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Development of an OBE-Oriented Digital Computational Physics Practicum Module on Numerical Root-Finding Using GNU Octave

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Abstract – The rapid development of digital technology and computational systems has increased the need for physics learning resources that can strengthen students' conceptual understanding, programming skills, and computational problem-solving abilities. In computational physics courses, students often have difficulty connecting numerical methods, algorithmic procedures, and software implementations, particularly in numerical root-finding. This study aimed to develop and determine the feasibility of an Outcome-Based Education (OBE)-oriented digital computational physics practicum module on numerical root-finding using GNU Octave. The study employed a Research and Development (R&D) approach using the ADDIE model, which consists of five stages: analysis, design, development, implementation, and evaluation. The developed module integrates OBE-based learning outcomes, numerical root-finding concepts, numerical algorithms, GNU Octave programming tutorials, practicum worksheets, instructional videos, and learning evaluation components. The feasibility of the module was examined through material expert validation, media expert validation, a small-scale trial involving 23 Physics Education students, and a large-scale trial involving 75 students from several universities. The results showed that the material expert validation obtained an average score of 87%, while the media expert validation achieved 88%, both categorized as "Very Good." Student responses in the small-scale trial showed percentages of 84.10% for display, 85% for material content, and 84% for video quality. In the large-scale trial, the display, material content, and video aspects obtained 85.3%, 87.78%, and 86.06%, respectively, all categorized as "Very Good." The novelty of this study lies in integrating OBE principles with GNU Octave-based computational practicum activities into a structured digital module for numerical root-finding. The findings indicate that the developed module is feasible for supporting computational physics learning and contributes to physics education by providing an accessible, competency-oriented, and technology-based learning resource that strengthens students' computational literacy, programming practice, and independent learning.

Keywords: computational physics; digital module; GNU Octave; numerical root; outcome-based education.

I. INTRODUCTION

The rapid development of information technology and computational systems in the era of the Industrial Revolution 4.0 has brought significant changes across sectors, including education and the learning process in higher education institutions (Adeoye et al., 2024). Higher education is currently expected not only to deliver theoretical knowledge, but also to prepare students to face complex, data-driven, and technology-based problems. As a result, learning is no longer focused solely on the conventional transmission of material from lecturers to students. Instead, it is increasingly focused on developing 21st-century skills, including critical thinking, problem-solving, digital literacy, collaboration, creativity, and computational abilities (Arifani et al., 2021). These competencies are particularly important in science education because scientific problems often require students to analyze data, construct models, interpret results, and use digital tools to support problem-solving processes.

In physics education, the integration of computational technology has become increasingly essential because many physical phenomena cannot always be solved analytically in a simple way. Various physics problems involve complex equations, nonlinear relationships, and iterative processes that require numerical approaches to obtain effective and efficient solutions (Irawati et al., 2025; Yanti et al., 2021). Therefore, computational physics plays a strategic role in bridging theoretical physics, mathematical formulation, and computer-based numerical analysis (Caballero & Odden, 2024; Behringer & Engelhardt, 2017). Through computational physics, students are not only introduced to physics concepts but are also trained to translate these concepts into algorithms and programming procedures (Weller et al., 2022). This learning experience is important for strengthening students' analytical reasoning, scientific programming skills, and ability to solve physics problems systematically (Hasanah et al., 2023).

Computational physics is a branch of science that integrates concepts of physics, mathematics, and computation to solve scientific problems through numerical methods (Nurmahasih & Jumadi, 2023). It enables students to understand physical systems by using computational models, simulations, and numerical calculations. One of the fundamental topics in computational physics is numerical root-finding (Mulyati et al., 2022). This topic focuses on methods for determining the roots of nonlinear equations, which frequently appear in physics, engineering, and applied sciences. Numerical root-finding methods, such as the Bisection method, False Position method, Newton–Raphson method, and Secant method, provide systematic procedures for approximating solutions when exact analytical solutions are difficult or impossible to obtain. Mastery of this topic is important because root-finding procedures are widely used to

solve equilibrium problems, analyze motion, solve energy equations, analyze electrical circuits, study wave phenomena, and model other mathematical systems in physics.

However, in actual learning practice, students often have difficulty understanding numerical algorithms and implementing them in programming languages (Caballero & Merner, 2018). These difficulties may arise because numerical methods require students to connect several layers of knowledge simultaneously, including mathematical concepts, algorithmic logic, programming syntax, and interpretation of computational results. Students may understand the formula for a numerical method but still struggle to translate it into a sequence of computational instructions. Conversely, students may be able to follow programming examples without fully understanding the underlying mathematical meaning. This gap shows that learning computational physics requires teaching materials that not only present formulas but also guide students step by step from conceptual understanding to algorithm construction, program implementation, and result interpretation (Caballero & Merner, 2018; Weller et al., 2022).

One of the factors contributing to these learning difficulties is the limited availability of practicum teaching materials that systematically integrate theory, algorithms, and computational practice (Haney et al., 2025). In many computational physics practicum activities, the modules used are still conventional, text-heavy, and less interactive. Such modules often provide procedural instructions without sufficient explanation of how numerical methods work or how to analyze computational outputs. Computational physics practicum learning also generally still uses conventional modules that have not fully supported students' independent learning (Anggraini et al., 2019; Sunardi et al., 2023). This condition can reduce students' opportunities to explore numerical methods independently, repeat simulations, and evaluate their own learning progress. In addition, the teaching materials used often fail to adequately guide students toward achieving measurable learning outcomes in accordance with the Outcome-Based Education (OBE) approach (Meiriza et al., 2025b).

The OBE approach is relevant to addressing this issue because it emphasizes the achievement of clearly defined student competencies through a planned, measurable, and learning-outcome-oriented educational process. In OBE-based learning, course objectives, learning activities, practicum tasks, and assessment instruments must be constructively aligned so that students can demonstrate the expected competencies. The implementation of the OBE approach in higher education is important because it can improve the quality of the educational process by aligning learning outcomes, learning strategies, and evaluation systems (Ali et al., 2023). In the context of computational physics practicums, OBE can help ensure that students not only complete practicum procedures but also achieve specific competencies, such as

understanding numerical concepts, constructing algorithms, writing computational programs, analyzing numerical errors, and interpreting simulation results.

