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Development and Preliminary Evaluation of an Interactive Flipbook Module for CAD/CAE Ship Lines Plan Design

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Abstract

Although CAD/CAE software such as Maxsurf is increasingly used in ship design, interactive digital practicum resources that integrate structured instructional guidance with CAD/CAE-based Ship Lines Plan modelling remain limited. This study aimed to develop and preliminarily evaluate an interactive flipbook-based digital practicum module for Ship Lines Plan design using Maxsurf. The module was developed using seven adapted stages of the Borg and Gall research and development model. Its feasibility was evaluated by three material experts and three media experts, followed by a one-group pretest-posttest evaluation involving 10 third-semester Naval Architecture students enrolled in the Ship Lines Plan course. Students' practical design performance was assessed using 30 technical criteria and analysed using normalized gain (N-Gain), a paired-samples t-test, and Cohen's d_z. Material and media validation scores were 92% and 85%, respectively, both classified as Very Valid, with S-CVI/Ave values of 1.00. Mean performance scores increased from 60.00 (SD = 7.50) at pre-test to 89.40 (SD = 4.55) at post-test. The mean N-Gain was 0.734, classified as High, and the paired-samples analysis showed a statistically significant within-group difference, $t(9) = 13.03$, $p < .001$, with a very large effect size (Cohen's $d_z = 4.12$). The overall student-response score was 97%, classified as Strongly Positive, and the questionnaire demonstrated acceptable internal consistency (Cronbach's alpha = .734). These findings provide preliminary evidence that the developed module is feasible, well accepted by students, and associated with substantial improvement in practical CAD/CAE-based Ship Lines Plan design performance.

Keywords: Ship Lines Plan; CAD/CAE; Maxsurf; Digital Practicum Module; Flipbook; Naval Architecture Education

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INTRODUCTION

Education plays an important role in preparing learners to respond to continuing developments in science and technology (Yuliasari, 2017; Yunian Putra & Anggraini, 2016). In engineering education, this role is particularly important because students are expected not only to understand theoretical concepts but also to apply them to authentic technical problems. Practical learning provides opportunities for students to connect disciplinary knowledge with real-world problem-solving and design activities (Inkermann & Ammersdörfer, 2024; Izaak, 2008). However, effective practical learning requires clear and systematic instructional guidance so that students can complete activities in a focused, consistent, and technically appropriate manner (Mastura et al., 2017; Zhong et al., 2024; Nurbaeti, 2020; Permadani & Sukmawati, 2021; Syamsu, 2017).

Naval Architecture is an engineering discipline concerned with ship design and related technical analyses (Ferreiro, 2024; Hilmy et al., 2023). Within the Naval Architecture curriculum, Ship Lines Plan practicum activities provide students with experience in developing the geometric representation of a ship hull from prescribed design data (Chandra et al., 2017; Fatwasari et al., 2021; Toyyibun, 2021). Because these activities require students to translate numerical and geometric information into a coherent hull form, the availability of structured practical guidance is particularly important. At the same time, developments in educational technology and Information and Communication Technology (ICT) provide opportunities to deliver such guidance through digital and interactive learning resources (Agustian & Salsabila, 2021; Majidah, 2021; Cholik, 2021).

These technological developments are increasingly relevant to engineering-design education because contemporary design practice makes extensive use of computer-aided design and computer-aided engineering (CAD/CAE) applications. CAD/CAE environments enable students and engineers to develop, visualize, modify, and evaluate engineering designs in a controlled digital environment (Li & Liang, 2024; Negahban, 2024; Jin & Yang, 2022; Li et al., 2023; Ningsih, 2005; Regassa Hunde & Debebe Woldeyohannes, 2022). In Naval Architecture, Maxsurf is one of the CAD/CAE applications used for ship-design activities (Rachman et al., 2020; Ramadhani et al., 2023). The software supports three-dimensional hull modelling and can subsequently be used in hydrodynamic and other ship-performance analyses (Anugrah & Awwaludien Al-Fath, 2022; Nababan et al., 2017; Nitonye et al., 2023). Thus, integrating CAD/CAE applications into Ship Lines Plan practicum activities can provide students with a design workflow that more closely reflects contemporary digital ship-design practice.

Despite these technological capabilities, practical instructional resources specifically guiding students through CAD/CAE-based Ship Lines Plan development remain limited. Existing practicum guidance in the study context has primarily relied on the NSP (Nederlandsch Scheepsbouwkundig Proefstation) method, whereas preliminary observations conducted during Ship Lines Plan practicum activities indicated that students experienced difficulties in using Maxsurf effectively. This gap suggests that access to CAD/CAE software alone is insufficient; students also require instructional resources that explain how the software should be applied systematically during the design process. Interactive digital learning resources can support this requirement by organizing explanations, demonstrations, and visual information into a format that can be repeatedly accessed during practical activities (Masykur et al., 2017).

Accordingly, a CAD/CAE-based Ship Lines Plan practicum resource should not only communicate technical procedures but should also present them in an informative, interactive, visually clear, and digitally accessible form. A flipbook-based module offers a means of integrating written explanations with visual examples, tutorial videos, reference images, navigation functions, and practical design guidance within a single digital resource (Kurniasari et al., 2023; Prasasti & Anas, 2023). Evidence from related engineering-learning contexts also supports the relevance of this approach. Rahmagandi et al. (2024), for example, developed a flipbook-based e-module for manufacturing-design learning involving 2D and 3D Autodesk Inventor sketching, while Wisnusuasono and Ngadiyono (2024) developed a flipbook-assisted e-module for a 3D CAD course. These studies demonstrate the applicability of interactive digital modules to CAD-oriented engineering learning; however, they do not address Ship Lines Plan development or a Maxsurf-based Naval Architecture workflow.

Within the specific context of Ship Lines Plan education, Hilmy et al. (2025) previously developed an interactive flipbook module for practicum activities using the manual NSP method. That module primarily supported the construction of two-dimensional Ship Lines Plan representations. The present study extends this instructional approach by integrating Maxsurf CAD/CAE into the practicum workflow so that students can develop a two-dimensional lines plan and subsequently examine the corresponding three-dimensional hull model. The ability to connect 2D geometric construction with 3D hull visualization provides additional opportunities for students to inspect hull proportionality, geometric continuity, and the consequences of design modifications before finalizing the design (Al Ghofur & Fahruddin, 2024).

Therefore, the novelty of the present study does not lie solely in the use of a digital flipbook or in the use of Maxsurf as an engineering application. Rather, it lies in the integration of an interactive flipbook-based practicum guide with a Maxsurf CAD/CAE workflow that connects structured two-dimensional Ship Lines Plan construction with three-dimensional hull visualization and technical design evaluation. The module combines step-by-step design instructions, tutorial videos, reference images, practical tips, and interactive digital functions to support students throughout the CAD/CAE-based practicum process.

Based on this research gap, the present study aimed to develop and preliminarily evaluate an interactive digital practicum module for CAD/CAE-based Ship Lines Plan design using Maxsurf. The evaluation focused on three aspects: (1) expert-validated content and media feasibility, (2) improvement in students' practical Ship Lines Plan design performance, and (3) students' acceptance of the developed module. Consistent with the pretest-posttest evaluation employed in the study, it was hypothesized that students would demonstrate higher practical Ship Lines Plan design-performance scores after using the interactive digital practicum module than before its implementation.

METHOD

Research Design and Methodological Framework

The present study represents a methodological extension of the flipbook-based practicum module previously developed by Hilmy et al. (2025). Whereas the previous study focused on manual Ship Lines Plan development using the NSP method, the present study integrates Maxsurf CAD/CAE to support both two-dimensional (2D) lines-plan development and three-dimensional (3D) hull modelling. The present study also extends the evaluation framework by incorporating content-validity analysis, questionnaire reliability analysis, inferential statistics, effect-size estimation, and a detailed technical performance assessment. The principal methodological differences between the previous and present studies are summarized in Table 1.

The study employed a quantitative one-group pretest-posttest design embedded within a research and development (R&D) framework based on the Borg and Gall model (Putra et al., 2020; Putri et al., 2023). Seven of the ten development stages were adapted to the objectives and context of the study (Amil et al., 2020). The resulting development sequence comprised problem identification, information gathering and research planning, product design, expert validation, product revision, product testing, and final product development, as illustrated in Figure 1.

Table 1. Comparison between Hilmy et al. (2025) and the Present Study

Feature	Hilmy et al. (2025)	Present Study
Design method	Manual Ship Lines Plan using NSP method	CAD/CAE-based Ship Lines Plan using Maxsurf
Output	2D Ship Lines Plan	2D Ship Lines Plan and 3D hull modelling
Media	Flipbook + QR video + tips + reference images	Flipbook + QR video + tips + reference images
Participants	10 students	10 students
Evaluation	Expert validation; one-group pretest-posttest performance assessment; N-Gain test; student response questionnaire	Expert validation; CVI; Cronbach's alpha; one-group pretest-posttest performance assessment; N-Gain test; paired-samples t-test; Cohen's d_z; student response questionnaire
Technical indicators	General 2D lines-plan performance indicators (not explicitly specified)	Thirty technical performance criteria including bow and stern configuration, hull geometry, line fairness, dimensional accuracy, superstructure accuracy, overall drawing quality, and 3D design quality

