JKTP: Jurnal Kajian Teknologi Pendidikan
Vol. 9, No. 4, November 2026: 462-472
e-ISSN: 2615-8787
DOI: 10.17977/um038v9i42026p462-472
https://journal-fip.um.ac.id/index.php/jktp

# INTEGRATION OF DESIGN THINKING AND COMPUTATIONAL THINKING IN PjBL TO IMPROVE THE UNDERSTANDING OF VOCATIONAL STUDENTS

**Priscillia Andrianita Effendy, Yerry Soepriyanto, Made Duananda Kartika Degeng**
*Educational Technology, State University of Malang*
*Corresponding Author E-Mail: paeffendy@gmail.com*

**Article History**
*Received: 01 October 2026, Accepted: 29 October 2026,* ***Published: 11 November 2026***

**Abstrak**
Pembelajaran berbasis proyek di SMK sering menekankan produk akhir sehingga proses berpikir dan pemahaman peserta didik kurang terbangun. Penelitian ini bertujuan menghasilkan dan menguji desain pembelajaran berbasis proyek yang mengintegrasikan fase Design Thinking dan Computational Thinking untuk meningkatkan pemahaman konsep dan prosedural murid Desain Komunikasi Visual (DKV) pada elemen menerapkan design brief. Penelitian pengembangan ini memakai model Dick and Carey sampai langkah kesembilan. Produk berupa panduan penggunaan desain pembelajaran dan modul ajar untuk proyek rebranding UMKM, yang divalidasi ahli desain pembelajaran dan ahli materi, lalu diujicobakan secara perorangan, kelompok kecil, dan kelompok besar pada siswa kelas XI DKV. Data dikumpulkan melalui lembar validasi, angket respons, penilaian proyek, serta *pretest* dan *posttest*, kemudian dianalisis secara deskriptif, dengan paired sample t-test dan N-Gain. Hasilnya menunjukkan bahwa produk tergolong sangat valid dan sangat praktis, pemahaman siswa meningkat secara signifikan dengan kategori peningkatan tinggi, dan kualitas proyek memenuhi kriteria ketercapaian. Temuan ini mengindikasikan bahwa pemetaan fase kedua pendekatan berpikir ke dalam sintaks proyek membantu murid memahami kebutuhan klien sekaligus menata langkah kerja secara sistematis. Namun, penerapannya memerlukan alokasi waktu yang lebih longgar serta bimbingan guru.

**Kata Kunci**: *Design Thinking*; *Computational Thinking*; pembelajaran berbasis proyek; desain komunikasi visual; konsep; prosedural

***Abstract***
*Project-based learning in vocational high schools frequently prioritizes the final output, leaving students' cognitive processes and comprehension underdeveloped. To address this, this study develops and evaluates a project-based learning framework that combines Design Thinking and Computational Thinking. The goal is to enhance the conceptual and procedural understanding of Visual Communication Design (DKV) students specifically regarding the design brief element. Utilizing the Dick and Carey development model up to the ninth stage, this research produced a comprehensive learning design guide and a teaching module focused on an SME rebranding project. These materials were validated by instructional design and subject matter experts before undergoing individual, small-group, and large-group testing with eleventh-grade DKV students. Data gathered via validation sheets, questionnaires, assessments, and pretests/posttests were analyzed using descriptive statistics, paired-samples t-tests, and N-Gain. The findings reveal the developed products are highly valid and highly practical. Students' understanding improved significantly, achieving a high gain category, and their project quality successfully met the achievement criteria. Ultimately, embedding these two cognitive frameworks into the project syntax enables students to systematically organize workflows while understanding client needs, though implementation requires flexible time allocation and active teacher guidance.*

***Keywords****: Design Thinking; Computational Thinking; project-based learning; visual communication design; conceptual; procedural*

