-solving abilities, particularly in technology-driven learning environments. Through visual thinking, students can connect mathematical representations with real-world phenomena, utilize digital tools for dynamic exploration, and develop relevant skills for various fields like engineering, economics, and data science. Integrating these skills equips students to tackle complex challenges in the digital era (Yilmaz & Argun, 2018).

Based on the results of several studies, it can be seen that teaching subjects are very much needed by students in the learning process. Therefore, in this study, researchers designed HOTS-based calculus teaching subjects to improve students' visual thinking skills in solving calculus problems on derivative and integral subjects.

METHOD

This study used the Research and Development (R&D) method which aimed to develop calculus worksheets to improve students' problem-solving and visual thinking skills. The development model used refers to the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) as shown in Figure 1, because this model was systematic and easy to adapt for the development of teaching subjects.

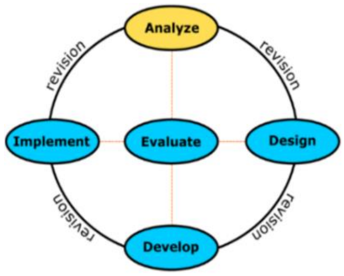

Figure 1. Stages of the ADDIE Development Model (Branch, 2009)

The subjects in this study were undergraduate students of the Mathematics Education Study Program at UIN Sayyid Ali Rahmatullah Tulungagung who had completed the calculus course. The selection of subjects was done using a purposive sampling technique, with the criteria being students who had taken the calculus course. This study collected two types of data, that is quantitative and qualitative data. Quantitative data were obtained from filling out the assessment sheet by experts at the product development stage and filling out the assessment sheet by students at the field trial stage, which were then analyzed descriptively. Meanwhile, qualitative data were obtained through observation, interviews at the analysis stage, and comments and suggestions for improvement from subject and media experts at the product development stage, including comments and suggestions from students. Data collection instruments included interview guidelines, observation sheets, validation sheets by experts, and practicality assessment sheets by students. Data from validation and practicality assessments were used to measure the quality of SW based on the validity, practicality, and effectiveness of the products that had been developed. The HOTS-based SW validity assessment indicators can be seen in Table 1 below.

Table 1. HOTS-based SW Assessment Indicators

No	Assessment Indicators
Content Eligibility	
1	Suitability of SW with Course Learning Outcomes (CPMK)
2	Suitability of SW with Objectives (sub-CPMK) to be achieved
3	Suitability of SW with subject substance
4	Suitability of SW with student learning subject needs
Language Eligibility	
5	Using language that is easy for students to understand

No	Assessment Indicators
6	Using clear sentence structures
7	Using consistent terms and abbreviations
8	Using good and correct Indonesian language rules
Presentation Eligibility	
9	The systematics of the SW (Title, instructions, activity instructions, and evaluation) are presented in full
10	The writing and images in the SW are presented clearly
11	There is enough space for students to write or describe the things they want to convey
Graphics Qualifications	
12	The type and size of the letters used are good and attractive
13	The layout of the SW is attractive
14	The illustrations/pictures used are good and related to the concept
15	The design of the SW display is attractive

Meanwhile, the assessment indicators for the student response questionnaire were shown in Table 2 below.

Table 2. Student Response Questionnaire Assessment Indicators

No	Assessment Indicators
1	Responses regarding the appearance of the SW
2	Responses regarding the subject contained in the SW
3	Responses regarding the practice questions in the SW
4	Responses regarding the language used in the SW
5	Responses regarding the SW support in helping students understand
6	Responses regarding interest in the SW

Calculating the average score of questionnaires using

$$Value\ p = \frac{f}{n} x100\%$$

with *p* representing the percentage score, *f* the number of points obtained, and *n* the total number of points. The MANOVA test is used to determine whether there are significant differences between the means of two or more dependent variables across different groups.

RESULTS AND DISCUSSION

This study used the ADDIE model which consists of 5 (five) steps, that is: analysis, design, development, implementation, and evaluation. Each step in the development process was explained as follows.