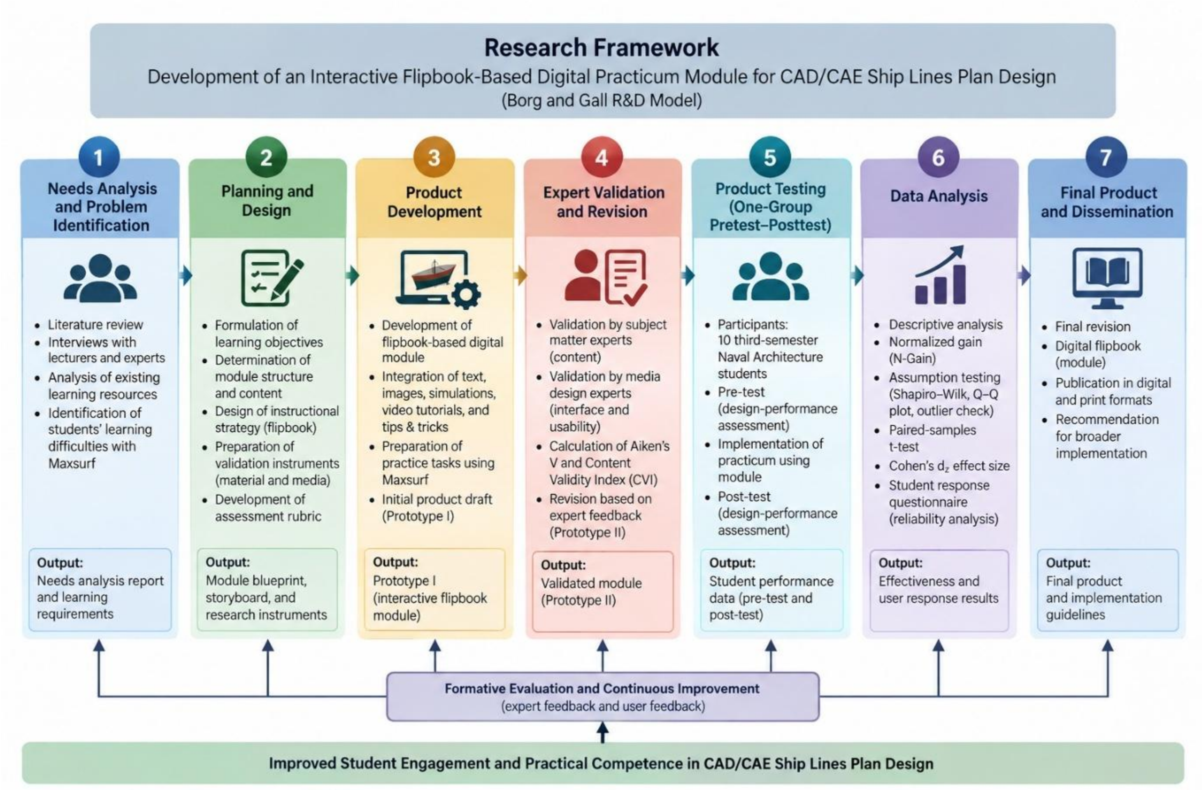


Figure 1. Research Stage

Participants and Ethical Considerations

The study was conducted in the Naval Architecture Study Program at Karimun University. The study cohort consisted of 10 third-semester Naval Architecture students enrolled in the Ship Lines Plan course. Because these 10 students constituted the entire cohort enrolled in the course, all eligible students were included using saturated (census) sampling.

The students had completed introductory instruction in CAD and Maxsurf software during the preceding semester. Therefore, all participants possessed basic operational knowledge of CAD/CAE applications before participating in the study. This prerequisite was important because the developed module was intended to guide Ship Lines Plan design rather than provide introductory software training.

The study was institutionally authorized by the Head of the Study Program and conducted under the supervision of the Institute for Research and Community Service (LPPM) in connection with the 2025 *Penelitian Dosen Pemula (PDP)* grant from the Ministry of Higher Education, Science, and Technology. All participants provided informed consent before participation. Participation was voluntary, participants could withdraw without academic consequences, and participation did not affect course grades. All research data were anonymized and used solely for research purposes.

Research Instruments and Measures

Four instruments were used to evaluate the developed module: a Material Expert Validation Sheet, a Media Expert Validation Sheet, a Student Response Questionnaire, and a Performance Assessment Rubric. The expert-validation instruments were used to determine the feasibility and suitability of the developed product (Lukman et al., 2019; Pawestri & Zulfiati, 2020), whereas the student questionnaire measured user acceptance and perceived usability. Practical learning outcomes were assessed using students' Ship Lines Plan design performance rather than a separate cognitive test. The characteristics and measurement functions of all instruments are summarized in Table 2.

Table 2. Research Instruments and Measurement Properties

Instrument	Construct	Dimensions	Items	Scale	Participant	Validity Evidence	Analysis
Material Expert Validation Sheet	Content validity of the digital practicum module	Content appropriateness; presentation feasibility; contextual feasibility	18	Five-point Likert	Three material experts	I-CVI and S-CVI/Ave	Expert agreement
Media Expert Validation Sheet	Media feasibility	Graphical feasibility; language appropriateness	27	Five-point Likert	Three media experts	I-CVI and S-CVI/Ave	Expert agreement
Student Response Questionnaire	User acceptance and perceived usability	Ease of use, attractiveness, usefulness, motivation, clarity, satisfaction	10	Five-point Likert	10 students	Expert review before implementation	Cronbach's alpha
Performance Assessment Rubric	Practical Ship Lines Plan design performance using Maxsurf CAD/CAE	Technical design quality across 30 criteria	30	0-100 per criterion	Course lecturer	Content validated by experts	N-Gain; paired-samples t-test; Cohen's d_z

Students were required to complete a Ship Lines Plan design using Maxsurf CAD/CAE software. The resulting designs were evaluated using the official Ship Lines Plan course assessment rubric consisting of 30 technical performance criteria. These criteria covered bow configuration, stern configuration, hull geometry, superstructure accuracy, line fairness, dimensional accuracy, overall drawing quality, and other technical components of Ship Lines Plan design. Clearly defined performance criteria and standardized scoring procedures are important for improving the consistency and interpretability of performance-based assessments (Windyariani & Setiono, 2024; Yılmaz, 2024).

Each criterion was scored on a 0-100 scale using five performance bands: Very Poor (0-20), Poor (21-40), Fair (41-60), Good (61-80), and Excellent (81-100). The overall performance score for each student was calculated as the arithmetic mean of the 30 criterion scores using Formula 1.

Final Performance Score = (sum of 30 criterion scores) / 30 (1)

Accordingly, the pre-test and post-test scores represented students' practical Ship Lines Plan design performance rather than a separate measure of general cognitive ability. A sample item from the performance-assessment rubric is shown in Figure 2.

NO	Indicator	Technical Definition	Scoring				
			0–20 (Very Poor)	21–40 (Poor)	41–60 (Fair)	61–80 (Good)	81–100 (Excellent)
		according to the design specifications.				affect the overall design.	all profile components.
6	Bow Streamlined Design Quality on CAD Drawing	The student's ability to produce a streamlined bow geometry in the CAD drawing that accurately represents the intended hull profile, maintains smooth line continuity, and conforms to the ship design specifications after completing the practicum.	The bow profile is not streamlined or fails to represent the intended ship geometry. Major errors prevent the drawing from meeting the required design standards.	The bow geometry shows substantial irregularities with poor curve continuity and incorrect proportions, resulting in a noticeably inaccurate bow profile.	The bow profile is partially streamlined. Several discontinuities, disproportionate curves, or alignment errors remain and require moderate revision.	The bow profile is generally streamlined and proportional. Minor geometric inconsistencies are present but do not significantly affect the overall hull shape or design quality.	The bow profile is fully streamlined with smooth and continuous curves. All geometric transitions are fair, proportional, and consistent with the design specifications. No visible irregularities or discontinuities are observed.

Figure 2. Sample of the Performance Assessment Rubric

Product Development Procedure

The product-development process followed the seven adapted stages shown in Figure 1. In the first stage, problem identification, preliminary observations were conducted during the Ship Lines Plan practicum to identify practical difficulties and opportunities for product development. Because these observations were informal, they were used only as an initial rationale for product development and were not treated as formal research outcome data.

The second stage involved information analysis and research planning. The preliminary analysis indicated that practical guidance integrating Ship Lines Plan design with CAD/CAE-based modelling was limited. This limitation suggested a need for stronger integration of digital modelling applications into contemporary engineering-design instruction (Damaren et al., 2025). Digital and simulation-supported learning environments can provide additional opportunities for engineering students to engage with complex technical processes in structured environments (Sidhu et al., 2024).

In the third stage, product design, Maxsurf was selected as the principal CAD/CAE application because it enables the development and visualization of ship designs in both 2D and 3D formats (Khoiriyah et al., 2025). The 3D representation enables students to examine the complete hull form generated from a 2D lines plan and to identify geometric inconsistencies before finalizing the design.

A preliminary framework for the flipbook-based practicum module was then prepared. It incorporated learning and practicum objectives, structured design instructions, video tutorials, reference images of completed work, and practical design tips. These components were organized into an interactive digital format. The structure and principal components of the proposed module are presented in Figure 3.

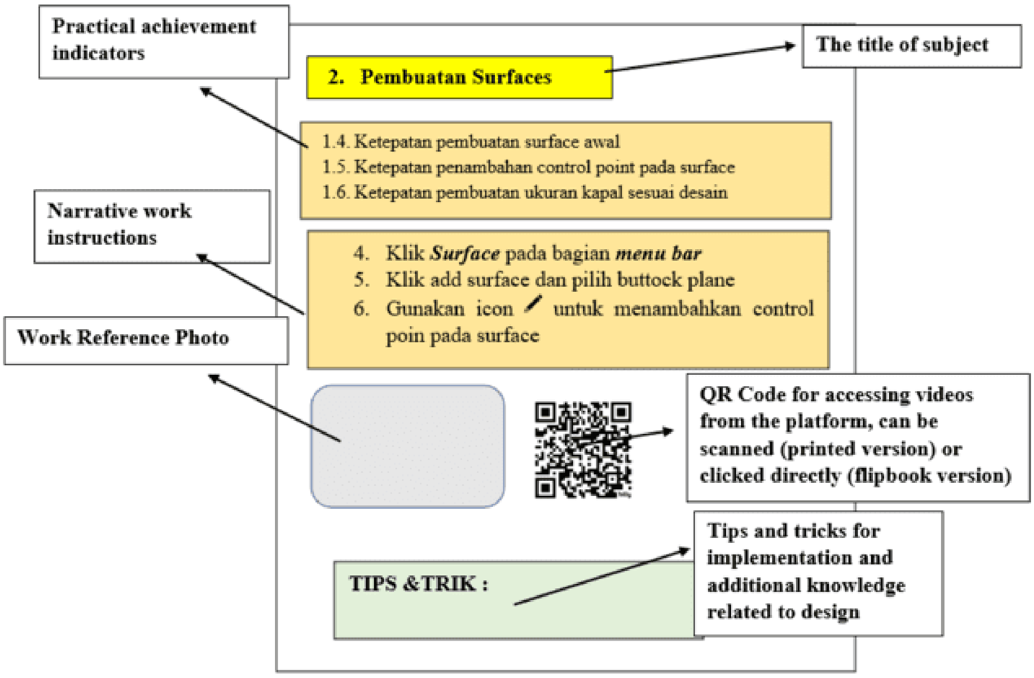


Figure 3. Product Draft

Expert Validation and Product Revision

The fourth development stage consisted of expert validation. Three material experts, comprising Naval Architecture lecturers and shipbuilding practitioners, evaluated the instructional content of the digital practicum module using an 18-item Material Expert Validation Sheet. The instrument covered three dimensions. The content-appropriateness dimension assessed the completeness, breadth, and depth of the material; accuracy of technical content, terminology, symbols, units, and references; alignment of the material with the Ship Lines Plan design process; relevance of images and illustrations to the design procedures; and the capacity of the module to support student understanding and provide standardized practical guidance. The presentation-feasibility dimension evaluated the consistency and logical sequence of the practicum content, organization of concepts and instructions, student involvement, sequencing of practical work steps, and availability of supporting explanations. The contextual-feasibility dimension assessed the relevance of the material to professional practice and its ability to connect theoretical content with its application in Ship Lines Plan design.