In computational physics practicums, the OBE approach can be implemented by developing digital modules that include skill-based learning activities, problem-solving tasks, and learning outcome assessments (Soamole et al., 2023). A digital module allows learning materials to be presented in a more flexible and interactive format. Compared with printed modules, digital modules can integrate text, images, tables, algorithms, program scripts, tutorial videos, and simulation activities into a single learning medium (Fidan & Tuncel, 2019; Fadillah et al., 2024; Millen & Supahar, 2023). Digital modules also offer several advantages, including ease of access, more interactive presentation of material, and the ability to combine various learning resources into a single medium that supports independent learning (Pratama & Sakti, 2020). For learning computational physics, these advantages are particularly useful because students need repeated practice, clear examples, and direct interaction with computational tools.

One of the software applications that can be used effectively in computational physics learning is GNU Octave (Latifi & Delkhosh, 2019; Eaton et al., 2018). GNU Octave is an open-source numerical computing software with syntax similar to MATLAB, making it suitable for learning numerical methods. Its open-source nature makes it accessible to students without requiring licensed software, which is an important consideration in higher education contexts. The use of GNU Octave in computational physics practicums enables students to directly study the implementation of numerical algorithms through programming. In addition, GNU Octave supports mathematical operations, iterative calculations, matrix computations, graphical visualization, and numerical analysis features required to solve root-finding problems. These features allow students to observe how numerical iterations work and how computational results are generated from algorithmic procedures.

Based on the explanation above, there is a clear need to develop an OBE-oriented digital computational physics practicum module on numerical root-finding using GNU Octave. Such a module is expected to provide structured learning experiences that integrate theoretical explanations, numerical algorithms, GNU Octave programming tutorials, practicum activities, and learning outcome-based evaluations. The developed module is also expected to help students understand numerical method concepts, improve computational programming skills, strengthen problem-solving abilities, and support the achievement of measurable learning outcomes. Therefore, this study aims to develop and determine the feasibility of an OBE-oriented digital computational physics practicum module on numerical root-finding using GNU Octave as supporting teaching material for computational physics learning at the higher education level.

II. METHODS

This study employed a Research and Development (R&D) method using the ADDIE development model, which consists of five systematic stages: Analysis, Design, Development, Implementation, and Evaluation (Yahya et al., 2024). The ADDIE model was selected because it provides a structured framework for developing, validating, implementing, and evaluating instructional products. This model is also appropriate for developing digital teaching materials aligned with the OBE approach, as it enables the researcher to connect learning needs, learning outcomes, instructional activities, media design, and evaluation procedures within a coherent development process. The product developed in this study was an OBE-oriented digital computational physics practicum module on numerical root-finding, implemented in GNU Octave. The module was designed to support students in understanding numerical methods, implementing algorithms through programming, and achieving measurable learning outcomes in computational physics practicum activities.

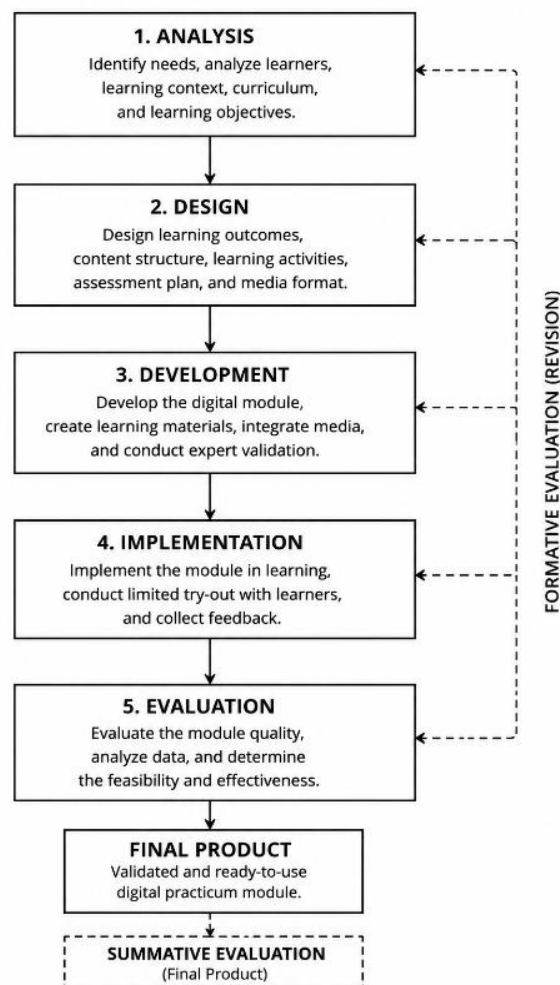


Figure 1. Steps of the ADDIE development model

2.1 Analysis stage

The analysis stage was conducted to identify the learning needs, instructional problems, and competency requirements in computational physics practicum activities, particularly on the topic of numerical root-finding. This stage focused on examining the gap between the expected learning outcomes and the existing practicum learning conditions. The analysis included three main activities. First, student characteristics were identified to determine their initial ability, learning needs, and potential difficulties in understanding numerical methods and programming activities. Second, the course learning outcomes were reviewed to ensure that the developed module aligned with the expected competencies in computational physics. Third, the need for digital-based teaching materials was analyzed by considering the limitations of conventional practicum modules and the importance of interactive learning resources. In addition, a review of the OBE-based curriculum was conducted to identify the learning outcome indicators to be achieved through the developed digital module (Meiriza et al., 2025a). The results of this stage served as the basis for designing the module content, practicum activities, assessment components, and learning evaluation instruments.