***To cite this article:***
Effendy, P. A., Soepriyanto, Y., & Degeng, M. D. K. (2026). Integration of design thinking and computational thinking in PjBL to improve the understanding of vocational students. *JKTP: Jurnal Kajian Teknologi Pendidikan*, *9*(4), 462–472. doi: 10.17977/um038v9i42026p462-472

## INTRODUCTION

The rapidly evolving creative industry demands vocational high school (VHS) graduates to possess not only technical proficiency but also the ability to think critically, be creative, collaborate, and communicate. These abilities are collectively known as the 4Cs of 21st-century skills (Indarta et al., 2021). Graduates entering an increasingly uncertain labor market need to develop creativity, collaboration, and critical thinking skills throughout their education (Habets et al., 2020; Rahayu et al., 2022). For vocational high schools institution, these demands are directly linked to curriculum alignment with the needs of industry and professional world (Industri dan Dunia Kerja, IDUKA), commonly referred to as link and match (Ahmanda et al., 2022), as well as to equipping students with the attitudes, knowledge, and skills required for employment (Sari, 2023; Tentama et al., 2024).

The Visual Communication Design (VCD) specialization is among the fields most affected by these demands. In Phase F, the 'Applying Design Briefs' element requires students to receive, read, understand, and execute written briefs provided by clients to produce appropriate visual designs. The expected learning outcome is a Brand Guidelines document or Graphic Standard Manual (GSM), which serves as a guide for the use of brand visual elements, including logos, typography, and color palettes (Aristi Putri et al., 2023). However, preliminary interviews with VCD vocational teachers revealed that many students still struggle to develop an in-depth understanding of design concepts and apply work procedures systematically. Learning activities tend to focus on the final product, leaving the thinking process and exploration of ideas largely overlooked. Consequently, students' work often lacks both conceptual strength and a well-structured design process, reflecting a gap between industry expectations and graduates' readiness for the workplace.

Project-Based Learning (PjBL) is widely used in vocational high schools because it integrates theory and practice through authentic projects while promoting critical thinking, collaboration, and problem-solving skills (Bell, 2010; Jalinus et al., 2017; Nirmayani & Dewi, 2021). The integration of PjBL with other approaches has also been reported to be associated with improvements in critical thinking skills and learning motivation (Wati et al., 2024). Nevertheless, PjBL implementation often focuses primarily on product completion without adequately guiding students through the exploratory stages and structured thinking processes that underpin the entire design process.

Previous studies have attempted to address this gap from two perspectives. The first integrates Design Thinking, an iterative, user-centered approach involving five stages: empathize, define, ideate, prototype, and test (Manjunath et al., 2023), into PjBL. Riti et al. (2021) developed a PjBL model incorporating design thinking to improve students' critical thinking skills in chemistry, while Satria and Muntaha (2022) and Aprianto (2023) investigated the application of design thinking, both in combination with PjBL and in developing creative thinking skills, within 21st-century learning. The second perspective integrates Computational Thinking, which encompasses decomposition, pattern recognition, abstraction, and algorithm design (Csizmadia et al., 2015; Yadav et al., 2016), into PjBL, as demonstrated in children's programming education (Nurhopipah et al., 2021), high school informatics education (Botutihe et al., 2024), and learning supported by interactive animation media (Deayantika et al., 2025).

The reviewed literature reveals three key observations. First, design thinking and computational thinking have generally been integrated into PjBL separately. Second, these studies have been conducted in subjects such as chemistry, informatics, and programming rather than in design education at vocational high schools. Third, the outcomes assessed have primarily focused on critical or creative thinking skills and general learning outcomes, rather than the conceptual and procedural understanding that lies at the core of VCD competencies. Therefore, there remains an opportunity to develop learning design that explicitly structures design thinking and computational thinking

processes within project stages, enabling students not only to produce design work but also to understand why and how their designs are created.