Media feasibility was evaluated independently by three media experts using a 27-item Media Expert Validation Sheet. The instrument comprised two main dimensions: graphical feasibility and language appropriateness. Graphical feasibility included the suitability of the digital flipbook format and page dimensions, readability and proportionality of typography, consistency of font use, harmony of colours and layout, relevance and proportionality of cover and content illustrations, spacing between textual and visual elements, organization of page components, clarity of audio, and quality of embedded video materials. Language appropriateness assessed sentence structure, sentence effectiveness, use of standard language, clarity and appropriateness of language used in video materials, communicativeness of the instructional messages, ability of the wording to motivate students and encourage critical thinking, and accuracy of grammar and spelling. Together, these dimensions were used to determine whether the module was sufficiently clear, visually appropriate, communicative, and technically suitable for implementation in the Ship Lines Plan practicum.

Expert scores from both validation instruments were converted to percentages and interpreted according to the predefined feasibility categories presented in Table 3. The quantitative assessment was complemented by qualitative comments from the validators, which were used to revise the module before student testing.

Table 3. Validation Criteria

Percentage (%)	Category
85-100	Very Valid
75-84	Valid
65-74	Valid Enough
55-64	Less Valid
0-54	Invalid

Content-validity evidence was quantified using the Item-level Content Validity Index (I-CVI) and the average Scale-level Content Validity Index (S-CVI/Ave). Explicitly distinguishing item-level and scale-level CVI calculations improves the interpretability of content-validity reporting (Polit & Beck, 2006), while the approach is consistent with the validation procedures applied in the original study framework (Suryadi et al., 2023; Zasali et al., 2023). For each item, I-CVI was calculated as the proportion of experts assigning a rating of 4 or 5, as shown in Formula 2.

I-CVI = number of experts rating the item as 4 or 5 / total number of experts (2)

The S-CVI/Ave was calculated as the mean of the I-CVI values across all items, as shown in Formula 3.

S-CVI/Ave = sum of I-CVI values / number of items (3)

These calculations were performed separately for the material and media validation instruments.

Practicum Trial and Performance Assessment

The sixth stage consisted of product testing with the 10 participating students. The trial used a one-group pretest-posttest performance design to provide preliminary within-group evidence of changes in practical Ship Lines Plan design performance after implementation of the module.

Data collection was conducted over eight weeks (approximately two months), with two practicum sessions per week, resulting in 16 sessions of approximately 3-4 hours each. During the first month, students completed practical activities under conventional instruction, in which the lecturer provided lectures and demonstrations. Their resulting design performance constituted the pre-intervention assessment.

During the second month, the interactive digital practicum module was integrated into the practical activities, and the resulting Ship Lines Plan designs constituted the post-intervention assessment.

The same 30-criterion performance rubric described in Table 2 was used to assess both conditions. The design outputs were evaluated by one assessor, the lecturer responsible for the Ship Lines Plan Design course. Because only one assessor was used, inter-rater reliability could not be estimated. This feature should therefore be considered when interpreting the resulting performance scores. The assessor nevertheless possessed disciplinary expertise through experience teaching Ship Lines Plan Design, relevant academic qualifications, and a research portfolio in Naval Architecture.

Normalized gain (N-Gain) was calculated from each student's pre-test and post-test performance scores using Formula 4.

$$g = (\text{Post-test Score} - \text{Pre-test Score}) / (\text{Maximum Score} - \text{Pre-test Score}) \quad (4)$$

The N-Gain value was used to describe the magnitude of normalized improvement in practical design performance. The interpretation criteria are presented in Table 4 and are consistent with the use of normalized gain in educational evaluation (Aziz et al., 2022; Rizalda & Nursaid, 2023).

Table 4. N-Gain Category

Limit of Category	Category	Code
$g \geq 0.70$	High	H
$0.30 \leq g < 0.70$	Moderate	M
$g < 0.30$	Low	L

Statistical Analysis of Performance Scores

Following the descriptive and N-Gain analyses, inferential analysis was performed on the paired pre-test and post-test performance scores. Before conducting the paired-samples t-test, the distribution of the paired difference scores (post-test minus pre-test) was examined. Because the sample was small (n = 10), normality was assessed using the Shapiro-Wilk test together with visual inspection of a Q-Q plot. Potential outliers in the paired differences were examined using the interquartile-range (IQR) criterion. The use of complementary statistical and graphical procedures provides a more informative assessment of distributional assumptions than reliance on a single normality test alone (Indra et al., 2025).

When the parametric assumptions were adequately supported, a paired-samples t-test was used to evaluate the mean within-student difference between pre-test and post-test performance scores. Statistical significance was evaluated at alpha = .05.

The magnitude of the paired difference was quantified using Cohen's d_z, calculated by dividing the mean of the paired differences by the standard deviation of those differences. This standardization is appropriate for paired or within-subject comparisons and should be explicitly identified because different versions of Cohen's d use different denominators (Lakens, 2013). The effect-size analysis also followed the within-subject reporting rationale described by Beyazhancer and Demir (2025) and Perugini et al. (2025).

$$d_z = \text{mean paired difference} / \text{SD of paired differences} \quad (5)$$

Because the study used a one-group pretest-posttest design without a control group, the inferential analysis was interpreted as evidence of within-group performance change rather than as definitive causal evidence of instructional effectiveness.

Student Response and Reliability Analysis

After completion of the post-intervention practicum activities, students completed the 10-item Student Response Questionnaire described in Table 2. Responses were recorded on a five-point Likert scale. The response options and corresponding numerical weights are presented in Table 5.

Table 5. Weight of the Assessment

Criteria	Description	Weight
SD	Strongly Disagree	1
D	Disagree	2
NAD	Neither Agree nor Disagree	3
A	Agree	4
SA	Strongly Agree	5

The weighted questionnaire score was converted to a percentage and interpreted using the categories presented in Table 6. Internal consistency of the Student Response Questionnaire was evaluated after administration using Cronbach's alpha in SPSS. Cronbach's alpha provides an index of the internal consistency of multi-item instruments and should be interpreted in relation to the construct and item composition rather than as evidence of validity by itself (Tavakol & Dennick, 2011).

Table 6. Response Category

Percentage (%)	Category
81-100	Strongly Positive
61-80	Positive
41-60	Positive Enough
21-40	Negative
0-20	Strongly Negative

Final Product Development

The seventh and final development stage involved preparation of the final product after completion of expert review, revision, and student testing. The resulting instructional product was entitled "*Buku Ajar Perancangan Lines Plan Kapal Menggunakan Computer Aided Design Engineering*." The module was produced in both interactive digital flipbook and printed formats.

RESULTS AND DISCUSSION

Development Outcome and Product Characteristics

The development process resulted in an interactive digital practicum module for Ship Lines Plan design using CAD/CAE. The module was developed in response to the identified need for structured digital guidance that could support students during practical Ship Lines Plan design activities. Its design incorporated digitally supported CAD-learning features consistent with developments in interactive and technology-enhanced engineering education (Khot et al., 2025; Manrique & Ayte, 2025).

The completed module incorporated six principal instructional and interactive components. These included informative work instructions that guided students through the sequence of Ship Lines Plan design activities, video tutorials that demonstrated the practical procedures in accordance with the written instructions, and QR codes that provided direct access to the tutorial videos. The module also included reference images of completed design work and practical tips to support students during the design process. In addition, the digital flipbook integrated interactive functions such as page-navigation controls, audio playback, full-screen viewing, image-display buttons, and embedded video playback. Together, these features were designed to provide structured, visually supported, and accessible guidance throughout the Ship Lines Plan practicum.

The module was produced as a digital flipbook that could be accessed using smartphones, laptops, and desktop computers. Figure 4 presents examples of the final product interface and its principal digital learning components.

The module was designed to support students in completing practical design activities with greater independence while retaining the lecturer's role as a facilitator when students encountered more complex design problems. This instructional arrangement is consistent with the facilitator-oriented use of interactive digital learning resources described by Syahfitri and Muntahanah (2024).

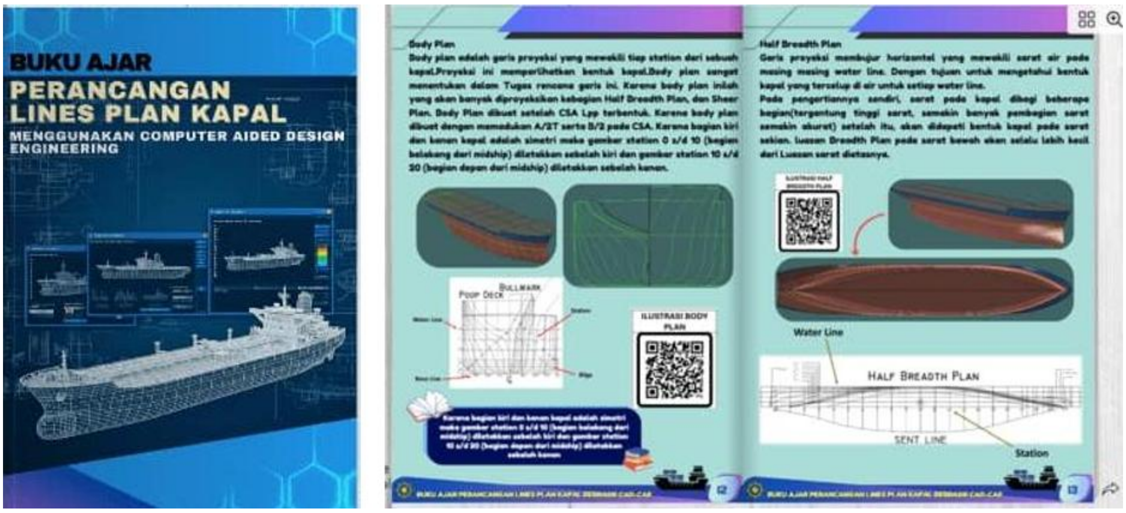


Figure 4. Final Product

Expert Validation and Content Validity

Material Expert Validation

Following product development, the module was evaluated by three material experts comprising Naval Architecture lecturers and shipbuilding practitioners. Their assessments covered content appropriateness, presentation feasibility, and contextual feasibility. The individual and average validation scores are presented in Table 7.

Table 7. Validation Score by Material Expert Validators

Indicators	Validator 1	Validator 2	Validator 3	Average (%)	Category
Content Appropriateness Aspect	95	93	93	93	Very Valid
Study Feasibility	92	88	96	92	Very Valid
Contextual Feasibility	90	90	90	90	Very Valid
Overall Average				92	Very Valid

As shown in Table 7, content appropriateness received an average score of 93%, study feasibility 92%, and contextual feasibility 90%. The overall material-validation score was 92%, placing the developed module in the Very Valid category according to the predefined validation criteria.

Media Expert Validation

The module was also evaluated by three media experts with experience in instructional-product development. Their assessment covered graphical feasibility and language appropriateness. Table 8 summarizes the results of the media validation.

Table 8. Validation Score by Media Expert Validators

Indicators	Validator 1	Validator 2	Validator 3	Average (%)	Category
Graphical Feasibility Aspect	90	86	84	87	Very Valid
Language Appropriateness Aspect	85	82	84	84	Valid
Overall Average				85	Very Valid

As presented in Table 8, graphical feasibility obtained an average score of 87%, whereas language appropriateness obtained 84%. The overall media-validation score was 85%, corresponding to the Very Valid category.