2.2 Design stage

The design stage was carried out by preparing the initial design of the digital computational physics practicum module. This stage aimed to transform the results of the needs analysis into a structured instructional design. The activities included organizing the material structure, formulating learning outcomes, designing the practicum flow, preparing the module interface layout, and developing OBE-based learning evaluation instruments. The module content was arranged to guide students gradually from conceptual understanding to computational implementation. The developed materials covered the fundamental concepts of numerical root-finding and numerical methods, as well as GNU Octave programming tutorials, exercises, and practicum assignments. The numerical root-finding methods included in the module consisted of the Bisection method, False Position method, Newton–Raphson method, and Secant method. The Newton–Raphson method was selected as one of the main examples for determining numerical roots because it provides relatively high accuracy and a simpler computational procedure than several other iterative methods. This method also allows students to observe the relationship among mathematical formulas, algorithmic procedures, and their programming implementations in GNU Octave.

2.3 Development stage

At the development stage, the digital module product was created based on the design prepared in the previous stage (Dewi & Setyasto, 2024; Tawil et al., 2023). The module was developed using supporting software to produce interactive, readable, and user-friendly digital

teaching materials. The development process included preparing learning materials, designing practicum instructions, integrating GNU Octave tutorials, arranging visual displays, and embedding supporting multimedia components. After the module was completed, expert validation was conducted to assess the product's feasibility and quality. The validation involved subject-matter and media experts to ensure that the module met academic, pedagogical, technical, and media-design standards (Reski et al., 2025). The evaluated aspects included content feasibility, language use, material presentation, media appearance, usability, and suitability with the OBE approach.

a. Material expert validation

Material expert validation was conducted using a validation questionnaire. The questionnaire was used to evaluate the accuracy, relevance, clarity, and appropriateness of the material presented in the digital module. The instrument was validated by material experts before the field research was conducted. The material expert validation instrument consisted of two main aspects: material feasibility and material presentation feasibility. The indicators are presented in Table 1.

Table 1. Instrument blueprint for material expert validation

No.	Aspect	Indicator	Number of items	Item number
1.	Material feasibility	Suitability of the material with basic competencies	2	1, 2
		Accuracy of the material	3	3, 4, 5
		Material concept	2	6, 7
		Encouraging curiosity	2	8, 9
2.	Material presentation feasibility	Material presentation techniques	2	10, 11
		Supporting material presentation	4	12, 13, 14, 15

b. Media expert validation

Media expert validation was conducted to assess the digital module's quality from the perspectives of media design, display feasibility, writing clarity, audio quality, and media usefulness. The initial design of the module was validated by media experts before the product was implemented in field trials. This validation was intended to identify technical and visual weaknesses that required improvement before students used the module. The media expert validation instrument is presented in Table 2.

Table 2. Instrument blueprint for media expert validation

No.	Aspect	Indicator	Number of items	Item number
1.	Media design feasibility	Suitability of color selection	2	1, 2
		Design suitability	2	3, 4
2.	Writing feasibility	Letter suitability	2	5, 6
		Font suitability	2	7, 8
3.	Display feasibility	Suitability of image display	2	9, 10
		Suitability of video display	2	11, 12
4.	Audio feasibility	Audio suitability	2	13, 14
5.	Media usefulness	Media usage	2	15, 16
		Media usefulness	2	17, 18

The suggestions and comments provided by the experts were used as the main basis for revising the module so that every weakness identified during the validation process could be addressed systematically, including aspects related to content accuracy, material organization, language clarity, media display, visual consistency, usability, and alignment with the OBE approach; therefore, when the product was found to have shortcomings after expert validation, revisions were made to improve the quality, clarity, readability, instructional coherence, and feasibility of the digital module, ensuring that the final product was more appropriate, practical, and ready to be tested in the implementation stage.

2.4 Implementation stage

The implementation stage was conducted through field trials involving students enrolled in Computational Physics courses. At this stage, the students used the developed digital module in practicum activities on numerical root-finding using GNU Octave. The implementation aimed to gather students' responses on the module's practicality, readability, display quality, material content, and instructional video quality. The field trial was conducted in two stages: a small-scale trial and a large-scale trial. The small-scale trial was used to identify initial student responses and product weaknesses, while the large-scale trial was conducted after revisions based on the small-scale trial results.

a. Small-scale trial

The small-scale trial was conducted at the Department of Physics Education, Universitas Muhammadiyah Prof. DR. HAMKA Jakarta. This trial involved 23 students who were enrolled in the Computational Physics course. During the trial, students used the digital module in practicum learning activities and then completed an effectiveness questionnaire (Sabo et al., 2026). The questionnaire was designed to measure students' responses to the module's display, material

content, and video aspects. The instrument blueprint for the small-scale trial is presented in Table 3.

Table 3. Instrument blueprint for the small-scale trial

No.	Aspect	Indicator	Number of items	Item number
1.	Display aspect	Display suitability	3	1, 2, 3
		Suitability of display support	2	4, 5
		Teaching material design	6	6, 7, 8, 9, 10, 11
		Media utilization	2	12, 13
2.	Material content aspect	Teaching material construction	4	14, 15, 16, 17
		Material up-to-dateness	5	18, 19, 20, 21, 22
3.	Video aspect	Video technical quality	4	23, 24, 25, 26
		Content and structure	5	27, 28, 29, 30, 31

b. Large-scale trial

The large-scale trial was conducted after the module had been revised based on the results and feedback from the small-scale trial. This trial involved 75 students enrolled in Computational Physics courses from several universities, namely Universitas Negeri Jakarta, Universitas Negeri Yogyakarta, Universitas Siliwangi, Universitas Nasional, Universitas Tadulako, Universitas Negeri Manado, and Universitas Malikussaleh. In this stage, the effectiveness questionnaire was used to gather broader student feedback on the quality and feasibility of the developed module. The assessed aspects were the same as those used in the small-scale trial, namely display, material content, and video quality. The instrument blueprint for the large-scale trial is presented in Table 4.