Development of Valid, Practical, and Effective SW

The first stage of SW development is analysis. At this stage, the researcher surveyed by distributing questionnaires to students and lecturers regarding the need for teaching subjects in the learning process of the calculus course. The researcher also made the interviews with lecturers teaching the calculus course at the Mathematics Education Study Program, UIN Sayyid Ali Rahmatullah Tulungagung. Furthermore, the researcher looked at the references in the central library of UIN Sayyid Ali Rahmatullah Tulungagung and the Semester Learning Plan (RPS) used in calculus lectures. Furthermore, to make it easier for researchers to compile SW for students and lecturers of Mathematics Education, UIN Sayyid Ali Rahmatullah Tulungagung as a learning resource, the researcher gave a calculus essay test to students of the 2022 semester IV grade who had taken the calculus course. The questions given were essay tests on the concepts of derivatives and integrals. The second stage is design. At this stage, the selection of subjects to be developed into HOTS-based teaching subjects was done. This teaching subject will be equipped with sample questions, and group discussion activities, and is designed to support students' independent learning. In addition, this teaching subject includes measurable questions that have been validated by calculus experts. Based on the analysis of student needs and interviews with calculus lecturers, calculus subject, especially derivatives and integrals, is considered difficult. Students also feel that the questions in the books used so far are quite complicated, especially about integral applications. Therefore, they need more relevant and easy-to-understand sample questions. Furthermore, the researcher designed and compiled the teaching subject, as well as created a validation instrument in the form of a questionnaire filled out by subject experts and calculus lecturers. In addition, the questionnaire was also used for small group trials of students and field trials on larger groups. The development of HOTS-based teaching subjects also aims to measure the ability of UIN Sayyid Ali Rahmatullah Tulungagung Mathematics Education students to solve problems and think visually. Therefore, the researcher also compiled an evaluation instrument for learning outcomes in the form of descriptive questions to measure students' understanding of the concepts and principles of derivatives and integrals.

The third stage is development. This stage is the process of writing teaching subjects in the form of SW. SW writing is based on the applicable RPS. In the SW, Graduate Learning Outcomes (CPL), Course Learning Outcomes (CPMK), and Sub-CPMK have to be included. The SW that has been prepared is validated by subject experts and lecturers teaching the calculus course. After that, the SW was tested on a small group of fourth-semester students of the 2022 intake. Suggestions and criticisms from the validators were used to revise the SW so that the teaching subjects were declared suitable for use. In addition to validation, the effectiveness of the teaching subjects was also measured through a test in the form of solving 2 (two) questions related to derivatives and integrals. This assessment instrument was filled out by subject experts and lecturers of Mathematics Education at UIN Sayyid Ali Rahmatullah Tulungagung. Researchers also prepared a questionnaire for testing on small groups of students and field trials. The SW developed based on HOTS is designed to measure problem-solving and visual thinking skills. At this stage, 2 (two) descriptive questions were prepared to measure the effectiveness of the use of SW on student learning outcomes.

The fourth stage is implementation. At this stage, a field trial was done in the Mathematics Education Study Program, Faculty of Tarbiyah and Teacher Training, UIN Sayyid Ali Rahmatullah Tulungagung. The purpose of this trial was to measure students' ability in problem-solving and visual thinking after using the revised HOTS-based SW which had been declared feasible. The SW was used during the learning process as a guide for teaching and learning activities. During the trial, the obstacles and weaknesses of the SW were also analyzed. After the learning was completed, students were asked to evaluate the SW by filling out a large-scale field trial questionnaire.

The fifth stage is evaluation. At this stage, the researcher assessed how effective the SW teaching subjects were in improving the problem-solving and visual thinking skills of Semester V students. In addition, this stage also compared the average results between classes that used SW teaching subjects and classes that did not use them. After the learning process was completed, the researcher did a posttest using an evaluation instrument that had been validated at the development stage. The results of this posttest were used to evaluate the improvement of students' problem-solving and visual thinking skills, as well as to compare the results between the two class groups.

This research produces a teaching subject product in the form of HOTS-based Student Worksheets (SW). This SW is designed to provide comprehensive guidance in learning the concepts of derivatives and integrals, as well as to help students develop HOTS skills, such as problem-solving and visual thinking skills. The content of the subject in this teaching subject is not much different from the subject taught in the undergraduate mathematics education/teaching program at other universities. However, this study adds more HOTS-based example questions so that students can learn independently and be helped in solving problems through guidance from the available examples. Based on the needs analysis, students expressed that the books used during lectures were considered very heavy, and the examples of questions provided were less helpful for them in solving problems. Therefore, the developed SW is present as a solution, with a display as shown in Figure 2.