Based on the literature reviewed, the authors found no studies that integrate design thinking and computational thinking into a single PjBL syntax for VCD education in vocational high schools. The two approaches are complementary in nature. Design thinking framework guides students in understanding client needs and developing visual ideas, whereas computational thinking provides a systematic reasoning framework for decomposing problems, recognizing patterns, filtering information, and organizing work procedures. Their integration is expected to support two types of understanding essential to the design process: (1) conceptual understanding, which concerns the relationships among concepts, and (2) procedural understanding, which involves knowing how to perform tasks and the steps required to complete them. These two types of understanding are distinguished within the knowledge dimension of the revised Bloom's taxonomy (Astuti et al., 2019; Widodo, 2005). The novelty of this article lies in mapping six pairs of design thinking and computational thinking phases onto the stages of PjBL, supported by evidence of the model's validity and practicality and improvements in learning outcomes in VCD education. This study addresses three research questions: how to design a project-based learning model that integrates these two approaches, how valid and practical the resulting model is, and how students' understanding improves following its implementation in vocational high school VCD education.

The development of instructional products is a common area of research in educational technology, for example the development of flipchart media (Pratiwi et al., 2018), chat novels (Putra et al., 2022), and collaborative project-based instructional design (Vani et al., 2023). In line with this research, this article aims to present a project-based instructional design that integrates design thinking and computational thinking and to evaluate its validity and practicality, as well as its effectiveness in improving vocational high school VCD students' conceptual and procedural understanding of the Applying Design Briefs learning element.

## METHOD

This study is a research and development that is conducted based on the Dick and Carey model, a systematic instructional design model that views learners, instructors, instructional materials, and the learning environment as interrelated components (Chang, 2006; Setyawan & El Hakim, 2023). The model consists of 10 steps and this study implemented the first nine: identifying instructional goals, conducting instructional analysis, analyzing learners and contexts, formulating performance objectives, developing assessment instruments, developing instructional strategies, developing and selecting instructional materials, conducting formative evaluation, and revising the instruction. Summative evaluation was not conducted because the instructional design was tested on only one learning outcome element, namely the Applying Design Briefs element in Phase F. Therefore, only formative evaluation was considered relevant (Bacquet, 2020)..

The developed products consisted of an instructional design implementation guide, a teaching module, and student worksheets. The instructional design was implemented over eight face-to-face sessions, spanning sessions 5 through 12, through a rebranding project for a micro, small, and medium-sized enterprise product, culminating in the development of Brand Guidelines or a GSM.

The validation was conducted by two experts, comprising an instructional design expert and a subject matter expert. Following validation, the products underwent three stages of testing. The individual trial involved three students representing high, medium, and low ability levels to assess the clarity of the module's content, language, and presentation. The small-group trial involved six students to assess the preliminary effectiveness of the instruction, while the large-group trial involved all students in one class. The research participants comprised 62 eleventh-grade VCD

students from two classes, with Class XI VCD 1 (31 students) designated as the experimental class. All data analyzed in this article were obtained from this class.

The research instruments comprised validation forms for the instructional design guide (18 items) and teaching module (20 items), student response questionnaires (15 items at each trial stage), a Brand Guidelines or GSM project assessment rubric covering ten assessment criteria, and a conceptual and procedural understanding test consisting of 20 multiple-choice questions and 10 open-ended questions. The test items were developed based on the conceptual and procedural knowledge dimensions of the revised Bloom's taxonomy (Widodo, 2005). The validation forms and questionnaires employed a five-point Likert scale (Joshi et al., 2015) and included a section for suggestions to collect qualitative data. The content validity of the test items was assessed by an expert who evaluated the alignment of each item with the test blueprint, indicators, and knowledge dimensions before the items were administered in the pretest and posttest. The other instruments were also evaluated for suitability by the same expert before use. Item reliability was calculated using the Kuder–Richardson Formula 20 (KR-20) coefficient based on binary responses (correct or incorrect) from 31 students. The resulting coefficients were 0.09 for the pretest and 0.19 for the posttest, both of which indicate low reliability.

