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PAPER

CT-Mobile: Enhancing Computational Thinking via Android Graphic Design App

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ABSTRACT

In the rapidly evolving digital age, the need for computational thinking (CT) skills is answered with the introduction of CT-Mobile, an innovative Android-based graphic design application. The app integrates basic computational concepts with graphic design principles, providing a unique platform for users to improve problem-solving, algorithmic thinking, and logical reasoning skills. This study used a research and development (R&D) approach with the 4-D Model (define, design, develop, and disseminate) as a guide. The validity test with experts categorized CT-Mobile as "valid" with values of 0.85 and 0.88 from media experts and material experts. The practicality of this application was rated as "very practical" by teachers (89.67%) and students (86.34%). These findings confirm the significant benefits of CT-Mobile in graphic design learning, both for educators and students. The analysis showed a positive impact on users' CT ability, reflected by improved problem-solving efficiency and a deeper understanding of algorithmic processes. This study provides valuable insights into the relationship between mobile application development, graphic design education, and the development of CT skills. CT-Mobile emerges as a promising tool to bridge technology, creativity, and cognitive skill development in the digital age.

KEYWORDS

CT-mobile, computational thinking (CT), android-based graphic design, mobile application, development

1 INTRODUCTION

In the contemporary landscape of digital education and technological advancement, the cultivation of computational thinking (CT) skills stands as a critical imperative [1]. As society increasingly relies on technology and innovation, individuals proficient in CT are better equipped to navigate complex problem-solving scenarios and contribute meaningfully to various fields [2]. This study focuses on the development and evaluation of CT-Mobile, an Android-based graphic design mobile application aimed at enhancing CT skills.

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The fusion of CT and graphic design is particularly interesting, as it creates a harmonious relationship between the realms of logical reasoning and creative expression [3]. CT-Mobile's novel approach presents an innovative way to integrate computational concepts into a graphic design context. This is in line with previous research that emphasizes the importance of understanding CT among students [4]. By providing dynamic applications, CT-Mobile gives users the opportunity to develop not only technical skills but also creativity and holistic problem-solving skills.

Exploring the potential of the CT-Mobile, as presented in previous research [5], has provided an understanding of the concept of CT connected to elements of game-based learning (GBL). The results of this study showed significant improvements in students' CT understanding and skills. However, there are shortcomings in this study, namely the lack of integration of mobile technology and the lack of focus on innovative pedagogical strategies that encourage CT in an era of rapidly evolving technology. Several previous research studies provide a relevant starting point for this CT-Mobile research. From the results of previous research, it is hoped that this study can be a catalyst, inspiration, and motivation for Informatics Engineering Education Study Program students to actively participate in the development of CT-Mobile applications. The main goal is to fulfill the need for CT skills in graphic design courses and improve students' CT skills through the integration of CT-Mobile applications in the learning process by applying graphic design principles.

2 LITERATURE REVIEW

In recent years, the integration of CT skills into educational paradigms has gained prominence as a response to the escalating demands of the digital age [6]. The rapid evolution of technology necessitates a workforce equipped not only with technical proficiency but also with the ability to think critically, solve problems algorithmically, and approach complex challenges with a computational mindset [7], [8]. This research focuses on the intersection of CT and graphic design through the introduction of CT-Mobile, an Android-based graphic design mobile application designed to enhance and assess CT skills [9].

The literature in this domain underscores the significance of CT as a fundamental skill set [10], transcending traditional computer science education to permeate various disciplines. CT involves a structured approach to problem-solving, algorithmic reasoning, and abstraction, making it a cornerstone for success in diverse professional fields [11]. As educational institutions grapple with the imperative to equip learners with these skills, there is a discernible shift toward innovative and interactive pedagogical tools [12].