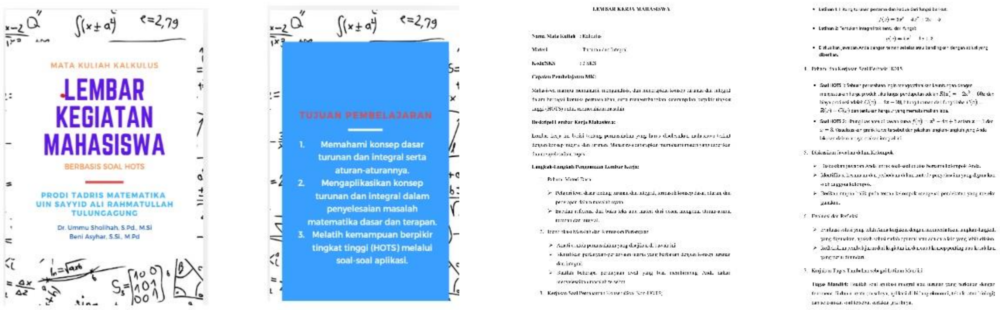

Figure 2. Student Worksheet

Furthermore, the feasibility of the SW teaching subjects was tested directly through the distribution of questionnaires to subject experts, calculus lecturers, and students. The questionnaires distributed were accompanied by the SW that had been prepared so that experts and students could provide comments or input related to the SW. First, validation by calculus subject experts aims to assess the extent of the validity of the calculus SW which includes HOTS-based derivative and integral subjects, especially in terms of learning content. In this process, 1 (one) lecturer from the Mathematics Education Study Program of UIN Sayyid Ali Rahmatullah Tulungagung and 1 (one) lecturer from the Mathematics Education Study Program of STKIP PGRI Madiun were involved. The results of the validation of the subject by the experts are presented in the diagram in Figure 3 below.

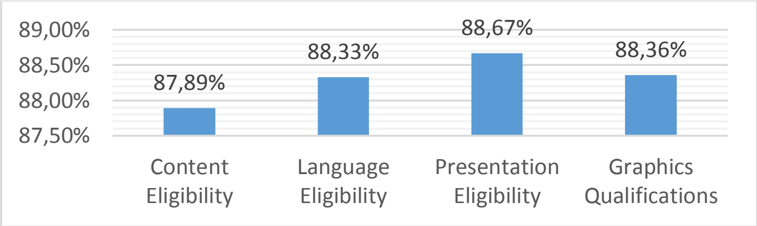

Figure 3. Bar Chart of Subject Expert Validation Results

The results of the evaluation by subject experts showed that the average percentage of overall assessment aspects was 88.31%. This shows that the subject in the SW, in terms of content, language, presentation, and graphics, is valid. With these results, it can be concluded that the subject on derivatives and integrals in the SW is suitable for use in calculus learning. Before providing comments regarding improvements to the SW, the subject experts first validated the RPS and subject indicators that had been selected by the researcher based on student needs and suggestions from colleagues. The subject experts adjusted the RPS to the guidelines in force at the institution where the teaching subjects would be created. After this was fulfilled, the subject experts began validating the SW that had been prepared by the researcher. After several improvements to the teaching subjects, in the final stage, the researcher submitted the revised teaching subjects and gave a questionnaire to the subject experts to assess the validity of the subjects that had been created. The subject experts provided a lot of input, and at the end of the questionnaire, they were asked to provide suggestions regarding HOTS-based derivative and integral subjects. Second, validation by lecturers of calculus courses aims to assess the feasibility of HOTS-based calculus SW on derivatives and integrals that have been developed, so that they can be used as teaching subjects in the teaching and learning process. In this process, 2 (two) lecturers were involved. The first lecturer came from FTIK UIN Sayyid Ali Rahmatullah Tulungagung, Mathematics Education Study Program, who was tasked with assessing the quality of teaching subjects and their level of difficulty. The second lecturer came from FKIP STKIP Jombang, who functioned as a controller of the validity of the SW created. The validation results from these two lecturers are shown in the diagram in Figure 4.