Content Validity Index

In addition to the percentage-based expert assessments, the validation data were analysed using the Item-level Content Validity Index (I-CVI) and the average Scale-level Content Validity Index (S-CVI/Ave). For the Material Expert Validation Sheet, all 18 items obtained an I-CVI of 1.00, resulting in an S-CVI/Ave of 1.00. Similarly, all 27 items of the Media Expert Validation Sheet obtained an I-CVI of 1.00, producing an S-CVI/Ave of 1.00. These results indicate that all evaluated material and media items met the predefined relevance criterion across the respective expert panels.

Students' Practical Ship Lines Plan Design Performance

Pre-test, Post-test, and N-Gain Results

Students' practical Ship Lines Plan design performance was assessed before and after implementation of the interactive digital practicum module. Table 9 presents the individual pre-test and post-test scores, paired score differences, normalized gain values, and corresponding N-Gain categories.

Table 9. Pre-test and Post-test Performance Scores

Student	Pre-test	Post-test	Post-Pre Difference	N-Gain	Category
AM	50	93	43	0.86	H
DCA	62	94	32	0.84	H
LJ	64	88	24	0.67	M
LLT	60	88	28	0.70	H
NAW	45	82	37	0.67	M
RRH	60	95	35	0.88	H
RZ	62	85	23	0.61	M
RP	71	95	24	0.83	H

Student	Pre-test	Post-test	Post-Pre Difference	N-Gain	Category
SPR	66	87	21	0.62	M
AD	60	87	27	0.68	M
Mean	60.00	89.40	29.40	0.734	H

As shown in Table 9, all 10 students obtained higher post-test than pre-test performance scores. The mean score increased from 60.00 at pre-test to 89.40 at post-test, corresponding to a mean increase of 29.40 points. Individual N-Gain values ranged from 0.61 to 0.88. The overall mean N-Gain was 0.734, which was classified as High according to the predefined criterion. Reporting N-Gain to two decimal places for individual students provides a clearer distinction between scores close to the 0.70 classification threshold.

Assumption Testing

Before inferential analysis, the distribution of paired difference scores was evaluated. Because the sample consisted of 10 students, the Shapiro-Wilk test was used together with visual inspection of the Q-Q plot and outlier assessment using the interquartile-range criterion. This combination of statistical and graphical assessment is appropriate when evaluating normality in small samples (Habibzadeh, 2024; Shatz, 2024). The results are summarized in Table 10.

Table 10. Results of Assumption Testing

Test	Result	Decision
Shapiro-Wilk	W = 0.926, p = .414	Normality assumption supported
Q-Q Plot	Points approximately followed the diagonal reference line	Normality supported
Outlier inspection (IQR)	No outliers detected	All observations retained

As presented in Table 10, the Shapiro-Wilk test showed no statistically significant departure from normality, $W = 0.926$, $p = .414$. Visual inspection of the Q-Q plot showed that the paired difference scores approximately followed the diagonal reference line. The IQR procedure identified no outlying observations. Accordingly, all 10 paired observations were retained for the subsequent paired-samples analysis.

Paired-Samples Comparison and Effect Size

After the assumption checks, a paired-samples t-test was conducted to compare pre-test and post-test performance scores, and Cohen's d_z was calculated to quantify the standardized within-group difference. The analysis followed the paired-data procedures used in previous methodological applications of the paired-samples t-test and within-subject effect-size reporting (Kharisma Putri Swastika et al., 2024; Perugini et al., 2025; Yeager, 2022). The results are presented in Table 11.

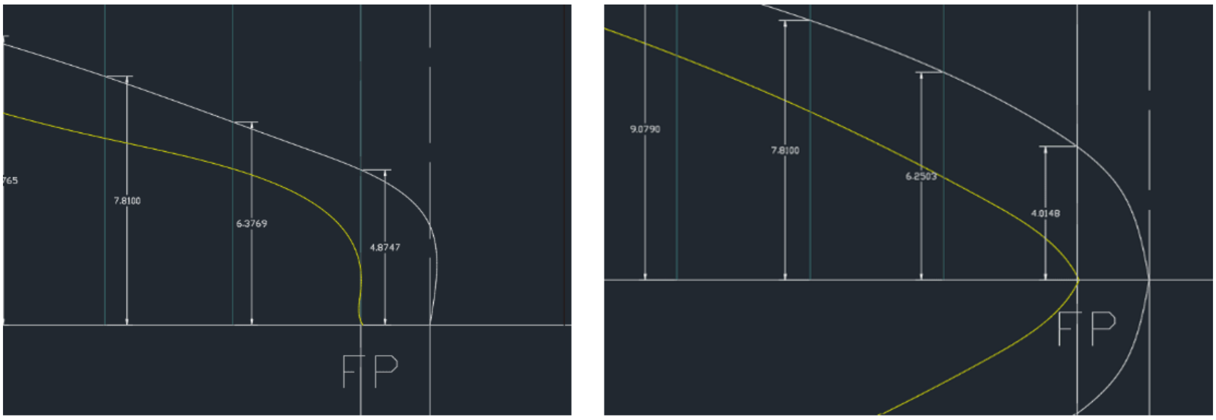
Table 11. Paired-Samples Comparison of Pre-test and Post-test Performance Scores

Measure	Pre-test M (SD)	Post-test M (SD)	Mean Difference	95% CI	t	df	p	Effect Size
Performance Score	60.00 (7.50)	89.40 (4.55)	29.40	24.29-34.51	13.03	9	< .001	Cohen's d_z = 4.12

As shown in Table 11, mean practical design-performance scores increased from 60.00 (SD = 7.50) at pre-test to 89.40 (SD = 4.55) at post-test. The mean paired difference was 29.40 points, with a 95% confidence interval of 24.29 to 34.51 points. The paired-samples analysis showed a statistically significant within-group difference, $t(9) = 13.03$, $p < .001$. The standardized paired effect size was Cohen's d_z = 4.12, representing a very large within-group difference between the two assessment occasions. Because this analysis was based on a one-group pretest-posttest design, these results are reported as within-group performance differences rather than as independent evidence of a causal treatment effect.

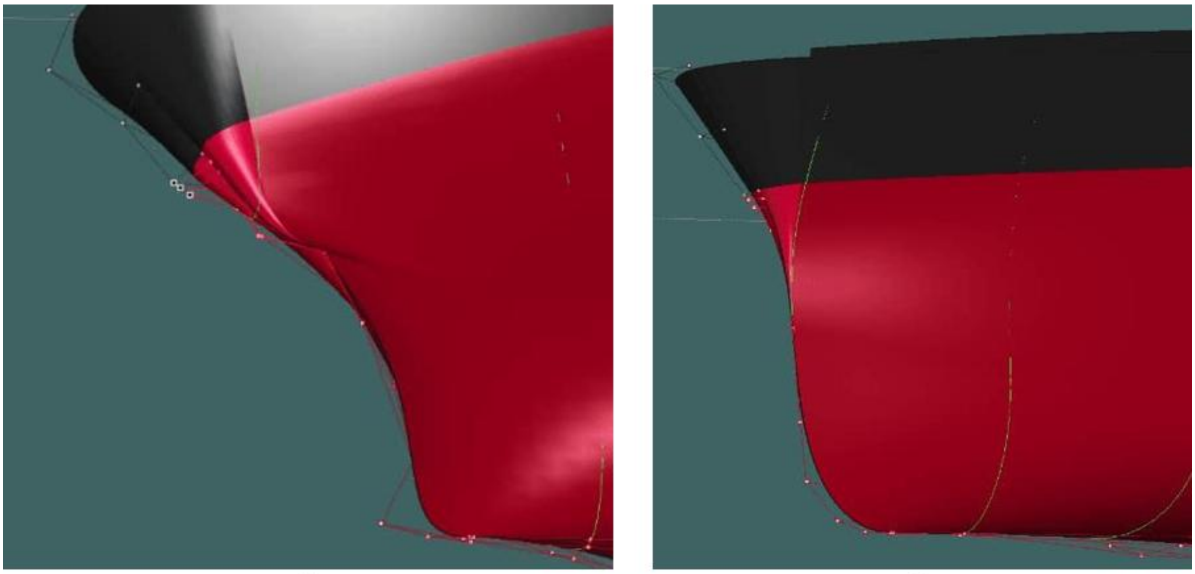
Representative Design Outputs

Representative pre- and post-implementation design outputs are shown in Figures 5 and 6. Figure 5 compares CAD-phase design results before and after module implementation, while Figure 6 compares the corresponding Maxsurf hull geometry. These figures provide visual context for the technical-performance scores reported in Table 9.



(a) (b)

Figure 5. Comparison of CAD Design Results Before (a) and After (b) Module Implementation



(a) (b)

Figure 6. Comparison of Maxsurf Design Results Before (a) and After (b) Module Implementation

Student Responses to the Digital Practicum Module

After completion of the module-supported practicum activities, all 10 students completed the Student Response Questionnaire. Table 12 presents the distribution of responses, item means, and item-level standard deviations for the 10 questionnaire items.

Table 12. Student Response Questionnaire Results

Description	SD	D	NAD	A	SA	Mean	SD
The digital practicum module has an attractive design	0	0	0	3	7	4.70	0.48
The digital practicum module is easy to use	0	0	0	2	8	4.80	0.42
The digital practicum module can be accessed anywhere	0	0	0	0	10	5.00	0.00
The practicum instructions make the procedures easier to understand	0	0	0	2	8	4.80	0.42
The tips provided in the module support the practicum process	0	0	0	1	9	4.90	0.32
The module helps reduce the risk of errors during design activities	0	0	0	0	10	5.00	0.00
The videos facilitate the practicum process	0	0	0	0	10	5.00	0.00
The module design increases enthusiasm during practicum activities	0	0	0	2	8	4.80	0.42
The images and examples facilitate practicum activities	0	0	0	2	8	4.80	0.42
The explanations are easy to understand and support understanding	0	0	0	2	8	4.80	0.42
Total / Overall	**0**	**0**	**0**	**14**	**86**	**4.86**	**0.33**
Obtained Score = Total x Weight	**0**	**0**	**0**	**56**	**430**		

As shown in Table 12, no student selected Strongly Disagree, Disagree, or Neither Agree nor Disagree for any questionnaire item. Across the 100 item responses, 14 responses were Agree and 86 were Strongly Agree. Item means ranged from 4.70 to 5.00. The overall mean response was 4.86, and the total weighted score was 486 of a possible 500 points, corresponding to 97.2%, or 97% when reported as a whole percentage. Based on the predefined response criteria in Table 6, the result was classified as Strongly Positive. Items concerning access to the module, perceived reduction of design errors, and usefulness of the embedded videos each obtained a mean score of 5.00. Because these results were obtained from self-reported questionnaire items, they represent students' perceptions of these module characteristics rather than independently measured effects.