Previous research into mobile apps highlights their success as an effective tool for enhancing the learning experience, not only by being accessible but also engaging [13]. CT-Mobile firmly positions itself at the intersection of CT and graphic design, recognizing the symbiotic relationship between logical reasoning and creative expression. In line with these findings, other studies have also capitalized on the prevalence of mobile devices as the most productive learning resource [14]. CT-Mobile ambitions to redefine how CT skills are developed, presenting a dynamic and user-friendly environment for learners to explore the synergy between technology and design.

This study aims to contextualize the development of CT-Mobile in a broader discourse on CT, CT-Mobile, and technology integration into education at Universitas Negeri Yogyakarta (UNY), especially the Informatics Engineering Education Study Program in graphic design courses. Based on the objectives of this study, it is expected

that this research can provide an exploration of relevant research and theoretical frameworks to build a theoretical foundation that supports the premise of CT-Mobile as a transformative tool to improve CT skills in the context of graphic design education.

3 METHODOLOGY

3.1 Research design

This study adopts a research and development (R&D) approach, leveraging the well-established 4-D model (define, design, develop, and disseminate) as its foundational framework [15]. The 4-D model guides the progression of this research, structuring it into distinct sequential stages that collectively shape the study's methodology and outcomes (see Figure 1).

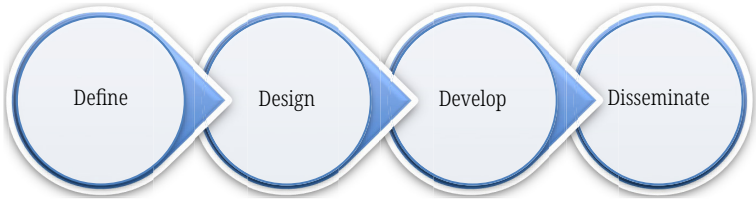

Fig. 1. CT-Mobile development procedure

Define. In the initial phase, the study begins with problem identification, as outlined in the background. This is followed by the analysis of field conditions, which includes determining research samples, examining student characteristics, exploring graphic design learning concepts, scrutinizing tasks for CT-Mobile development, and formulating precise graphic design learning objectives.

Design. This stage involves the compilation of media design users, material design, and research instrument design. It includes designing the development of learning media, reviewing criteria for media development, selecting appropriate media and applications for graphic design lessons, choosing CT-Mobile media formats, compiling material scope, formulating research validity instruments, and creating the initial design for CT-Mobile applications.

Develop. In this phase, the development of the CT-Mobile application begins. The process begins with aligning the learning media with the school curriculum and syllabus, followed by the development of graphic design learning material content. Next, learning videos are created, and progress is driven by conducting discussions with experts in the field of media and material validation.

Disseminate. In the dissemination stage, simulations and initial trials of the media are conducted before implementation. Furthermore, thorough validation is carried out by media experts and material experts. After the media and materials are declared valid, they are considered ready to be integrated into the research, so that validity data can be collected through questionnaires given to media experts and material experts who act as validators of CT-Mobile media.

Hopefully, the success of this media development can have implications for other related subjects, leading to the creation of an effective learning application to support students in their educational journey. Such an application is expected to stimulate interest, increase learning motivation, and ultimately contribute to the improvement of overall learning outcomes.

3.2 Research participants

This study utilized a purposive sampling technique [16], which is a deliberate selection of participants with certain attributes that fit the research objectives. The selection criteria involved interest in graphic design, proficiency in mobile technology, and willingness to improve CT skills through the CT-Mobile app. Therefore, data collection was contextualized through a transparent and systematic process. The focus of this research is on 32 students in the Informatics Engineering Education Study Program, Faculty of Engineering, Universitas Negeri Yogyakarta (UNY), Indonesia.