Table 4. Instrument blueprint for the large-scale trial

No.	Aspect	Indicator	Number of items	Item number
1.	Display aspect	Display suitability	3	1, 2, 3
		Suitability of display support	2	4, 5
		Teaching material design	6	6, 7, 8, 9, 10, 11
		Media utilization	2	12, 13
2.	Material content aspect	Teaching material construction	4	14, 15, 16, 17
		Material up-to-dateness	5	18, 19, 20, 21, 22
3.	Video aspect	Video technical quality	4	23, 24, 25, 26
		Content and structure	5	27, 28, 29, 30, 31

2.5 Evaluation stage

The evaluation stage was conducted to determine the final quality and feasibility of the developed digital module based on expert validation results and student responses. Evaluation was carried out formatively at each stage of development to identify weaknesses and improve the

module. The implementation of the media produced data from field trials, media expert validation, material expert validation, and student responses collected through motivation and feasibility questionnaires (Haetami et al., 2023). The collected data were analyzed using a Likert scale. Each response option was assigned a score from 1 to 5, ranging from strongly disagree to strongly agree. The Likert scale used in this study is presented in Table 5.

Table 5. Likert scale

Alternative answer	Description	Score
SA	Strongly agree	5
A	Agree	4
N	Neutral	3
D	Disagree	2
SD	Strongly disagree	1

The evaluation results were used as the basis for improving the product in order to obtain a computational physics practicum digital module that was feasible for use in the learning process (Laili et al., 2025). This evaluation was conducted to ensure that the developed module met the expected quality standards for content, presentation, media design, readability, usability, and alignment with the learning outcomes. The feedback from expert validation and student responses was analyzed to identify the module's strengths and weaknesses before the final revision was completed. Through this process, the module could be systematically refined to better support numerical root-finding practicum activities using GNU Octave. The evaluation stage also helped determine whether the module was practical and suitable for implementation in computational physics learning. The feasibility percentage was calculated using the following formula:

$$P = \frac{\sum X}{\sum X_i} \times 100\% \quad (1)$$

Description:

P= feasibility percentage,

$\sum X$ = total score obtained,

$\sum X_i$ = maximum total score.

The percentage scores from expert validation and student responses were then interpreted using product eligibility categories to determine the developed digital module's feasibility level. This interpretation was necessary to ensure that the quantitative data from the validation and trial processes could be classified into clear, meaningful quality levels. Each percentage score was compared with predetermined criteria ranging from "Not Good" to "Very Good," enabling the researchers to assess whether the module met the minimum standard for use in computational

physics learning. The eligibility categories also helped identify which aspects of the module required further improvement, particularly in terms of material quality, media design, readability, and practicality. By using these criteria, the feasibility assessment became more systematic, objective, and easier to interpret. The criteria used to determine the developed module's feasibility level are presented in Table 6.

Table 6. Product eligibility categories

No.	Score	Category
1.	81–100%	Very good
2.	61–80%	Good
3.	41–60%	Enough
4.	21–40%	Less
5.	<20%	Not good

2.6 Data collection and analysis techniques

The data collection techniques used in this study consisted of observations, expert-validation questionnaires, and student-response questionnaires. Observation was conducted to identify learning needs and problems in computational physics practicum activities. Expert validation questionnaires were used to assess the feasibility of the digital module in terms of material and media aspects. Meanwhile, student response questionnaires were used to evaluate the module's practicality, readability, display quality, material content, and instructional video quality after implementation.

The data obtained from expert validation and student responses were analyzed descriptively using quantitative methods. The analysis was conducted by calculating the percentage of feasibility scores based on the total score obtained and the maximum possible score. The results of the analysis were then interpreted using the product eligibility categories. The final interpretation was used to determine the feasibility level of the OBE-oriented computational physics practicum digital module on numerical root-finding using GNU Octave.

III. RESULTS

This study developed an OBE-oriented digital practicum module in computational physics on numerical root-finding, implemented in GNU Octave. The module was developed as supporting teaching material to help students understand numerical method concepts, implement numerical algorithms, and improve computational skills through structured practicum activities aligned with learning outcomes. The developed product comprises several main components,

including OBE-based learning outcomes, numerical root-finding materials, numerical methods algorithms, GNU Octave tutorials, programming examples, practicum worksheets, and learning evaluation components. The numerical methods presented in the module include the Bisection method, the False Position method, the Newton–Raphson method, and the Secant method. These methods were selected because they represent fundamental numerical techniques commonly used to solve nonlinear equations in computational physics.