Reliability of the Student Response Questionnaire

The internal consistency of the Student Response Questionnaire was assessed using Cronbach's alpha before interpreting the overall response score, consistent with the questionnaire-reliability procedure described by Hinton et al. (2023). The reliability result is presented in Table 13.

Table 13. Reliability Analysis of the Student Response Questionnaire

Instrument	Number of Items	Cronbach's Alpha	Interpretation
Student Response Questionnaire	10	.734	Acceptable Internal Consistency

As shown in Table 13, the 10-item Student Response Questionnaire produced a Cronbach's alpha coefficient of .734. This value indicated acceptable internal consistency for the questionnaire used to describe students' responses to the developed digital practicum module.

Discussion

Expert Validation and Content Validity of the Digital Practicum Module

The expert-validation findings provide complementary evidence regarding the instructional and media feasibility of the developed digital practicum module. As reported in Table 7, the material-validation process yielded an overall score of 92%, classified as Very Valid. The individual dimensions also received consistently high evaluations, including content appropriateness (93%), presentation or study feasibility (92%), and contextual feasibility (90%). These findings indicate that the instructional content was judged by the expert panel to be relevant to Ship Lines Plan design, appropriately structured for practicum use, and sufficiently connected to the professional context of Naval Architecture. Similar use of expert feasibility assessment has been reported in previous electronic-module development studies, in which expert judgement serves as an important stage before implementation with learners (Rochsun & Agustin, 2020; Purba, 2024).

The media-validation results in Table 8 provide a complementary perspective on the presentation of the module. Graphical feasibility obtained an average score of 87%, whereas language appropriateness obtained 84%, resulting in an overall media-validation score of 85% and classification as Very Valid. The comparatively lower language score is important because it indicates that linguistic presentation remained an area in which refinement was warranted even though the overall module met the predefined feasibility criterion. This interpretation is consistent with the development process described in the Methods, in which qualitative comments from validators were used to improve wording, instructional clarity, and presentation after the quantitative expert assessment.

The percentage-based validation findings were further supported by the Content Validity Index analysis. All 18 items in the material-validation instrument and all 27 items in the media-validation instrument obtained an I-CVI of 1.00, resulting in an S-CVI/Ave of 1.00 for both instruments. These values indicate complete agreement among the respective expert panels that all evaluated items met the predefined relevance criterion. However, an S-CVI/Ave of 1.00 should be interpreted as complete agreement regarding item relevance rather than as evidence that no further refinement was necessary. Qualitative feedback from the validators was therefore still used to improve language, instructional clarity, and presentation. This interpretation is consistent with recommendations that quantitative content-validity evidence should be considered together with expert qualitative judgement during instrument and educational-resource development (Polit & Beck, 2006).

The strong expert agreement obtained in this study is consistent with previous educational and instrument-development studies reporting that high I-CVI and S-CVI/Ave values provide evidence that evaluated content adequately represents the intended construct or learning objectives (Ahmad et al., 2025; Swaramarinda et al., 2022; Weerasinghe et al., 2023). Similar interpretations have also been reported by Muhamad Jamil et al. (2024) and de Araújo Baptista et al. (2024). Taken together, the results in Tables 7 and 8 and the narrative CVI findings support the content and media feasibility of the module for subsequent practicum testing while also providing a basis for iterative refinement before student implementation.

Changes in Practical Ship Lines Plan Design Performance

The performance results indicate a substantial within-group improvement in students' practical Ship Lines Plan design performance following implementation of the digital practicum module. As shown in Table 9, the mean performance score increased from 60.00 at pre-test to 89.40 at post-test, corresponding to an average increase of 29.40 points. The mean N-Gain was 0.734, which falls within the High category according to the criterion presented in Table 4. Because the assessment was based on 30 technical Ship Lines Plan design criteria, these changes are more appropriately interpreted as improvement in practical design performance rather than as a direct measure of general cognitive ability.

The visual comparison of students' design outputs provides technical context for this numerical improvement. Figures 7 and 8 show representative differences between the pre- and post-implementation CAD and Maxsurf outputs, while the scoring criteria illustrated in Figure 5 explain how technical quality was evaluated. In the pre-implementation example, geometric inaccuracies were evident in the lines-plan construction and bow configuration, which subsequently affected the corresponding three-dimensional hull representation. In the post-implementation example, the design displayed smoother and more proportionate geometry according to the technical criteria represented in the performance rubric. These visual differences complement, rather than replace, the quantitative performance evidence reported in Table 9.

A relevant feature of the module is its integration of two-dimensional lines-plan development with three-dimensional Maxsurf visualization. This connection allows students to inspect how modifications to a 2D representation influence the resulting hull geometry and to identify inconsistencies before finalizing a design. Maxsurf therefore provides a visual feedback environment in which the relationship between lines-plan geometry and the corresponding three-dimensional hull form can be examined more directly. This interpretation is consistent with studies describing the use of digital ship-modelling environments for geometric visualization and design evaluation (Ramadhani et al., 2025; Zhang et al., 2024).

The module's instructional structure may also help explain the observed performance pattern. Students were provided with step-by-step instructions, reference images, practical tips, and video demonstrations within a single practicum resource. Such support can reduce the need to reconstruct complex procedures from isolated lecturer demonstrations and may allow students to revisit specific stages of the design process when difficulties occur. Guo (2025) reported advantages of integrating engineering software tools into project-oriented education, while Ilmi et al. (2021) showed that structured digital learning modules can support learning improvement. Broader digital-learning research has likewise reported benefits associated with interactive digital resources and structured instructional support (Vaiopoulou et al., 2021; Yaniawati et al., 2021). In engineering education specifically, Portillo et al. (2025) found that combining digital laboratory activities with structured instructional strategies can improve students' practical learning performance.

Statistical Evidence for Within-Group Performance Improvement

The descriptive and N-Gain findings were supported by the inferential analysis. Before the paired-samples comparison, the assumption checks reported in Table 10 indicated no statistically significant departure from normality in the paired difference scores, and no outliers were identified using the IQR criterion. These findings supported the use of the paired-samples t-test for the available data.

As reported in Table 11, the mean increase of 29.40 points was statistically significant, $t(9) = 13.03$, $p < .001$, with a 95% confidence interval of [24.29, 34.51]. The confidence interval indicates that the observed mean within-student increase was not only statistically distinguishable from zero but was also substantial on the 0-100 performance scale. The use of a paired-samples analysis after assessing the distributional assumption is consistent with the analytical approach reported by Zhumabay et al. (2024).

The standardized paired effect size was also very large, Cohen's $d_z = 4.12$. Because d_z standardizes the mean paired difference by the standard deviation of the paired differences, it specifically describes the magnitude of change within the same students rather than a standardized difference between two independent groups. Explicit identification of the effect-size standardizer is important because different formulations of Cohen's d answer different questions and are not necessarily directly interchangeable (Lakens, 2013; Perugini et al., 2025). Thus, the value observed here should be interpreted as a very large within-group standardized difference while recognizing the small sample and study design.

The magnitude of the observed change is plausibly related to the combination of structured instructional guidance and CAD/CAE-supported visualization. Pando Cerra et al. (2023) reported that CAD learning can benefit from interactive learning resources that support self-directed practice and formative feedback. Similarly, Afify et al. (2024) and Dasgupta et al. (2021) emphasized the value of CAD-supported learning environments for analysing, synthesizing, and evaluating engineering designs. In the present module, students could move between procedural explanations, visual examples, tutorial videos, two-dimensional drawings, and three-dimensional hull representations. This combination may have supported iterative checking and refinement of design decisions rather than relying solely on the final drawing as the point of evaluation.

Nevertheless, the statistical improvement should not be interpreted as definitive evidence that the module alone caused the observed change. The study used a one-group pretest-posttest design without a comparison group. Therefore, practice effects, repeated exposure to Ship Lines Plan activities, lecturer guidance, maturation across the eight-week period, or other uncontrolled influences could also have contributed to the observed improvement. Single-group pre-post designs are particularly vulnerable to such alternative explanations, including testing effects, history, maturation, and regression to the mean (Marsden & Torgerson, 2012). Accordingly, the results provide strong preliminary evidence of within-group performance improvement associated with module implementation, but stronger causal conclusions require a controlled experimental or quasi-experimental design.

Instructional Value of the CAD/CAE-Based Learning Approach

Beyond the statistical improvement, the integration of Maxsurf into the module has implications for the type of design reasoning that students can practise. Traditional two-dimensional lines-plan construction requires students to infer the three-dimensional consequences of changes made to individual curves. By integrating 2D construction with 3D hull visualization, the present module allows students to examine those consequences directly and revise the geometry when necessary. This feature is particularly relevant in Naval Architecture, where fairness, proportionality, dimensional consistency, and relationships among hull sections must ultimately describe a coherent three-dimensional form.

The learning approach also aligns with project-based engineering education, in which students develop knowledge through iterative design, problem-solving, and production of a technical artefact. Jiang and Pang (2023) reported that project-based learning can strengthen engineering-design skills through active engagement and application of theoretical knowledge. Within this context, the developed module may function as a scaffold that supports students as they progress through a longer Ship Lines Plan design project while allowing the lecturer to focus on more complex conceptual or geometric difficulties.

The use of industry-relevant CAD/CAE tools also has potential implications for students' digital engineering preparation. Hermansah et al. (2025) reported that the integration of digital engineering technologies into vocational learning can contribute to the development of technology-related competencies and professional readiness. In the present study, however, digital competency and employability were not measured directly. Therefore, these should be regarded as potential educational implications of using Maxsurf rather than as outcomes demonstrated by the present data.

Student Acceptance and Perceived Usability

The student-response findings complement the performance results by showing how students perceived the module during implementation. As reported in Table 12, the questionnaire produced an overall weighted score of 97%, classified as Strongly Positive according to the response categories in Table 6. All responses were either Agree or Strongly Agree, and the highest-rated items concerned accessibility, perceived reduction of design errors, and the usefulness of the embedded video tutorials. These findings indicate high user acceptance of the module among the participating students. They should, however, be interpreted as self-reported perceptions rather than objective measures of accessibility, error reduction, or instructional effectiveness.

The positive responses are consistent with previous studies indicating that accessible and interactive digital learning resources are generally well received by learners (Juniantari et al., 2023; Yulianisa & Sudihartinih, 2022). The digital flipbook format may be particularly useful because it combines several instructional resources within a single access point rather than requiring students to consult separate printed instructions, videos, and examples. The accessibility of digitally distributed learning resources has also been discussed in previous flipbook and mobile-learning studies (Hilmy et al., 2025; Zhang et al., 2017).

Interpretation of the questionnaire results is further supported by the reliability analysis reported in Table 13. The 10-item Student Response Questionnaire yielded a Cronbach's alpha of .734, indicating acceptable internal consistency (Hinton et al., 2023). This result supports interpretation of the questionnaire as a reasonably coherent measure of students' responses to the module. However, internal consistency does not by itself establish all aspects of instrument validity, and the result should therefore be interpreted together with the prior expert review of the questionnaire and the specific constructs represented by its items (Tavakol & Dennick, 2011).