3.3 Research instruments

CT-Mobile validity instrument. The validity instrument used in this study is a questionnaire, used to obtain data on the validity level of the CT-Mobile media developed. The media validation instrument grids for media experts and material experts can be seen in Tables 1 and 2 below:

Table 1. Grid of validation instruments for media experts

Aspect	No	Indicator
View	1	Log in page and main page display
	2	CT-Mobile menus and icons are easy to understand
	3	Layout display is easy to understand
	4	Easy to understand media display
	5	Media and multimedia displays are easy to understand
Usage	6	Ease of program operation
	7	Ease of use of the media features provided
Media usefulness	8	Utilization of CT-Mobile in helping teachers and students
	9	Ease of understanding computational thinking

Table 2. Grid of validation instruments for material experts

Aspect	No	Indicator
Content	1	Clarity of graphic design learning outcome criteria
	2	Suitability of graphic design material
	3	Factualization and actualization of the content of the material
	4	The suitability and attractiveness of the material content
Learning	5	Clarity of graphic design learning objectives
	6	Suitability between learning outcomes and material
	7	Selection of material in accordance with learning tools
	8	The attractiveness of the material in asking and motivating users
Evaluation	9	Suitability of tasks and evaluation questions with the material

Practicality instrument. Practicality measures the level of ease of use and implementation of learning using CT-Mobile developed, including three categories, namely aspects of ease of use of CT-Mobile, time efficiency and usefulness of CT-Mobile developed. Practicality results are obtained through a questionnaire, which includes responses, input, and suggestions from lecturers and students of the Informatics Engineering Education Study Program who have used the media. Practicality questionnaire instruments for lecturers and students are presented in Tables 3 and 4.

Table 3. Practicality instrument for lecturers

Aspect	No	Indicator
Ease of use of CT-Mobile	1	The developed media is simple and easy to use.
	2	The content used is easy to understand.
	3	CT-Mobile provides flexibility of use anytime and anywhere.
	4,5	The material presented is easy to understand
Time efficiency	6	CT-Mobile saves study time
	7	Students are more able to understand learning concepts
	8,9	CT-Mobile can be used effectively
Usefulness of CT-Mobile	10	Can effectively assist in delivering the material
	11,12	CT-Mobile functions as a versatile learning media.
	13	CT-Mobile can be redeveloped for other learning materials.

Table 4. Practicality instrument for students

Aspect	No	Indicator
Ease of use of CT-Mobile	1	How easy was it for you to find and access the login page?
	2	How does the interface design help you use the app?
	3	Are the instructions for use easy to understand?
	4	The developed application can be used anywhere?
Time efficiency	5,6	The developed application can be used anywhere?
	7	CT-Mobile help you save time in understanding the material?
	8	Whether student grades can be known directly.
Usefulness of CT-Mobile	9,10	Thinking concepts in graphic design?
	11	Does CT-Mobile provide variety in graphic design learning?
	12	Can CT-Mobile provide computational thinking skills?

3.4 Data analysis technique

Validity analysis technique. The validity data were subjected to analysis utilizing Aiken's V validity coefficient, a formula devised by Aiken to compute the content validity coefficient. This coefficient relies on the evaluation of a panel consisting of n experts regarding an item's representation of the measured construct. Subsequently, the average score is determined by following these outlined steps:

1. Score the answers with a number between 1 (not very representative or not very relevant) to 5 (very representative or very relevant).
2. Add up the scores from each validator for all indicators.
3. Aiken's V statistic is formulated as:

$$V = \sum S / [n(c-1)]$$

Information:

V = validity index; s = r – lo; lo = lowest validity assessment number; c = highest validity assessment number; r = the number given by the validator; n = number of validators

In this learning media development research, primary data were collected using the following instruments:

1. Validation instruments for media experts assessing aspects like view, usage, and media usefulness.
2. Validation instruments for material experts assessing aspects such as content, learning, and evaluation.
3. Validation achievement levels between 0.6 and 1.0 (> 0.6–1.0) were considered valid, while levels below 0.6 (< 0.6) were deemed invalid. Data presented in Table 5.