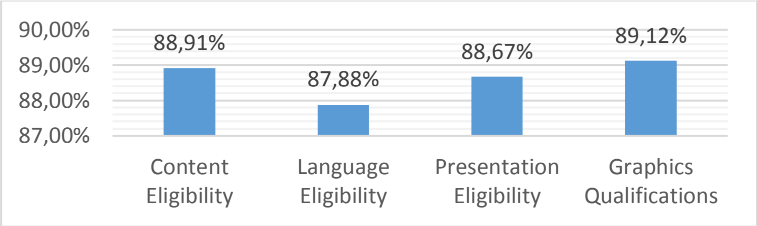

Figure 4. Bar Chart of Course Lecturer Validation Results

The validation results from the calculus lecturer showed that the average overall assessment of the aspects reached 88.65%. This shows that the HOTS-based calculus SW developed is valid in terms of content, language, presentation, and graphics. Thus, the SW is suitable for use in calculus learning, especially in derivative and integral subjects. The lecturer's suggestion is to simplify the appearance of the SW which contains subjects, examples, group discussions, independent questions, and steps for using it. In addition, it is necessary to deepen the discussion of questions or exercises in each existing subject, increase the number of relevant example questions, and present questions with a level of difficulty that is appropriate to the basic abilities of students. Third, small group trials aim to identify deficiencies in the SW that have been developed so that the SW can meet the needs of students and their basic abilities. After revisions are made based on the validation results from subject experts and calculus lecturers, the expected information is not only related to the quality of teaching subjects but also to how this SW is used as a source in the learning process in the classroom. The trial was done on 10 students, and the assessment results were given through a questionnaire, which was then presented in the diagram in Figure 5 below.

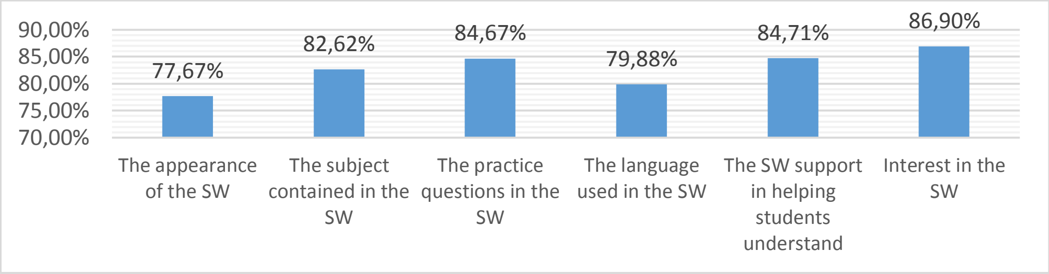

Figure 5. Bar Chart of Small Group Trial Results

The results of the small group trial showed an average percentage of overall assessment of 81.53%. This shows that the HOTS-focused calculus teaching subjects developed have very good quality. Some suggestions given by participants (students) in small groups include overcoming the difficulty of questions, clarifying existing example questions, forming group discussions, and deepening the application of the subject. Based on the results of the validation and trial, the HOTS-oriented calculus SW teaching subjects are very suitable for use in field trials (large scale). Before being used, the teaching subjects need to be revised according to input from subject experts, calculus lecturers, and students in small group trials. Fourth, HOTS-oriented calculus SW teaching subjects, after being revised based on the validation results and tested in small groups, were then tested in the field. The SW that had been revised several times was used as teaching subjects in the learning process. The purpose of the field trial was to find out the assessment and responses of students to the products that had been made when used in learning. The field trial was done in the Mathematics Education Study Program, FTIK UIN Sayyid Ali Rahmatullah Tulungagung with 38 students. The assessment was done through a field trial questionnaire, and the results of the field trial are presented in the following diagram Figure 6.