Practical and Research Implications

The findings have several practical implications for Ship Lines Plan instruction. First, the interactive digital flipbook can function as a structured practicum guide within a semester-long design project. By combining procedural instructions, visual examples, tutorials, and CAD/CAE-based modelling, the module can provide students with a consistent reference that remains available beyond lecturer demonstrations. This structure may support a learning arrangement in which students work more independently while lecturers concentrate on conceptual clarification and technically complex design problems.

Second, the module provides a bridge between lines-plan construction and subsequent digital ship-design activities. Because the workflow produces both 2D lines plans and 3D hull models in Maxsurf, the resulting models can potentially be extended to later learning activities involving stability, resistance, motion, and other ship-performance analyses. Such extension would allow future versions of the module to connect hull-form development with a broader CAD/CAE workflow rather than treating Ship Lines Plan design as an isolated drawing exercise. More broadly, numerical and computational analyses are already used for downstream technical evaluation in naval engineering (Ghofur et al., 2022).

Third, the digital flipbook itself can be accessed using smartphones and computers, which facilitates repeated access to instructions, images, and QR-linked tutorial videos. This accessibility should be distinguished from the computational requirements of the actual Maxsurf design activities: students still require access to compatible CAD/CAE software and appropriate computer hardware to perform the modelling tasks. In the present study, implementation was facilitated by the fact that participants had previously completed introductory CAD and Maxsurf instruction and therefore entered the practicum with basic software-operating skills.

From a research perspective, the study demonstrates the feasibility of evaluating an engineering practicum module using complementary evidence from expert validation, technical performance assessment, inferential statistics, effect-size estimation, and student-response measurement. Future evaluations could extend this framework through controlled comparisons, multi-institutional implementation, independent scoring, delayed post-tests, and objective geometric-error measures.

Research Limitations and Directions for Future Research

Several limitations should be considered when interpreting the findings. First, the study involved only 10 students from a single institution. Although all eligible students in the cohort participated, the small and institution-specific sample limits the generalizability of the results to other Naval Architecture programmes, institutions, student populations, and instructional settings. Future studies should therefore involve larger samples from multiple institutions.

Second, the absence of a control or comparison group substantially limits causal inference. Although Tables 9 and 11 demonstrate clear within-group improvement, the design cannot isolate the contribution of the module from practice effects, maturation, repeated lecturer interaction, increased familiarity with Maxsurf, or other events occurring during the eight-week practicum. This is a recognized limitation of single-group pretest-posttest designs (Marsden & Torgerson, 2012). Future research should employ controlled experimental or quasi-experimental designs where feasible.

Third, students' design outputs were assessed by a single lecturer. The assessor's subject-matter expertise supports the disciplinary relevance of the scoring, but the use of one assessor prevents evaluation of inter-rater reliability and creates the possibility of scorer-specific bias. Future studies should use at least two independent assessors, preferably with blinded or partially blinded scoring procedures, and report inter-rater agreement or reliability.

Fourth, the study assessed performance immediately after the module-supported learning period. Consequently, the findings do not establish whether improvements in Ship Lines Plan design are retained over time or transferred to different ship types and more complex design tasks. Delayed post-tests and transfer tasks would provide stronger evidence regarding retention and application of the acquired skills.

Fifth, several post-test scores approached the upper range of the performance scale. This pattern suggests a possible ceiling effect and may have reduced the ability of the assessment rubric to discriminate among higher-performing students. Future versions of the assessment could include more demanding technical criteria or objective geometric-error metrics to provide greater sensitivity at the upper end of performance.

Finally, the module-development process revealed a practical challenge in translating a complex CAD/CAE workflow into concise and unambiguous step-by-step instructions. Although expert review and iterative revision were used to improve instructional clarity, future module development should include additional task-based usability testing in which students' difficulties, navigation behaviour, task-completion time, and points of procedural confusion are systematically recorded. This would complement expert validation with direct evidence about how clearly the instructional sequence functions during actual practicum use.

Future research should therefore combine larger multi-institutional samples, experimental or quasi-experimental comparison groups, multiple independent assessors, delayed performance assessments, objective design-error measures, and systematic usability evaluation. A particularly informative comparison would examine 2D-only instruction against an integrated 2D/3D Maxsurf workflow to determine more precisely which components of the digital CAD/CAE learning environment contribute to students' design performance.

CONCLUSIONS

This study developed and preliminarily evaluated an interactive digital flipbook module for CAD/CAE-based Ship Lines Plan design using Maxsurf. Expert evaluation indicated that the module met the predefined feasibility criteria for both instructional content and media design, while the content-validity analysis demonstrated strong agreement among the expert panels regarding the relevance of the evaluated items.

The one-group pretest-posttest evaluation involving 10 Naval Architecture students showed a substantial improvement in practical Ship Lines Plan design performance. The mean performance score increased from 60.00 at pre-test to 89.40 at post-test, with a mean N-Gain of 0.734, classified as High. The paired-samples analysis confirmed a statistically significant within-group difference, $t(9) = 13.03$, $p < .001$, with a very large standardized paired effect size (Cohen's $d_z = 4.12$). These findings provide preliminary evidence that the developed module is associated with meaningful improvement in students' practical CAD/CAE-based Ship Lines Plan design performance.

Students also reported a strongly positive response to the module, with an overall response score of 97% and acceptable internal consistency of the Student Response Questionnaire (Cronbach's alpha = .734). These results indicate that the module was well accepted by the participating students and that its instructional presentation, digital features, and integrated practical guidance were perceived as useful during the practicum activities.

The findings support the feasibility and practical potential of the interactive digital practicum module as a structured learning resource for Ship Lines Plan design. The integration of written instructions, visual examples, video tutorials, and Maxsurf-based 2D and 3D modelling provides students with a coherent workflow for developing and evaluating hull geometry during practical learning. However, because the study involved a small single-institution sample and used a one-group pretest-posttest design without a control group, the findings should be interpreted as preliminary evidence rather than definitive causal proof of instructional effectiveness.

RECOMMENDATIONS

Future research should extend the content of the module beyond Ship Lines Plan development to include subsequent CAD/CAE-based ship-performance analyses, such as stability, resistance, motion, and other relevant Maxsurf applications. Such expansion would allow students to connect hull-form development with a broader digital ship-design workflow.

Future studies should also employ controlled experimental or quasi-experimental designs with larger, multi-institutional samples to strengthen causal inference and improve the generalizability of the findings. Longitudinal studies incorporating delayed post-tests are recommended to examine the retention of practical CAD/CAE-based ship-design skills over time.

Additional research should investigate different ship hull types, use multiple independent or blinded assessors, incorporate objective geometric-error measures, and evaluate usability indicators such as task-completion time, navigation difficulty, and procedural errors. Comparative studies between 2D-only instruction and integrated 2D/3D CAD/CAE learning workflows would also help determine which components of the digital learning environment contribute most strongly to students' practical design performance.

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Conflict of Interest Statement
The authors declare no conflict of interest.

Informed Consent
Informed consent was obtained from all individuals involved in this study.

Data Availability
Data availability is not applicable to this article because no new data were created or analyzed in this study.

Author Contributions Statement

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Zakwan Hilmy	✓	✓	✓		✓	✓		✓	✓	✓	✓		✓	✓
Zalmi Dzirrusydi		✓		✓			✓			✓				
Trisno Susilo				✓	✓		✓			✓				

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

REFERENCES

Afify, M., Moubachir, Y., Guennoun, Z., & Hassar, J. (2024). A hybrid CAD/CAE/CAM project-based laboratory framework integrating topology optimization and laser powder bed fusion for engineering education. *Computer Applications in Engineering Education*, *32*(3). https://doi.org/10.1002/cae.22745

Agustian, N., & Salsabila, U. H. (2021). Peran teknologi pendidikan dalam pembelajaran. *ISLAMIKA*, *3*(1). https://doi.org/10.36088/islamika.v3i1.1047

Ahmad, M. S., Izahar, N. A., & Hashim, Z. (2025). Integrating design thinking and blended learning in science education: Development and expert validation of the inno-blendt module. *Perspektif Jurnal Sains Sosial Dan Kemanusiaan*, *17*(ISU KHAS). https://doi.org/10.37134/perspektif.vol17.sp.1.2025

Al Ghofur, S. M., & Fahruddin, A. (2024). The effect of bow flare angle variation on speed boat resistance. *Wave: Jurnal Ilmiah Teknologi Maritim*, *18*(1). https://doi.org/10.55981/wave.2024.5004

Amil, A. J., Setyawan, A., & Dellia, P. (2020). Development of Android-based learning media for reading skills on the topic of legends of the villages in Madura in the language learning process. *Jurnal Pendidikan Bahasa dan Sastra Indonesia Metalingua*, *5*(2), 83–86. https://doi.org/10.21107/metalingua.v5i2.8628

Anugrah, R. A., & Awwaludien Al-Fath, M. P. (2022). Simulasi numerik kapal katamaran pendeteksi kedalaman banjir menggunakan software Maxsurf untuk mencari resistance. *Quantum Teknika: Jurnal Teknik Mesin Terapan*, *3*(2). https://doi.org/10.18196/jqt.v3i2.13900

Aziz, A. A., Hafawati Adam, I. N., Jasmis, J., Elias, S. J., & Mansor, S. (2022). N-Gain and system usability scale analysis on game based learning for adult learners. *2021 6th IEEE International Conference on Recent Advances and Innovations in Engineering, ICRAIE 2021*. https://doi.org/10.1109/ICRAIE52900.2021.9704013

Beyazhancer, R., & Demir, B. (2025). Enhancing techno-mathematical literacy and AI self-efficacy in engineering education through artificial intelligence applications. *Frontiers in Education*, *10*. https://doi.org/10.3389/feduc.2025.1695351

Chandra, G. A., Hadi, E. S., & Zaki, A. F. (2017). Analisa pengaruh sudut masuk kapal perintis 750 DWT terhadap resistance kapal dengan menggunakan metode computational fluid dynamic (CFD). *Jurnal Teknik Perkapalan*, *5*(2), 465–472. https://ejournal3.undip.ac.id/index.php/naval/article/view/16965

Cholik, C. A. (2021). Perkembangan teknologi informasi komunikasi/ICT dalam berbagai bidang. *Jurnal Fakultas Teknik UNISA Kuningan*, *2*(2), 39–46. https://jurnal.unisa.ac.id/index.php/jft/article/view/83

Damaren, E., Consell, R., Gryguć, A., Koenig, C., Olechowski, A., & Rosales, J. (2025). An educator's framework for modern computer-aided design instruction. *Proceedings of the Canadian Engineering Education Association Conference*, *2025*. https://doi.org/10.24908/pceea.2025.19633