Table 5. CT-Mobile validity category table

Average Score	Criteria
> 0.6–1.0	Valid
< 0.6	Invalid

3.5 Practicality analysis technique

Practicality analysis was carried out by involving lecturers teaching graphic design courses and students enrolled in the Informatics Engineering Education Study Program with a focus on graphic design. A questionnaire was administered to gauge the effectiveness of the CT-Mobile media. Practicality was measured using a Likert scale comprising five alternative responses, namely very practical (5), practical (4), moderately practical (3), less practical (2), and not practical (1) (see Table 6). Practicality scores were determined by summing responses and calculating the percentage using the formula:

$$Practicality = \frac{\sum Score\ obtained}{\sum Maximum\ Score} x\,100\%$$

Table 6. CT-Mobile practicality category

Achievement Level (%)	Practicality Category
0–20	Not practical
21–40	Less practical
41–60	Moderately practical
61–80	Practical
81–100	Very practical

4 RESULT AND DISCUSSION

4.1 Design results

Analysis of CT-Mobile prototype development, which features graphic design subject matter, interactive multimedia, and video tutorials that help students to understand the material. The typeface used is Times New Roman with size 12 with 1.5 spaces. The media preparation format follows the CT-Mobile systematics, modified and adapted to the Ministry of National Education (DEPDIKAS) guidelines consisting of: (a) main page; (b) material page; (c) material page; (d) evaluation page. The development stages of the CT-Mobile platform application are as follows:

Main Page, which is the page that appears when the learning media application is opened. This initial page contains animated icons that describe the material to be studied. Then, on this opening page, there is also a "Login" button that will direct users to the instructions page. The initial page display can be seen in Figure 2.

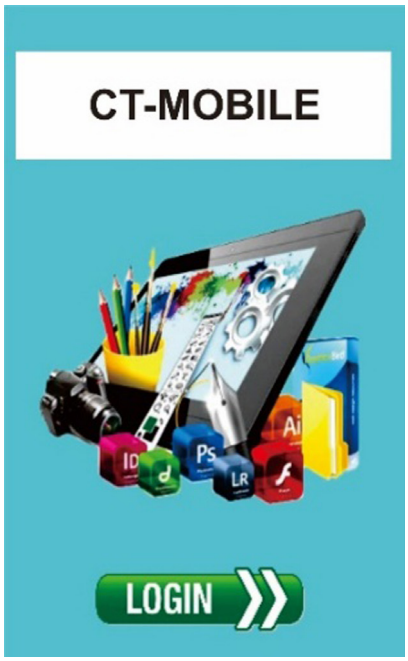

Fig. 2. Main page

The Materials page is a specialized section consisting of 16 graphic design lesson modules. Each of these modules is enriched with a pretest and posttest menu strategically inserted to assess the CT understanding and effectiveness of the students' learning outcomes. The material menu presented in Figure 3 provides a clear and structured visual overview of the material to be learned by the students during the lesson.

Fig. 3. The materials page

The Content page is a comprehensive section that elucidates students' understanding of each graphic design learning material. It is augmented with meticulously crafted video tutorials aimed at facilitating student learning. Figure 4 visually represents the layout and features of the content page.

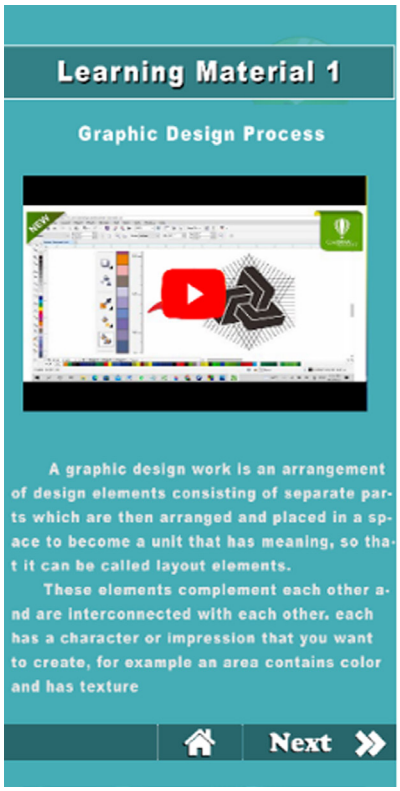

Fig. 4. The content page

The evaluation page is a page that contains questions that will test students' abilities. The evaluation presented in the form of objective questions consists of pre-test, post-test, and evaluations of each learning material. The display of the evaluation page can be seen in Figure 5.