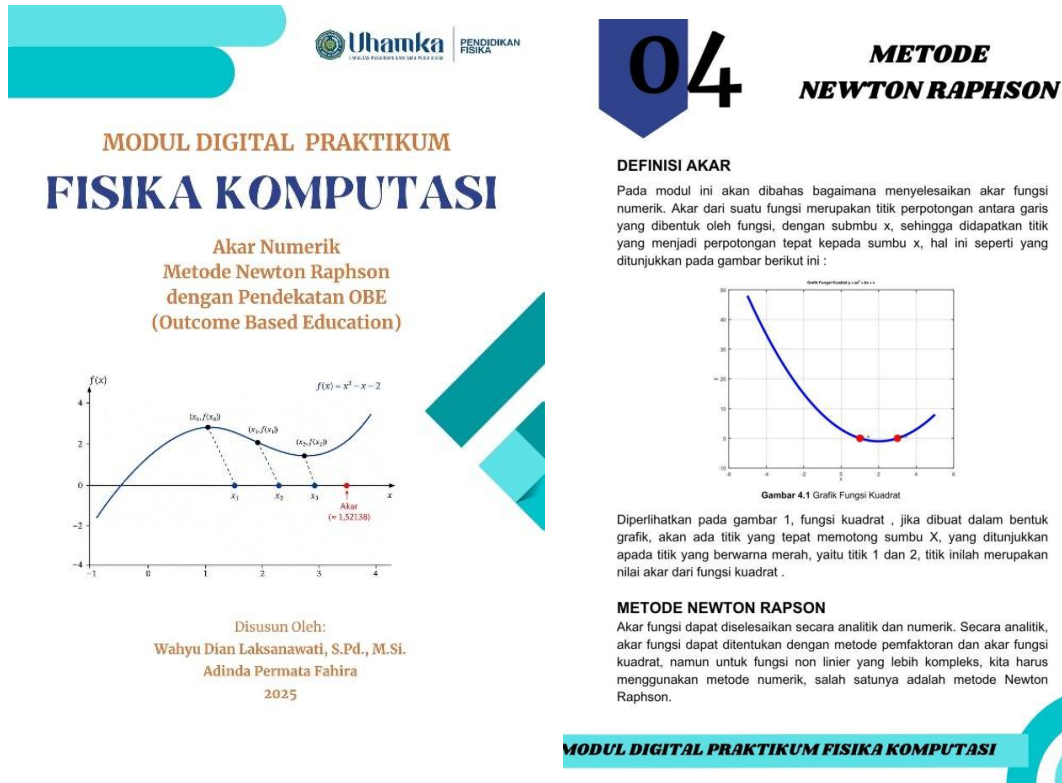


Figure 2. Display of the computational physics practicum module

In the implementation process, students conducted root-finding simulations using the numerical algorithms presented in the module. One of the methods applied in the practicum activity was the Newton–Raphson method. This method was introduced because it allows students to observe an iterative numerical procedure and understand how an approximate root is obtained through repeated computational steps. The Newton–Raphson formula used in the module is presented as follows:

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)} \tag{2}$$

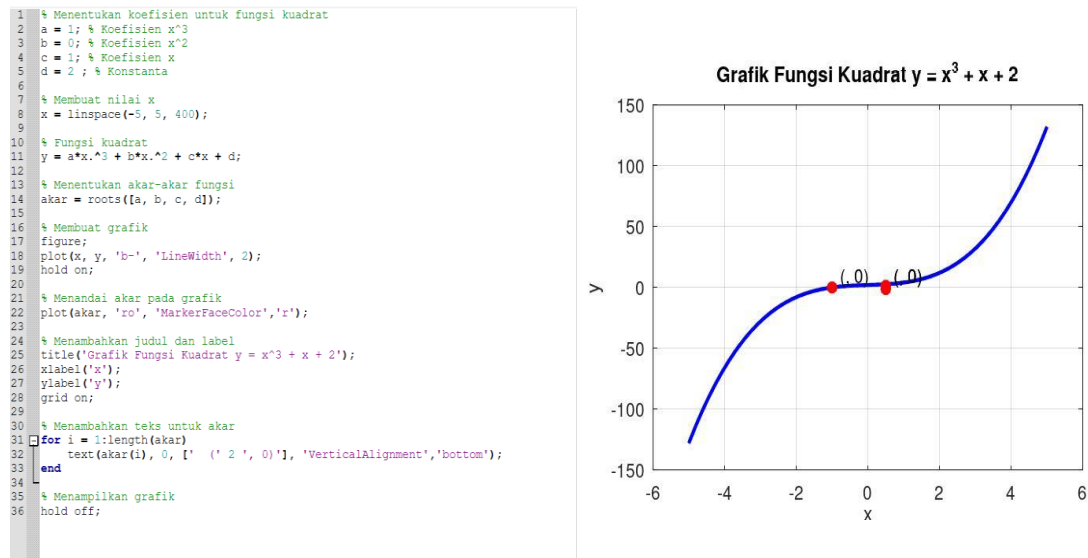


Figure 3. Display of the GNU Octave script editor in the application of the Newton–Raphson numerical root-finding method

The Newton–Raphson method was implemented using GNU Octave so that students could directly observe the numerical iteration process through programming. This implementation enabled students to connect mathematical formulas with computational procedures, including defining functions, determining initial values, writing iteration commands, and interpreting numerical outputs. Therefore, the integration of conceptual explanation, algorithmic structure, and programming practice provided a more applicable learning experience compared with conventional practicum activities that rely mainly on written instructions.

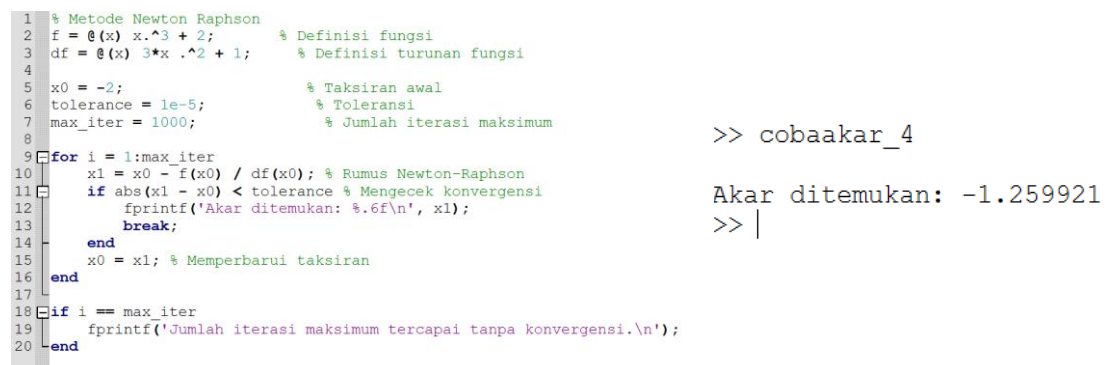


Figure 4. Results of root-finding analysis using computational methods

3.1 Material expert and media expert validation

The feasibility of the developed digital module was assessed through validation by material and media experts. The material expert validation achieved an average score of 87%, while the media expert validation achieved an average score of 88%. Both scores were categorized as “Very good.” These results indicate that the developed module met the required criteria for content

feasibility, material presentation, media display, usability, and suitability with the OBE approach. The results of material expert validation are presented in Table 7.