Dasgupta, C., Magana, A. J., & Kirkham, L. (2021). Investigating teachers' enactment of engineering design practices in a cad simulation-enhanced learning environment. *Computer Applications in Engineering Education*, *29*(6). https://doi.org/10.1002/cae.22400

de Araújo Baptista, V. I., Braga, L. P., de Sousa Mata, Á. N., Carreiro, B. O., dos Santos Rosa, L. P. G., de Morais, H. H. A., de Azevedo, G. D., & Appenzeller, S. (2024). Validation of clinical simulation scenarios for the teaching of soft skills in child-centered care. *BMC Medical Education*, *24*(1). https://doi.org/10.1186/s12909-024-05284-7

Fatwasari, F., Farhum, S. A., & Jaya, I. (2021). Static stability study of purse seine vessels in Bone Regency, South Sulawesi. *Jurnal Riset Kapal Perikanan*, *1*(1), 9–16. https://doi.org/10.29244/jrisetkapal.1.1.9-16

Ferreiro, L. D. (2024). Naval architecture saved the United States at its birth. *Ship Technology Research*, *71*(2). https://doi.org/10.1080/09377255.2023.2196042

Ghofur, A. A., Zakki, A. F., & Yudo, H. (2022). Analisa respon tegangan lokal rantai jangkar pada kapal perintis 1200 GT di perairan Kepulauan Seribu. *Jurnal Teknik Perkapalan Universitas Diponegoro*, *10*(3), 21–31. https://ejournal3.undip.ac.id/index.php/naval/article/download/29421/2752

Guo, G. (2025). Enhancing project-based manufacturing education with integrated engineering software tools. *Computer Applications in Engineering Education*, *33*(2). https://doi.org/10.1002/cae.70012

Habibzadeh, F. (2024). Data distribution: Normal or abnormal? Journal of Korean Medical Science, 39(3), e35. https://doi.org/10.3346/jkms.2024.39.e35

Hermansah, B., Setywati, H., Nasuka, N., & Setiawaty, E. (2025). Enhancing digital competencies through technology integration in vocational education. *Jurnal MENTARI: Manajemen, Pendidikan Dan Teknologi Informasi*, *4*(1). https://doi.org/10.33050/mentari.v4i1.906

Hilmy, Z., Khairiyah, K. Y., Dasira, A., Prawira, M. Z., & Shakri, M. (2023). AutoCAD practicum teaching strategies and systems using the TeamViewer application. *Jurnal Imiah Pendidikan Dan Pembelajaran*, *7*(1). https://doi.org/10.23887/jipp.v7i1.59258

Hilmy, Z., Mardalena, T., & Dzirrusydi, Z. (2025). Development of interactive digital practicum module Ship Lines Plan method Nederlandsch Scheepsbouwkundig Proefstation (NSP) based flipbook. *Paedagoria: Jurnal Kajian, Penelitian dan Pengembangan Kependidikan*, *16*(1), 21–28. https://doi.org/10.31764/paedagoria.v16i1.27009

Hinton, P. R., McMurray, I., Brownlow, C., & Terry, P. C. (2023). Using SPSS to analyse questionnaires: Reliability. In *SPSS explained* (3rd ed., pp. 349–358). Routledge. https://doi.org/10.4324/9780429350863-18

Ilmi, R., Arnawa, I. M., Yerizon, & Bakar, N. N. (2021). Development of an Android-based for math e-module by using Adobe Flash Professional CS6 for Grade X students of senior high school. *Journal of Physics: Conference Series*, *1742*(1). https://doi.org/10.1088/1742-6596/1742/1/012026

Indra, I., Yudoko, G., & Mulyono, N. B. (2025). Empirical validation of prevention-focused quality cost management: Evidence from Indonesia manufacturing. *Cogent Business and Management*, *12*(1). https://doi.org/10.1080/23311975.2025.2543515

Inkermann, D., & Ammersdörfer, T. (2024). Towards simulation games in engineering design education – design and evaluation of a se simulation game. *Proceedings of the Design Society*, *4*. https://doi.org/10.1017/pds.2024.289

Izaak, H. wenno. (2008). Physics practicum using competence based process skills lks as an evaluation tool. *Jurnal Kependidikan*, *38*(1), 93–108. https://journal.uny.ac.id/index.php/jk/article/view/2274

Jiang, C., & Pang, Y. (2023). Enhancing design thinking in engineering students with project-based learning. *Computer Applications in Engineering Education*, *31*(4). https://doi.org/10.1002/cae.22608

Jin, H., & Yang, J. (2022). Using computer-aided design software in teaching environmental art design. *Computer-Aided Design and Applications*, *19*(s1). https://doi.org/10.14733/CADAPS.2022.S1.173-183

Juniantari, M., Ulfa, S., & Praherdhiono, H. (2023). Design thinking approach in the development of cirgeo's world media. *Jurnal Nasional Pendidikan Teknik Informatika (JANAPATI)*, *12*(1). https://doi.org/10.23887/janapati.v12i1.55203

Kharisma Putri Swastika, Irma Herliana, & Emi Yuliza. (2024). Efektivitas pendidikan kesehatan dengan media audio visual dan metode demonstrasi terhadap pengetahuan dan kemampuan remaja putri dalam melakukan SADARI di SMP Taruna Mandiri Tangerang Selatan 2023. *Vitamin: Jurnal Ilmu Kesehatan Umum*, *2*(2), 215–231. https://doi.org/10.61132/vitamin.v2i2.311

Khoiriyah, L., Al Hazman, M., Ruddianto, Djumiati, A., Nastiti, Y. A., & Rahayuningsih, S. (2025). Analisis validasi perhitungan hidrostatik kapal niaga: Perbandingan antara metode manual dan simulasi komputasi menggunakan Maxsurf. *INOVTEK Polbeng*, *15*(2), 173–185. https://doi.org/10.35314/wvxefe21

Khot, S. B., Magdum, R., Jadhav, P., Desavale, R., & Shirguppikar, S. (2025). Bridging the gap: A case study on implementing and evaluating a virtual cad modelling lab for enhanced accessibility and learning. *Journal of Engineering Education*

Transformations, *38*(Special Issue). https://doi.org/10.16920/jeet/2025/v38is2/25062

Kurniasari, Y., Subandowo, M., & Karyono, H. (2023). Pengembangan media interaktif Kvisoft Flipbook Maker pada pembelajaran bahasa Indonesia. *Jurnal Teknologi Pendidikan: Jurnal Penelitian Dan Pengembangan Pembelajaran*, *8*(2). https://doi.org/10.33394/jtp.v8i2.6627

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for t-tests and ANOVAs. *Frontiers in Psychology*, *4*, 863. https://doi.org/10.3389/fpsyg.2013.00863

Li, C., Wei, P., Luo, X., Jiang, Z., & Wang, D. (2023). An unified CAD/CAE/VR tool for ship structure design and evaluation based on multi-domain feature mapping. *Ocean Engineering*, *280*. https://doi.org/10.1016/j.oceaneng.2023.114888

Li, J., & Liang, W. (2024). Effectiveness of virtual laboratory in engineering education: A meta-analysis. *PLoS ONE*, *19*(12). https://doi.org/10.1371/journal.pone.0316269

Lukman, A., Hayati, D. K., & Hakim, N. (2019). Pengembangan video animasi berbasis kearifan lokal pada pembelajaran IPA kelas v di sekolah dasar. *Elementary: Jurnal Ilmiah Pendidikan Dasar*, *5*(2). https://doi.org/10.32332/elementary.v5i2.1750

Majidah, A. A. (2021). Kajian teoritik teknologi pendidikan dan teoritik teknologi pembelajaran [Unpublished manuscript]. Universitas Muhammadiyah Sidoarjo. https://eprints.umsida.ac.id/8429/1/1.%20Adelia%20ok.pdf

Manrique, M. F. M., & Ayte, J. A. S. (2025). A systematic review on innovations in computer aided design in engineering education. *International Journal of Evaluation and Research in Education*, *14*(3). https://doi.org/10.11591/ijere.v14i3.30250

Marsden, E. J., & Torgerson, C. J. (2012). Single group, pre-and post-test research designs: Some methodological concerns. *Oxford Review of Education*, *38*(5), 583–616. https://doi.org/10.1080/03054985.2012.731208

Mastura, M., Mauliza, M., & Nurhafidhah, N. (2017). Design of a nature-based chemistry practicum guide. *Jurnal IPA & Pembelajaran IPA*, *1*(2). https://doi.org/10.24815/jipi.v1i2.9695

Masykur, R., Nofrizal, N., & Syazali, M. (2017). Development of math learning media with Macromedia Flash. *Al-Jabar: Jurnal Pendidikan Matematika*, *8*(2). https://doi.org/10.24042/ajpm.v8i2.2014

Muhamad Jamil, N. K., Mohamed, I. N., Mokhtar, S. A., Leong, J. F., Kamudin, N. A. F., & Muhammad, N. (2024). Development of self-administered questionnaire on barriers, prescription practices, and guideline adherence of osteoporosis management among tertiary care clinicians: Content validity and reliability analysis. *Frontiers in Endocrinology*, *15*. https://doi.org/10.3389/fendo.2024.1393500

Nababan, A., Chrismianto, D., & Adietya, B. A. (2017). Optimasi bentuk haluan kapal ferry untuk mendapatkan olah gerak yang terbaik di daerah Kepulauan Mentawai. *Jurnal Teknik Perkapalan*, *5*(2). https://ejournal3.undip.ac.id/index.php/naval/article/view/16960

Negahban, A. (2024). Simulation in engineering education: The transition from physical experimentation to digital immersive simulated environments. *Simulation*, *100*(7). https://doi.org/10.1177/00375497241229757

Ningsih, D. H. U. (2005). Computer aided design/computer aided manufactur [CAD/CAM]. *Dinamik*, *10*(3), 143–149. https://doi.org/10.35315/dinamik.v10i3.23

Nitonye, S., Feniobu, C., & Eragbai, B. O. (2023). Floodable length analysis of a container vessel using computer aided design. *Global Journal of Engineering and Technology Advances*, *14*(3), 84–98. https://doi.org/10.30574/gjeta.2023.14.3.0048

Nurbaeti, R. U. (2020). Development of 2013 curriculum-based science practicum module for elementary school teacher education students. *Jurnal Elementaria Edukasia*, *3*(1). https://doi.org/10.31949/jee.v3i1.2115

Pando Cerra, P., Fernández Álvarez, H., Busto Parra, B., & Castaño Busón, S. (2023). Boosting computer-aided design pedagogy using interactive self-assessment graphical tools. *Computer Applications in Engineering Education*, *31*(1). https://doi.org/10.1002/cae.22569

Pawestri, E., & Zulfiati, H. M. (2020). Pengembangan lembar kerja peserta didik (LKPD) untuk mengakomodasi keberagaman siswa pada pembelajaran tematik kelas II di SD Muhammadiyah Danunegaran. *TRIHAYU: Jurnal Pendidikan Ke-SD-an*, *6*(3). https://doi.org/10.30738/trihayu.v6i3.8151

Permadani, K. G., & Sukmawati, I. (2021). Development of practical guidance based on research to improve science process skills and learning outcome in biology education students. *Indonesian Journal of Biology Education*, *4*(1), 31. https://doi.org/10.31002/ijobe.v4i1.3341