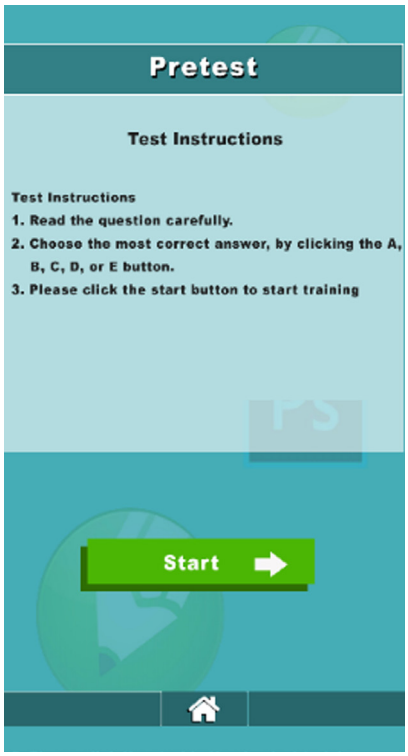

Fig. 5. The evaluation page

This CT-Mobile format combines different learning elements in one application that is easily accessible to users. By presenting content in diverse formats, CT-Mobile media becomes more interactive and engaging for students, thus increasing learning effectiveness and motivation.

4.2 Research results

Validity analysis results. The CT-Mobile was tested for validity. Validation was conducted by two media experts and two material experts. The media aspects validated were appearance, use, and usefulness of the media, and the material aspects validated were appearance, content, learning, and evaluation. The data analysis for this study was carried out using descriptive statistical analysis techniques. Descriptive statistics to analyze the results of the questionnaire trial. Thus, the validity coefficient of the experts can qualify as a valid instrument and can be used in this study.

The validity of the CT-Mobile application depends on questionnaire data collection. Furthermore, researchers also distributed questionnaires to two validators who validated the material in the developed learning module. The validated aspects are the media and material of the CT-Mobile application presented based on the graphic design course. The assessment results of each aspect given by the validators were analyzed using Aiken's V statistical formula. The results of the validation analysis of the CT-Mobile application for graphic design courses are presented in Figures 6 and 7.