Table 7. Assessment results of material validation

Aspect	Indicator	\bar{NP}	Category
Appropriateness of material	Appropriateness of material	90%	Very good
	The accuracy of the material	87%	Very good
	Material concept	80%	Good
	Encourage curiosity	90%	Very good
Feasibility of material presentation	Material presentation techniques	80%	Good
	Supporting material presentation	93%	Very good
Average		87%	Very good

Based on Table 7, the material expert validation showed that the OBE-oriented computational physics practicum digital module achieved an overall average score of 87%, which falls into the “Very good” category. This result indicates that the material presented in the module is suitable for supporting computational physics practicum learning, particularly on the topic of numerical root-finding. In the aspect of material appropriateness, the indicator “Appropriateness of material” obtained a score of 90% and was categorized as “Very good.” This finding indicates that the material included in the module is relevant to the expected learning objectives and competencies. The indicator “The accuracy of the material” received a score of 87%, categorized as “Very good,” indicating that the concepts, explanations, and numerical procedures presented in the module are scientifically appropriate. Meanwhile, the “Material Concept” indicator obtained a score of 80%, categorized as “Good.” This result suggests that the conceptual presentation is acceptable, although several parts may still require refinement to improve clarity and depth. The “Encourage curiosity” indicator reached 90%, categorized as “Very good,” indicating that the module has the potential to stimulate students’ interest and motivation in learning numerical methods.

In terms of material presentation feasibility, the “Material presentation techniques” indicator received a score of 80%, categorized as “Good.” This result shows that the organization and presentation of the material are sufficiently systematic and understandable. The “Supporting material presentation” indicator achieved the highest score, 93%, and was categorized as “Very good.” This finding indicates that supporting elements, such as examples, illustrations, programming guidance, and practicum activities, effectively strengthen the presentation of the learning material. Media expert validation was conducted to evaluate the module from the perspectives of media design, writing, visual display, audio quality, and media usefulness. The results are presented in Table 8.

Table 8. Assessment results: media validation

Aspect	Indicator	NP	Category
Media design feasibility	Appropriateness of color selection	80%	Good
	Appropriateness of design	90%	Very good
Writing feasibility	Lettering suitability	80%	Good
	Font suitability	80%	Good
Display feasibility	Appropriateness of image display	80%	Very good
	Appropriateness of video display	90%	Very good
Audio feasibility	Audio suitability	100%	Very good
Media usefulness	Use of media	90%	Very good
	Media usefulness	90%	Very good
Average		88%	Very good

Based on Table 8, the media expert validation indicated that the developed digital module achieved an overall average score of 88%, categorized as “Very good.” This result indicates that the module is highly feasible in terms of visual design, readability, multimedia quality, and usefulness as a digital learning medium. In the media design feasibility aspect, the “Appropriateness of color selection” indicator obtained a score of 80%, categorized as “Good.” This result indicates that the color selection used in the module is appropriate and supports readability. The “Appropriateness of design” indicator achieved a score of 90%, categorized as “Very good,” indicating that the layout and visual organization of the module are attractive, well-structured, and suitable for learning.

In the writing feasibility aspect, both “Lettering Suitability” and “Font Suitability” obtained scores of 80%, each categorized as “Good.” These results indicate that the typography used in the module is readable and appropriate, although improvements in visual consistency could further strengthen its appearance. In the display feasibility aspect, the “Appropriateness of image display” indicator scored 80%, while the “Appropriateness of video display” indicator scored 90%. These findings indicate that the images and instructional videos included in the module are useful in supporting students’ understanding of the practicum material.

The highest score was obtained in the audio feasibility aspect, where the “Audio Suitability” indicator reached 100% and was categorized as “Very good.” This result indicates that the audio component in the module is clear, appropriate, and supportive of the learning process. Furthermore, in the media usefulness aspect, both “Use of media” and “Media usefulness” obtained scores of 90%, categorized as “Very good.” These results show that the module is practical, accessible, and useful for supporting computational physics practicum activities.

3.2 Feasibility testing

After the product passed validation by material and media experts, the digital module was tested in field trials. The feasibility testing consisted of two stages: a small-scale trial and a large-scale trial. The small-scale trial was conducted to obtain initial student responses and identify aspects that required revision, while the large-scale trial was conducted to evaluate the module with a broader group of respondents after improvements were made. In the small-scale trial, the assessment involved 23 Physics Education students as respondents. Students used the developed digital module in computational physics practicum activities and then provided responses through a questionnaire covering display, material content, and video aspects. The results of the small-scale trial are presented in Figure 5.

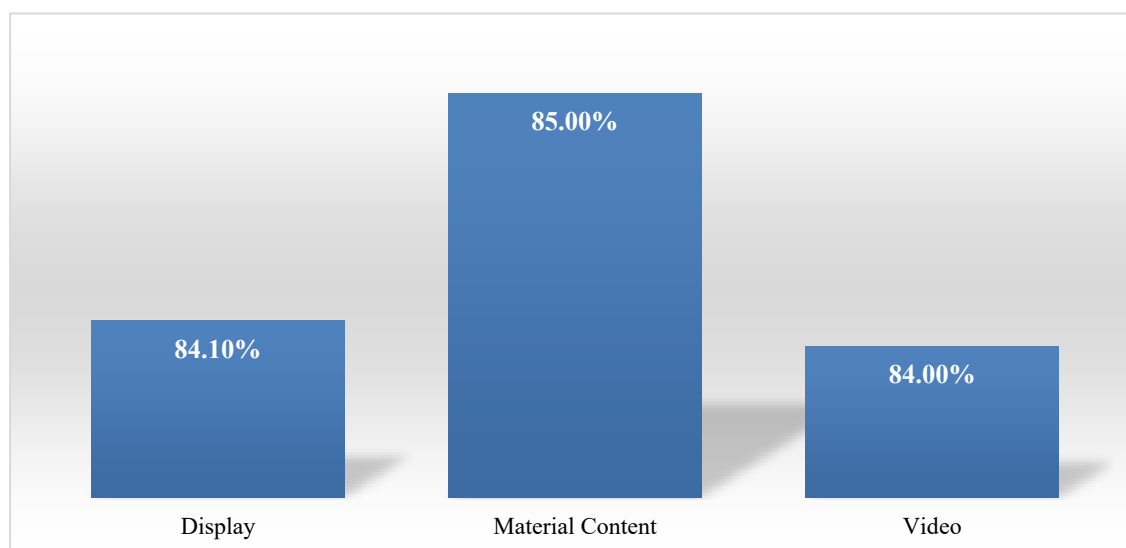


Figure 5. Percentage results of the small-scale trial assessment

Based on Figure 5, the display aspect obtained a percentage score of 84.10%, which was categorized as “Very good.” This result indicates that students considered the module's visual appearance, layout, and display support appropriate for practicum learning. The material content aspect achieved 85.00%, also categorized as “Very good.” This finding shows that the material presented in the module was considered clear, relevant, and useful in helping students understand numerical root-finding concepts. In addition, the video aspect obtained a percentage score of 84.00%, which was also categorized as “Very good.” This result indicates that the instructional videos included in the module supported students’ understanding of the practicum procedures and the GNU Octave implementation.