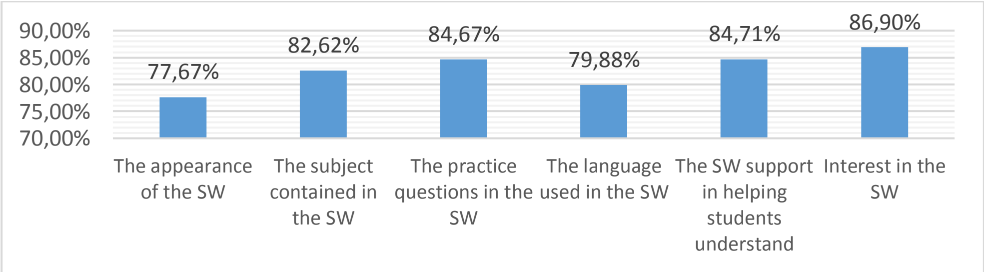

Figure 6. Bar Chart of Field Trial Results

The results of the field trial obtained an average percentage of overall assessment aspects of 82.74%. This shows that the Student Worksheet that has been developed has a very good interpretation. In the final stage, that is implementation, the SW calculus teaching subject was tested in the field to assess students' opinions about the teaching subject. In addition, another purpose of this trial is to measure the effectiveness of the teaching subject in improving problem-solving and visual thinking skills. To find out if there was an increase in these abilities, a post-test evaluation was done on the control and experimental classes after using SW in the experimental class. The evaluation questions were in the form of 2 (two) essay questions that had been checked and validated by subject experts and lecturers of the calculus course. After obtaining validation regarding the content of the subject and questions, the teaching subject was considered valid and could be used to measure the increase in problem-solving and visual thinking skills. The results of the student post-test were analyzed using the MANOVA test, by comparing the experimental class that used SW and the control class that did not use SW. The data obtained from this large-scale trial are presented in Table 3 and Table 4.

Table 3. Results of Problem Solving Ability (Y1) and Visual Thinking (Y2) of Experimental Class

No.	Student Name	Y1	Y2	No.	Student Name	Y1	Y2
1	CHM	85	81	20	SAP	91	81
2	KANA	84	80	21	NAF	87	83
3	DRIS	91	86	22	ARR	75	81
4	KAPB	87	86	23	EDU	78	82
5	PMS	75	78	24	EBN	86	86
6	NHR	78	75	25	EE	79	78
7	KPM	86	87	26	GTS	87	78
8	MNA	79	75	27	SNA	75	75
9	WRR	80	81	28	RMH	84	79
10	FR	81	82	29	UNH	91	87
11	SKN	81	81	30	FDS	86	78
12	URJ	87	90	31	AR	78	80
13	SA	88	86	32	ZTR	75	73
14	MAWA	86	78	33	DS	80	74
15	SF	84	75	34	TAN	81	82
16	FASPP	86	78	35	RFA	86	81
17	NFP	86	86	36	MLA	86	82
18	MTA	80	79	37	HW	80	83

No.	Student Name	Y1	Y2	No.	Student Name	Y1	Y2
19	AZF	79	78	38	AZB	81	80

Table 4. Results of Problem Solving Ability (Y1) and Visual Thinking (Y2) of Control Class

No.	Student Name	Y1	Y2	No.	Student Name	Y1	Y2
1	HED	67	71	20	ESP	75	78
2	KSR	75	73	21	MDNL	69	73
3	NH	73	72	22	SDA	80	81
4	FA	72	69	23	IKU	76	78
5	RDN	75	73	24	VSNR	81	80
6	AJ	69	69	25	WBU	76	79
7	AR	80	78	26	NS	68	70
8	INH	76	73	27	SAKCH	72	73
9	FA	82	83	28	ZI	70	72
10	ZZS	76	77	29	EKP	68	73
11	MSI	77	80	30	MRS	73	70
12	FK	78	75	31	MCS	75	71
13	NDC	75	72	32	RAN	76	71
14	DDP	81	82	33	ISA	72	74
15	SL	76	80	34	SR	80	78
16	FDA	77	80	35	NAM	81	75
17	ASLF	80	78	36	RADS	78	76
18	AAT	76	77	37	CNS	73	72
19	GAM	79	77				

The results of the posttest data analysis using SPSS 21, the MANOVA test was continued to find out the effect of the use of HOTS-based SW on the problem-solving and visual thinking abilities of students in the experimental and control classes.

Table 5. The output of the MANOVA test for the average visual thinking and problem-solving ability

Descriptive Statistics

	Student_Worksheet	Mean	Std. Deviation	N
visual_thinking	experiment class	80.66	4.082	38
	control class	75.22	3.917	37
	Total	77.97	4.827	75
problem_solving	experiment class	82.87	4.622	38
	control class	75.32	4.083	37
	Total	79.15	5.763	75

Based on Table 5, it is known that the descriptive statistics regarding the average post-test and students' self-efficacy questionnaire based on factors, standard deviation, and data count (N) are presented. The results of the Box's Test of Covariance Matrices are shown in the following Table.