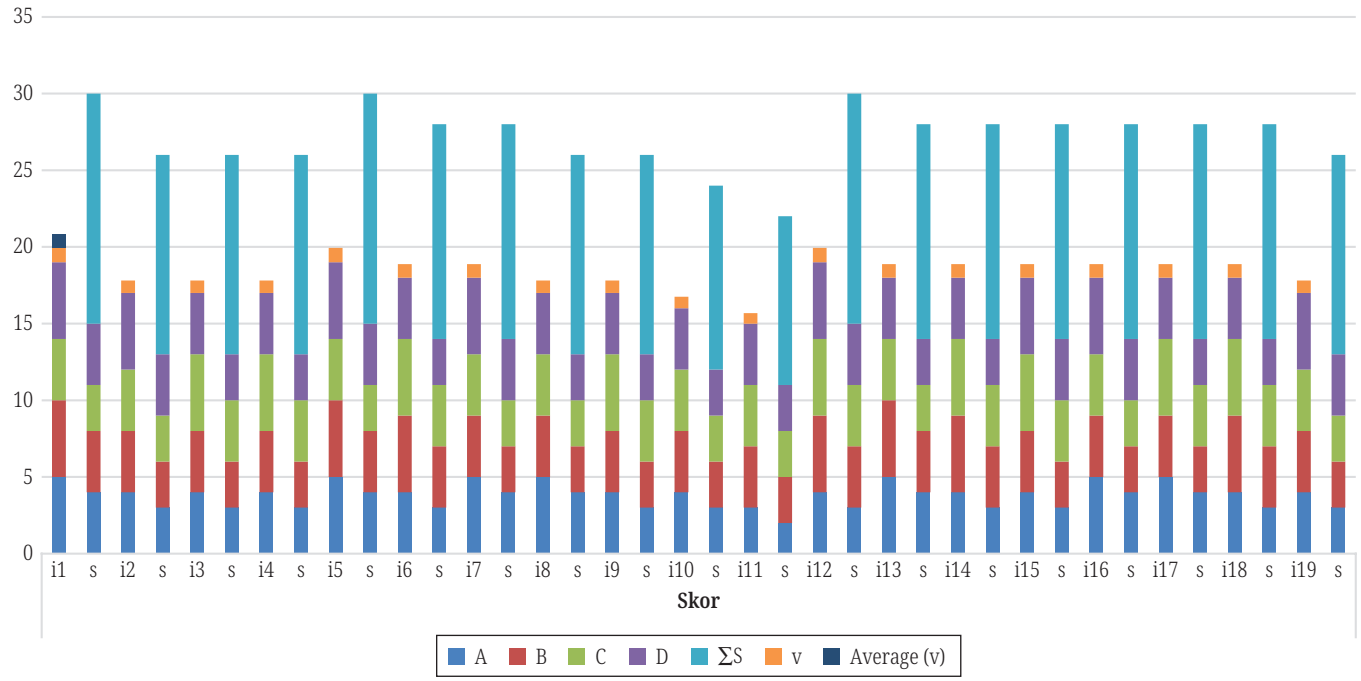

Fig. 6. Media expert validation results

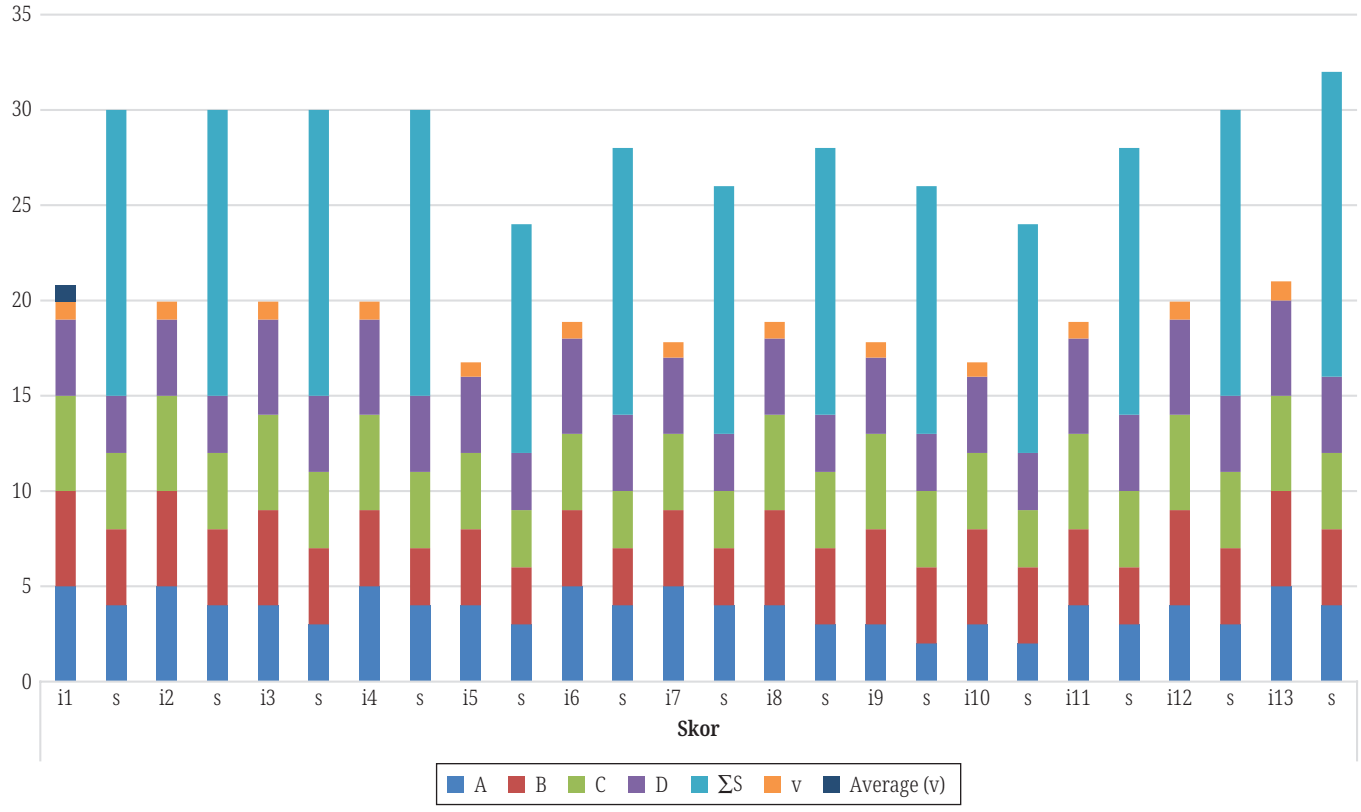

Fig. 7. Material expert validation results

The results of data analysis of the validity of the CT-Mobile application used for graphic design learning in the electrical engineering study program, Faculty of Engineering, Universitas Negeri Yogyakarta (UNY), Indonesia. Based on validation analysis data from media experts and material experts, a summary is provided in Table 7.

Table 7. Analysis results of media experts and material experts

Validator	Aiken's Coefficient V	Classification
Media validation results	0.85	Valid
Material validation results	0.88	Valid

The results of the validity test analysis for media experts obtained an average aspect of 0.85 > 0.667, so the CT-Mobile application is included in the "valid" category. Furthermore, the results of validation with material experts obtained an average of 0.88 > 0.667, so the material contained in the CT-Mobile application in graphic design lessons is declared "valid."

Practicality analysis results

Practicality analysis results based on lecturer responses. The practicality analysis focused on the responses of the lecturers, who gave their views on their assessment of the practicality of the CT-Mobile application that had been developed. The practicality test, based on the responses of lecturers teaching graphic design courses, aims to measure the effectiveness and convenience of using the CT-Mobile application. The results of the practicality evaluation conducted among the graphic design course lecturers are outlined in Table 8.

Table 8. Practicality analysis results of teacher response

Aspect	Average	Category
Ease of use of CT-Mobile	84%	Very Practical