Perugini, A., Gambarota, F., Toffalini, E., Lakens, D., Pastore, M., Finos, L., & Altoè, G. (2025). The benefits of reporting critical-effect-size values. *Advances in Methods and Practices in Psychological Science*, *8*(2). https://doi.org/10.1177/25152459251335298

Polit, D. F., & Beck, C. T. (2006). The content validity index: Are you sure you know what's being reported? Critique and recommendations. *Research in Nursing & Health*, *29*(5), 489–497. https://doi.org/10.1002/nur.20147

Portillo, F., Soler-Ortiz, M., Sanchez-Cruzado, C., Garcia, R. M., & Novas, N. (2025). The impact of flipped learning and digital laboratory in basic electronics coursework. *Computer Applications in Engineering Education*, *33*(1). https://doi.org/10.1002/cae.22810

Prasasti, R. D., & Anas, N. (2023). Pengembangan media digital berbasis flipbook untuk meningkatkan kemampuan berpikir kritis pada peserta didik. *Munaddhomah*, *4*(3). https://doi.org/10.31538/munaddhomah.v4i3.589

Purba, S. C. (2024). Development of integrated electronic module with instructional videos. *EduMatSains: Jurnal Pendidikan, Matematika Dan Sains*, *9*(1). https://doi.org/10.33541/edumatsains.v9i1.6103

Putra, D. D., Okilanda, A., Arisman, A., Lanos, M. E. C., Putri, S. A. R., Fajar, M., Lestari, H., & Wanto, S. (2020). Kupas tuntas penelitian pengembangan model Borg & Gall. *Wahana Dedikasi: Jurnal PkM Ilmu Kependidikan*, *3*(1). https://doi.org/10.31851/dedikasi.v3i1.5340

Putri, S. N., Anak Agung Gede Agung, & I Kadek Suartama. (2023). E-module with the borg and gall model with a contextual approach to thematic learning.

Journal for Lesson and Learning Studies, *6*(1). https://doi.org/10.23887/jlls.v6i1.57482

Rachman, R., Pranatal, E., & Santosa, P. I. (2020). Analisis perbandingan metode simulasi software Maxsurf dengan metode matematis untuk perhitungan hambatan dan daya mesin utama kapal tanker 6500 DWT. *Prosiding Seminar Teknologi Kebumian dan Kelautan (SEMITAN)*, *2*(1), 193–201. https://doi.org/10.31284/j.semitan.2020.1079

Rahmagandi, I. O., Khumaedi, M., & Anis, S. (2024). Development of a flipbook-based e-module to enhance learning outcomes in manufacturing design for vocational high school students. *Journal of Vocational and Career Education*, *9*(1), 62–68. https://doi.org/10.15294/jvce.v9i1.23623

Ramadhani, A. I., Kusuma, D. D. A., Murtono, A., & Aji, A. T. T. R. (2023). Prototipe perahu listrik: Pengaruh ukuran propeller terhadap resistance dan power pada software Maxsurf Resistance. Zona Laut Jurnal Inovasi Sains Dan Teknologi Kelautan. https://doi.org/10.62012/zl.v4i3.30775

Ramadhani, A. I., Murtono, A., & Halimi, A. D. (2025). Mapping the implementation of Maxsurf software to marine vehicle simulation. *Zona Laut Jurnal Inovasi Sains dan Teknologi Kelautan*, *6*(3), 369–376. https://doi.org/10.62012/zl.vi.46119

Regassa Hunde, B., & Debebe Woldeyohannes, A. (2022). Future prospects of computer-aided design (CAD)—A review from the perspective of artificial intelligence (AI), extended reality, and 3D printing. *Results in Engineering*, *14*, 100478. https://doi.org/10.1016/j.rineng.2022.100478

Rizalda, S., & Nursaid, N. (2023). Pengaruh model pembelajaran proyek belajar karakter terhadap keterampilan menulis teks eksplanasi siswa kelas viii SMP Negeri Padang. *Jurnal Pendidikan*, *32*(1). https://doi.org/10.32585/jp.v32i1.3564

Rochsun, R., & Agustin, R. D. (2020). The development of e-module mathematics based on contextual problems. *European Journal of Education Studies*, *7*(10), 400–412. https://doi.org/10.46827/ejes.v7i10.3317

Shatz, I. (2024). Assumption-checking rather than (just) testing: The importance of visualization and effect size in statistical diagnostics. *Behavior Research Methods*, *56*(2). https://doi.org/10.3758/s13428-023-02072-x

Sidhu, M. S., Mousakhani, S., Lee, C. K., & Sidhu, K. K. (2024). Educational impact of metaverse learning environment for engineering mechanics dynamics. *Computer Applications in Engineering Education*, *32*(5). https://doi.org/10.1002/cae.22772

Suryadi, T., Alfiya, F., Yusuf, M., Indah, R., Hidayat, T., & Kulsum, K. (2023). Content validity for the research instrument regarding teaching methods of the basic principles of bioethics. *Jurnal Pendidikan Kedokteran Indonesia: The Indonesian Journal of Medical Education*, *12*(2). https://doi.org/10.22146/jpki.77062

Swaramarinda, D. R., Isa, B., Yusof, N. M., Kadir, M. A. B. A., & Rahman, Z. A. (2022). Improving the quality of youth: Scale development of entrepreneurial intention. *Quality - Access to Success*, *23*(191). https://doi.org/10.47750/QAS/23.191.17

Syahfitri, J., & Muntahanah. (2024). The effectiveness of local wisdom-based interactive digital module on students' critical thinking disposition. *International Journal of Evaluation and Research in Education*, *13*(4). https://doi.org/10.11591/ijere.v13i4.28256

Syamsu, F. D. (2017). Pengembangan penuntun praktikum IPA berbasis inkuiri terbimbing untuk siswa SMP kelas VII semester genap. *Bionatural: Jurnal Ilmiah Pendidikan Biologi*, *4*(2), 13–27. https://ejournal.stkipbbm.ac.id/index.php/bio/article/view/190/177

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education*, *2*, 53–55. https://doi.org/10.5116/ijme.4dfb.8dfd

Toyyibun, M. M. (2021). Design appropriateness of boat lift net based on Archipelagic Fishing Port of Karangantu. *Jurnal Perikanan dan Kelautan*, *10*(2). https://doi.org/10.33512/jpk.v10i2.10064

Vaiopoulou, J., Papadakis, S., Sifaki, E., Stamovlasis, D., & Kalogiannakis, M. (2021). Parents' perceptions of educational apps use for kindergarten children: Development and validation of a new instrument (PEAU-P) and exploration of parents' profiles. *Behavioral Sciences*, *11*(6). https://doi.org/10.3390/bs11060082

Weerasinghe, G. D. D. B., Patabendige, P. N. M., Thuduwage, S. V. R., Arumapperumachchi, P. M., Gamage, C. K. W., & Hettigoda, K. (2023). The cross-cultural adaptation of the Schutte Self-Report Emotional Intelligence Test (SSEIT) for use among nursing students in a defence university, Sri Lanka. *KDU Journal of Multidisciplinary Studies*, *5*(1). https://doi.org/10.4038/kjms.v5i1.71

Windyariani, S., & Setiono, S. (2024). Performance assessment creative thinking rubric in science technology engineering and mathematics (STEM) learning. *Journal of Innovative Science Education*, *13*(2), 64–73. https://doi.org/10.15294/jise.v13i2.4218

Wisnusuasono, B. D., & Ngadiyono, Y. (2024). Development of 3D printing e-modules for 3D cad courses in the department of mechanical engineering. *Jurnal Pendidikan Vokasional Teknik Mesin*, *12*(1), 11–21. https://journal.uny.ac.id/publications/jpvtm/article/view/571

Yaniawati, P., Al-Tammar, J., Supianti, I. I., Md Osman, S. Z., & Saeful Malik, A. (2021). Using of Sigil software in math education: E-module development and effects on self-regulated learning skills. *Journal for the Education of Gifted Young Scientists*, *9*(3), 251–268. https://doi.org/10.17478/jegys.954829

Yeager, K. (2022). *SPSS tutorials: Paired samples t test*. Kent State University. https://libguides.library.kent.edu/SPSS/PairedSamplestTest

Yulianisa, A., & Sudihartinih, E. (2022). Pengembangan media pembelajaran matematika materi perkalian aljabar berbasis aplikasi Scratch. *Jurnal Pendidikan Matematika Universitas Lampung*, *10*(2). https://doi.org/10.23960/mtk/v10i2.pp142-156

Yuliasari, E. (2017). Experimentation of pbl model and gdl model on mathematical problem solving ability in view of learning independence. *JIPM (Jurnal Ilmiah Pendidikan Matematika)*, *6*(1). https://doi.org/10.25273/jipm.v6i1.1336

Yunian Putra, R. W., & Anggraini, R. (2016). Development of teaching materials for trigonometry materials assisted by iMindMap software for high school students. *Al-Jabar: Jurnal Pendidikan Matematika*, *7*(1). https://doi.org/10.24042/ajpm.v7i1.129

Yılmaz, F. N. (2024). Comparing the reliability of performance task scores obtained from rating scale and analytic rubric using the generalizability theory. *Studies in Educational Evaluation*, *83*. https://doi.org/10.1016/j.stueduc.2024.101413

Zasali, N., Mohd Isa, N. K., Halim, H. A., Yunos, M. Y. M., Mohd Isa, N. J., & Mustofa, H. A. (2023). Content validity of an instrument to assess the low carbon approach in the front office department of tourist accommodation using I-CVI and mean analysis. *Geojournal of Tourism and Geosites*, *47*(2). https://doi.org/10.30892/gtg.47206-1038

Zhang, J., Cai, Z., Zhao, Z., & Ji, K. (2017). Cell phone-based online biochemistry and molecular biology medical education curriculum. *Medical Education Online*, *22*(1), 1374135. https://doi.org/10.1080/10872981.2017.1374135

Zhang, Z., Song, C., Zhang, J., Chen, Z., Liu, M., Aziz, F., Kurniawan, T. A., & Yap, P. S. (2024). Digitalization and innovation in green ports: A review of current issues, contributions and the way forward in promoting sustainable ports and maritime logistics. *Science of the Total Environment*, *912*, 169075. https://doi.org/10.1016/j.scitotenv.2023.169075

Zhong, B., Liu, X., & Li, X. (2024). Effects of reverse engineering pedagogy on students' learning performance in STEM education: The bridge-design project as an example. *Heliyon*, *10*(2). https://doi.org/10.1016/j.heliyon.2024.e24278

Zhumabay, N., Yelemessova, Z., Balta, N., Abylkassymova, A., Bakytkazy, T., & Marynowski, R. (2024). Designing effective STEM courses: A mixed-methods study of the impact of a STEM education course on teachers' self-efficacy and course experiences. *Frontiers in Education*, *9*. https://doi.org/10.3389/feduc.2024.1276828