After the small-scale trial was completed, the teaching material was revised based on students’ comments and suggestions. These revisions were made to improve several aspects of the module, particularly the clarity of instructions, the readability of the material, the consistency

of the visual display, and the ease of use during practicum activities. Student feedback was considered important because it provided direct information about how the module was understood and used in actual learning conditions. The revision process also ensured that the module became more accessible and practical for students with different levels of computational ability. In addition, improvements were made to strengthen the connection between the numerical method concepts, GNU Octave programming activities, and practicum tasks. Therefore, the revised module was expected to provide a clearer, more structured, and more user-friendly learning experience before being implemented in the large-scale trial.

The large-scale trial involved 75 students who were enrolled in Computational Physics courses. This trial was conducted to obtain broader feedback regarding the feasibility of the developed module after revision. Compared with the small-scale trial, the large-scale trial provided more comprehensive information because it involved a larger number of respondents from a wider learning context. The students used the revised digital module in computational physics practicum activities and then evaluated its display quality, material content, and instructional video components. The data obtained from this stage were used to determine whether the module remained feasible, practical, and effective when implemented with more participants. The results of the large-scale field testing are presented in Figure 6.

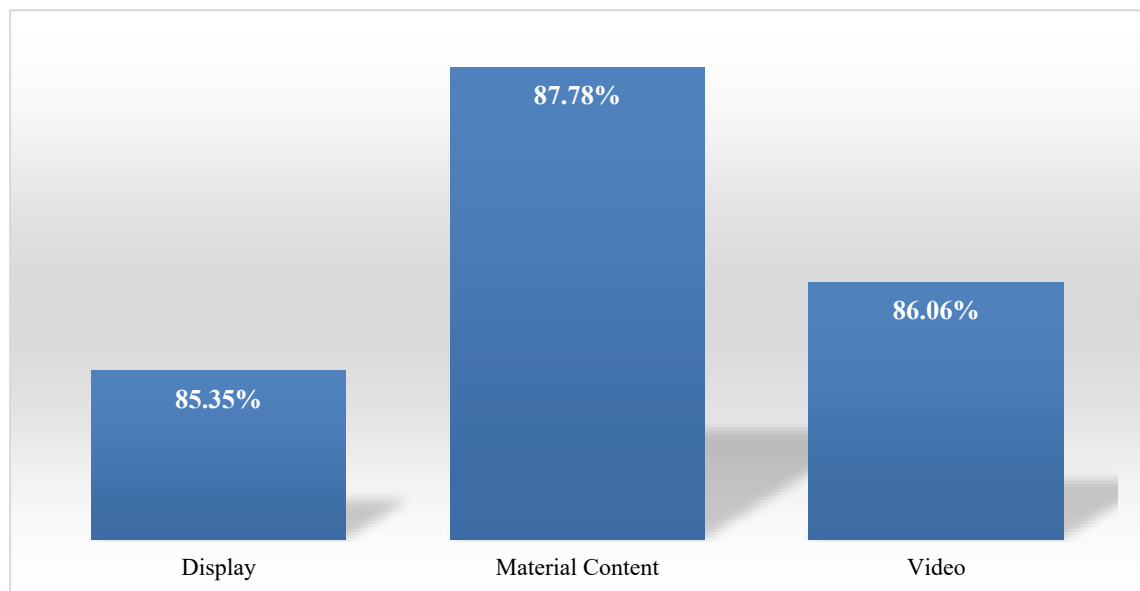


Figure 6. Results of the large-scale trial assessment

Based on Figure 6, the display feasibility aspect obtained a percentage score of 85.35% and was categorized as “Very good.” This result indicates that the revised module had a clear and attractive display that supported learning activities. The material content aspect received the highest score, 87.78%, and was categorized as “Very good.” This finding indicates that the

module's content was considered relevant, systematic, and helpful for understanding numerical methods and their implementation in GNU Octave. Meanwhile, the video feasibility aspect obtained a score of 86.06%, categorized as "Very good." This result indicates that the instructional videos were effective in supporting students' learning process and helping them follow the computational practicum procedures.

IV. DISCUSSION

The results of this study indicate that the developed OBE-oriented digital computational physics practicum module demonstrated a very high level of feasibility, as evidenced by validation by materials and media experts and implementation trials. The material expert validation obtained an average percentage of 87%, while the media expert validation achieved 88%, and both were categorized as "Very good." These results show that the module has met the expected standards in terms of content accuracy, material organization, media design, visual presentation, and suitability with the OBE approach. Furthermore, the small-scale and large-scale trials showed positive student responses, with percentages above 84% for display, material content, and instructional video quality. These findings indicate that the developed digital module is feasible for use in computational physics learning because it provides structured learning materials, clear practicum procedures, and relevant computational activities. The results also suggest that the module can support students in understanding numerical root-finding concepts, practicing GNU Octave programming, and achieving measurable learning outcomes through guided practicum activities.

The findings of this study are consistent with previous studies reporting that digital modules and technology-based learning media can improve learning effectiveness and student engagement in physics education. [Bahtiar and Azmar \(2022\)](#) reported that the use of virtual laboratories significantly improved students' motivation and physics learning outcomes. Similarly, [Ghadzia et al. \(2023\)](#) found that discovery-learning-based physics e-modules were highly valid, practical, and effective for improving students' conceptual understanding. Furthermore, [Praptama et al. \(2023\)](#) demonstrated that project-based learning modules enhanced students' creative thinking skills in physics learning. These previous findings strengthen the present study's results, as they show that well-designed digital teaching materials can support students' learning in physics. In this study, the digital computational practicum module not only presents learning content but also integrates algorithms, programming examples, practicum worksheets, and outcome-based evaluations. Therefore, the module contributes positively to students' learning experiences by helping them connect physics concepts, numerical procedures, and computational implementation.