Time efficiency	90%	Very Practical
Usefulness of CT-Mobile	95%	Very Practical
Average	89.67%	Very Practical

Based on Table 8, the average score of the practicality of the CT-Mobile application reviewed from the teacher's response reached 89.67%. The results of the learning media practicality test assessed from the teacher's response put the application in the "Very Practical" category. Therefore, it can be concluded that the results of this study show that the use of the CT-Mobile application is very useful for teachers in facilitating the graphic design learning process.

Practicality analysis results based on student responses. This analysis is rooted in student feedback, specifically aimed at assessing their perception of the practicality of the CT-Mobile application. The data obtained from the practicality test, centered on student responses, sought to measure the level of practicality in using the developed CT-Mobile application. The results of the student practicality assessment are outlined in Table 9.

Table 9. Practicality analysis results of student response

Aspect	Average	Category
Ease of use of CT-Mobile	85.78%	Very Practical
Time efficiency	85.47%	Very Practical
Usefulness of CT-Mobile	87.76%	Very Practical
Average	86.34%	Very Practical

Based on Table 9, the average score of the practicality of the CT-Mobile application based on student responses is 86.34%. The results of the data analysis led to the conclusion that this application is included in the "Very Practical" category. This data representation shows that the use of the CT-Mobile application is very helpful for students of the electrical engineering study program at Universitas Negeri Yogyakarta (UNY) in the graphic design learning process.