Table 6. The output of the MANOVA variance/covariance test

Box's M	4,394
F	1.421
df1	3
df2	982330.772
Sig.	0.234

Based on the Table 6 above, the output of Box's Test of Equality of Covariance Matrices shows a significant covariance value of 0.594, which is greater than 0.05. Therefore, the MANOVA analysis can proceed. The results of the multivariate significance test are presented in the Table below.

Table 7. The output of the visual thinking and problem-solving ability

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.998	15816.528b	2.000	72.00 0	.000
	Wilks' Lambda	.002	15816.528b	2.000	72.00 0	.000
	Hotelling's Trace	439.348	15816.528b	2.000	72.00 0	.000
	Roy's Largest Root	439.348	15816.528b	2.000	72.00 0	.000
student_worksheet	Pillai's Trace	.441	28.375b	2.000	72.00 0	.000
	Wilks' Lambda	.559	28.375b	2.000	72.00 0	.000
	Hotelling's Trace	.788	28.375b	2.000	72.00 0	.000
	Roy's Largest Root	.788	28.375b	2.000	72.00 0	.000

The results of the MANOVA test showed that the posttest scores between the two classes showed significant differences, with F values in various tests (Pillai's Trace, Wilk's Lambda, Hotelling's Trace, and Roy's Largest Root) all significant (value 0.000 <0.05). This means that there is a difference in problem-solving and visual thinking abilities between the experimental and control classes. Furthermore, Levene's test was used to check the equality of variance between groups.

Table 8. The MANOVA test output on Variance/Homogeneity

	F	df1	df2	Sig.
visual_thinking	.193	1	73	.662
problem_solving	2.342	1	73	.130

The test results show that the variable "problem-solving ability" has a significance of 0.130 and "visual thinking ability" 0.662, both of which are greater than 0.05, indicating that the variance between data groups is the same. The results of the F-test calculation are presented in the Table below.

Table 9. The MANOVA Test Output on F-Test

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F
Corrected Model	visual_thinking	555.124[a]	1	555.124	34.671
	problem_solving	1066.936[b]	1	1066.936	56.015
Intercept	visual_thinking	455482.857	1	455482.857	28447.636
	problem_solving	469134.296	1	469134.296	24630.011
student_worksheet	visual_thinking	555.124	1	555.124	34.671
	problem_solving	1066.936	1	1066.936	56.015
Error	visual_thinking	1168.823	73	16.011	
	problem_solving	1390.450	73	19.047	
Total	visual_thinking	457712.000	75		
	problem_solving	472272.000	75		
Corrected Total	visual_thinking	1723.947	74		
	problem_solving	2457.387	74		

Based on the Table 9 above, for the relationship between problem-solving ability, the test results show an F value of 56.015 with a significance of 0.000, which means that H_0 is rejected. This shows that HOTS-based SW affects students' problem-solving ability in derivative and integral subjects. Likewise, for the relationship between visual thinking ability, the test results show an F value of 34.671 with a significance of 0.000, which also shows that HOTS-based SW affects students' visual thinking ability.

Overall, the MANOVA analysis shows that there is a significant difference in problem-solving and visual thinking abilities between the experimental class and the control class, with a significance showing a value of $0.000<0.05$. Therefore, H_0

is rejected, and it can be concluded that HOTS-based Calculus SW is effective in improving students' problem-solving and visual thinking abilities in derivative and integral subjects.

Students' Visual Thinking Ability in Solving Calculus Problems

Based on the validation process that has been done, it is known that the average calculation results of the assessment aspects of SW subject experts are valid and suitable for use with an average value of 88.31% and from the course lecturer of 88.63%. These results were obtained after doing several processes of improving the subject in the developed teaching subjects. This shows that the results of the development of teaching subjects are valid and can be used without revision.

SW that has been developed effectively improves problem-solving and visual thinking skills as seen from the results of the post-test and statistical analysis there are differences in the results of the problem-solving and visual thinking ability tests between the experimental class and the control class seen from the significance of 0.031<0.05. Teaching subjects are said to be practical if they meet the criteria for the practicality of 50% of students who give positive responses to several aspects asked in the student response sheet. The practicality of SW can be seen from student responses which show that the average in the small sample trial class is 81.53% and the field test is 82.74%. So the results of the development of practical teaching subjects for use as teaching subjects for derivative and integral subjects.