The implementation of computational approaches and interactive digital learning environments in physics education has also been widely reported to improve students' higher-order thinking skills and problem-solving abilities. [Yuliani et al. \(2025\)](#) reported that integrating problem-based learning e-modules significantly improved students' problem-solving skills in physics. Likewise, [Agato et al. \(2025\)](#) found that differentiated learning strategies integrated with problem-based learning effectively enhanced students' understanding of complex physics concepts. These studies are in line with the findings of the present research, where the integration of GNU Octave-based computational activities supported students' numerical analysis and computational thinking skills. Through the developed module, students were guided to understand mathematical formulas, translate them into algorithms, implement the algorithms in GNU Octave, and interpret the computational results. This sequence of activities is important because learning computational physics requires students to integrate conceptual understanding, logical reasoning, and programming skills. As a result, the module provides a meaningful learning experience that is more active and problem-oriented than conventional practicum learning.

Compared with previous studies, this research offers a more comprehensive integration between the OBE approach and GNU Octave-based computational practicum activities. Most previous studies focused primarily on e-module development, virtual laboratories, or problem-based learning separately. In contrast, the present study integrates measurable learning outcomes, computational programming, numerical analysis, and practicum activities into a single structured digital module. This integration supports competency achievement in accordance with the principles of Outcome-Based Education, as each learning activity is directed toward specific, observable, and assessable outcomes. The module also provides students with opportunities to practice numerical root-finding methods while developing programming and analytical skills. The findings are supported by [Mardova et al. \(2025\)](#), who stated that OBE-based interactive e-modules can improve students' scientific literacy and independent learning. Therefore, the main contribution of this study lies in the development of a digital practicum module that integrates OBE principles, instruction in numerical methods, and open-source computational tools into a single learning resource.

The implementation of the Newton–Raphson method using GNU Octave enabled students to visualize iterative numerical processes more effectively. Through computational simulations, students could observe how an initial approximation is processed repeatedly to obtain a numerical root. This activity helped students understand the relationship between mathematical concepts and their implementation in programming by presenting the formula not only theoretically but also as executable commands in GNU Octave. This finding is consistent with [Khaharsyah et al. \(2025\)](#), who reported that GNU Octave-based simulations increased students' motivation, interest,

and positive attitudes toward physics learning. GNU Octave also provides an open-source computational environment that is relevant to current technological developments and accessible for students in higher education. The use of GNU Octave is beneficial because it reduces dependence on licensed software while still allowing students to practice numerical programming, data visualization, and computational analysis. Thus, the module supports both conceptual understanding and practical computational competence in learning computational physics.

From a physics education perspective, the developed module contributes to improving students' computational literacy, problem-solving abilities, and independent learning skills. The integration of computational thinking into physics education is essential for preparing students to navigate technological developments in the era of digital education and Industry 4.0. Students need to be able to analyze scientific problems, construct numerical models, use computational tools, and evaluate the results of simulations or calculations. In addition, the implementation of OBE principles supports competency-based higher education, as emphasized by [Irvani et al. \(2024\)](#), who explained that OBE-oriented curricula contribute significantly to achieving graduate competencies in physics education programs. In this study, the OBE approach was reflected in the alignment between learning outcomes, practicum activities, programming tasks, and evaluation components. Therefore, the developed digital practicum module has the potential to become an innovative learning resource that supports interactive, technology-based, and outcome-oriented computational physics learning.

The implementation of the OBE approach in the module also positively impacted students' achievement of competencies, as the module was designed around measurable learning outcomes. Each practicum activity had clear learning objectives, enabling students to understand which competencies should be achieved upon completing the activity. Students not only learned mathematical concepts but also acquired programming and numerical analysis skills relevant to computational physics. The findings of this study are consistent with previous studies indicating that the use of digital teaching materials can improve learning effectiveness and students' motivation to learn. Other studies have also shown that implementing computational software for learning numerical methods can enhance students' problem-solving abilities and computational thinking skills. However, this study has the advantage of integrating the OBE approach with GNU Octave into a structured digital practicum module. This integration makes the learning process more focused, measurable, and aligned with the expected competencies in higher education.

V. CONCLUSION AND SUGGESTION

This study concluded that the OBE-oriented digital practicum module for computational physics on the topic of numerical root-finding using GNU Octave was successfully developed using the ADDIE development model. The module consists of materials on numerical methods, GNU Octave programming tutorials, practicum worksheets, and OBE-based learning evaluations designed to support the achievement of student learning outcomes. The feasibility test results showed that the module achieved a “Very good” category rating based on expert validation, with material expert validation at 87% and media expert validation at 88%. The implementation results also showed positive student responses in both small-scale and large-scale trials, with average percentages above 84% for appearance, material content, and instructional video quality. These findings indicate that the developed module is feasible for use as supporting teaching material in computational physics practicum activities and can help students understand numerical root-finding concepts, improve programming skills, and conduct numerical analysis using GNU Octave more effectively.

Although the developed module demonstrated strong feasibility and elicited positive student responses, this study has several limitations. The effectiveness of the module was evaluated primarily through expert validation and student response questionnaires; therefore, further studies are needed to measure its direct impact on students’ computational thinking skills, problem-solving abilities, and learning achievement using experimental or quasi-experimental designs. In addition, the module was limited to numerical root-finding methods, including Bisection, False Position, Newton–Raphson, and Secant; therefore, future research is recommended to expand the module to other computational physics topics, such as numerical integration, differential equations, data fitting, and physical system simulations. Future studies may also add more interactive simulations, automated feedback, and broader implementation across different institutional contexts. The main contribution of this study lies in the integration of OBE principles, GNU Octave-based programming activities, and numerical method practicums into a structured digital module. This contribution supports the development of technology-based, competency-oriented, and accessible learning resources in physics education, particularly for strengthening students’ computational literacy and independent learning in higher education.

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