4.3 Discussion

The findings of this study, in conjunction with the research of [17], [18], explain the significant impact of CT-Mobile, an Android-based graphic design mobile application, in enhancing CT skills among users. The integration of computational concepts in the context of graphic design has proven to be a promising approach, encouraging a synergistic relationship between logical reasoning and creative expression. The results of this study are in line with [19], [20], showing a marked improvement in users' problem-solving ability, algorithmic thinking, and overall computational skills. College students who engaged with the mobile application [21] showed increased efficiency in tackling complex challenges, demonstrating a deeper understanding of algorithmic processes. These positive results suggest that CT-Mobile effectively contributes to the development of CT skills within the targeted user demographic. In line with [22], [23], the purposive sampling strategy in this study, which focused on students with diverse backgrounds in graphic design, educators, and professionals, enhances the external validity of these findings. The varied demographic spectrum ensured that the efficacy of the app was assessed across a range of different user profiles, making the results applicable to a wider audience within the graphic design education domain [24], [25]. In addition, discussions and feedback generated during the development stage, including collaboration with experts in the field of media and material validation, have played an important role in refining the app content and instructional videos [26]. This iterative development process has contributed to the robustness and relevance of CT-Mobile in meeting the specific needs of users engaged in graphic design learning.

The implications of this study are related to the results of [27]. The potential of implementing and developing android-based mobile learning applications can have a major impact on the broader landscape of education and technology integration. The success of the CT-Mobile in enhancing CT is not only in line with the demands of today's digital age but also underscores the importance of innovative and engaging approaches in education. Future research could explore the scalability of the CT-Mobile across different educational environments and its long-term impact on users' CT skills. In conclusion, the CT-Mobile emerges as a valuable tool at the intersection of graphic design education and CT development. The findings of this study, in line with [28], [29], contribute to the growing body of knowledge on mobile

applications in education, providing insights that can inform educators, researchers, and practitioners seeking effective strategies to enhance CT in the digital age.

5 CONCLUSION

This study explored CT-Mobile, an Android-based graphic design mobile application, and its effectiveness in enhancing users' CT skills. Integrating computational concepts into graphic design proved successful, offering a unique application for developing problem-solving and algorithmic thinking. The validity test analysis with experts categorized CT-Mobile as "valid," obtaining scores of 0.85 and 0.88 from media and material experts, respectively. In terms of practicality, teachers' responses indicated an average score of 89.67%, categorizing CT-Mobile as "Very Practical." Similarly, student responses yielded an 86.34% practicality score, placing the application in the "Very Practical" category. These results suggest the CT-Mobile application is highly beneficial for both teachers and students in graphic design learning. This study is in line with research results [30] showing notable improvements in users' CT skills, supported by efficient problem solving and a deeper understanding of algorithmic processes. The purposeful sampling [31], which involved a diverse range of participants in graphic design, enhanced the generalizability of the findings. Collaboration with experts in the field of media and material validation also enhanced the CT-Mobile, ensuring its alignment with user needs. The implications extend to education, emphasizing the role of innovative mobile applications in fostering CT skills. CT-Mobile addresses the contemporary demand for digital skills, emphasizing creative and interactive education. Along with the advancement of educational technology, CT-Mobile emerges as a promising tool to bridge technology, creativity, and cognitive skill development. In conclusion, CT-Mobile significantly contributes to graphic design education and the development of CT. The findings have the same objectives as previous studies [32]; enriching knowledge about mobile applications in education, guiding pedagogical practices, and enhancing technology-enhanced learning experiences.

6 AUTHOR CONTRIBUTIONS

(M. H): Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Software; Writing-original draft; Writing—review and editing. **(H):** Conceptualization; Data curation; Formal Analysis, Methodology; Writing—review and editing. **(R. F):** Validation; Software; Formal Analysis, Methodology; Writing—review and editing. **(Y. H):** Validation, Software; Writing—review & editing. **(R. Z):** Formal analysis; Writing—review and editing. **(V. Y. Y):** Data curation; Formal analysis; Writing—review and editing.

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