Good students' visual thinking skills are indicators of looking (85%), seeing (79%), showing and telling (72%), while the lowest is imagining (71%), and there are differences in visual thinking skills between male and female students which lie in the process of seeing and recognizing when making a solution plan, where male students are better able to process images than female students. The application of HOTS-based SW has succeeded in improving students' problem-solving and visual thinking skills in calculus courses, especially in derivative and integral subjects. Based on data analysis, there was a significant increase in the experimental group compared to the control group that did not use HOTS-based SW. This increase in problem-solving skills is by the theory that states that problem-solving skills can be improved through HOTS-based learning strategies, which involve analytical and critical thinking stages. According to Polya (1985), problem-solving skills follow steps such as understanding the problem, making a plan, implementing the plan, and evaluating the results. HOTS-based SW helps students through each of these stages, especially with tasks that guide them in critical thinking and finding solutions independently.

In line with the theory of higher-order thinking Skills (HOTS) which emphasizes the importance of critical thinking processes in problem-solving. HOTS involves analysis, evaluation, and creation that allows students to understand problems more deeply and create creative solutions (Anderson & Krathwohl, 2001). In calculus learning, HOTS allows students to not only apply the concepts of derivatives and integrals procedurally but also to adapt them to new contexts.

Students' visual thinking skills are improved through the use of SW which integrates visual approaches, such as the use of graphs and diagrams to understand the concepts of derivatives and integrals. Arcavi (2003) suggests that visual thinking allows students to connect visual representations with a deeper understanding of mathematical concepts. Students in visual activities in SW tend to more easily understand the relationship between elements in calculus problems, which makes them more skilled in analyzing and solving problems based on graphs and diagrams. In the context of calculus, this ability makes it easier for students to visualize the integral area and changes represented by derivatives, thus helping them connect concepts with their applications in real situations. The application of HOTS-based SW helps students develop critical and creative thinking skills in dealing with complex calculus problems. By the opinion of Maharani (2022), HOTS-based teaching subjects encourage students to practice analytical skills and develop broader understanding through independent and collaborative learning activities. Costa and Kallick (2000) and Junaedi et al. (2021) also emphasize that effective mathematical problem-solving requires a flexible approach, where students need to adapt to various problem-solving strategies, such as new patterns or visual approaches to describing problems. Based on the revised Bloom's taxonomy (Anderson & Krathwohl, 2001), HOTS is located at the analysis, evaluation, and creation levels. These levels are important in calculus because students have to be able to describe abstract concepts (analysis), consider the implications of each concept in solving problems (evaluation), and finally create new problem-solving strategies (creation). HOTS requires students to relate and organize information in new ways to deal with confusing situations, which is also seen in students who successfully apply the concepts of derivatives and integrals with a visual approach. HOTS-based SW is very relevant in mathematics learning, especially in topics that require an understanding of abstract concepts such as calculus. Through SW, students can practice solving advanced mathematics problems, develop logical and critical thinking skills, and learn to apply mathematics in solving real problems. Arcavi (2003) emphasizes the importance of visual thinking in mathematics to facilitate understanding of abstract concepts such as derivatives and integrals.

CONCLUSION

Based on the development process and trial results of the developed teaching subjects, it can be concluded that: 1) The research and development of this teaching subject produced a product in the form of HOTS-based SW to improve students' visual thinking skills in solving valid, practical, and effective calculus problems which were developed using the ADDIE research and development model. The results of the validation test analysis showed that the HOTS-based SW that had been developed was in the "valid" category so that it was suitable for use in calculus courses; 2) The practicality of HOTS-based SW was seen from the results of student responses in positive responses and in the "very good" category; 3) The effectiveness of HOTS-based SW was seen from the results of the posttest which showed that there was a difference in the results of the problem-solving and visual thinking ability tests between the experimental class and the control class with a significance showing a value of $0.000<0.05$. The good visual thinking ability of students is the indicator of looking (85%), seeing (79%), showing and telling (72%), while the lowest is imagining (71%), and there is a difference in visual thinking ability between male and female students which lies in the process of seeing and recognizing when making a solution plan, where male students are better able to process images than female students.

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