Validation and questionnaire data were analyzed by comparing the obtained scores with the maximum possible scores and expressing the results as percentages (Harpe, 2015). Practicality was calculated using the formula Kp = (total obtained score : total maximum score) × 100. Improvements in learning outcomes were analyzed using a paired-samples t-test to compare pretest and posttest scores in SPSS 25 at a significance level of 0.05. Additionally, the N-Gain was calculated by dividing the difference between the posttest and pretest scores by the difference between the maximum score (100) and the pretest score. The N-Gain criteria were classified as high (> 0.7), moderate (0.3–0.7), and low (< 0.3) (Riti et al., 2021). Project scores were compared against the achievement criterion of 80. Qualitative data comprising feedback from experts and students were analyzed descriptively and used as the basis for product revisions.

## RESULTS

The main product developed in this study is a PjBL learning syntax that integrates the design thinking and computational thinking phases into six stages, as illustrated in Figure 1.

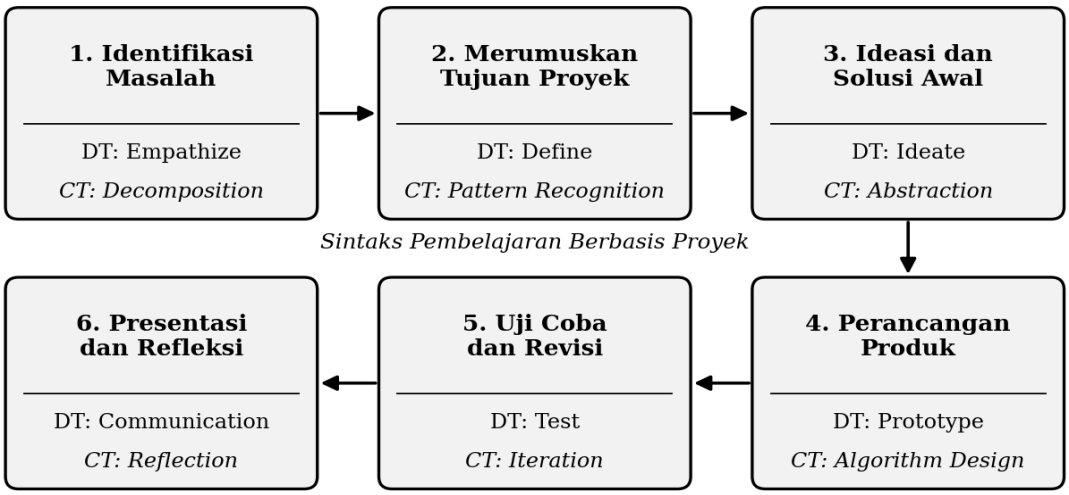



**Figure 1. Framework of the Project-Based Learning Syntax Integrating Design Thinking and Computational Thinking**

During the problem identification stage, students interview business owners, conduct online research, and observe products to understand client needs (empathize), while breaking down branding problems into smaller components (decomposition). In the project goal formulation stage, students develop key questions, brand values, and brand positioning (define), while identifying visual patterns among competitors (pattern recognition). During the ideation stage, students create concept maps, logo matrices, and preliminary sketches (ideate), while filtering key ideas and disregarding less relevant information (abstraction). The product design stage involves producing mood boards, stylescapes, digital logos, and Brand Guidelines or a GSM (prototype) through a systematically organized sequence of tasks (algorithm design). In the testing and revision stage, prototypes are evaluated based on feedback from teachers and peers and subsequently refined (test and iteration). The presentation and reflection stage concludes with the presentation of the GSM and students' self-reflection on both the process and the outcomes (communication and reflection).

The validation results are presented in Table 1. The instructional design implementation guide received a mean score of 96%, while the teaching module received 95.5%; both were classified as highly valid. The experts recommended strengthening the visual examples in the module, explaining the relationship between the design thinking and computational thinking stages more explicitly at the beginning of the guide, aligning the operational verbs with the learning outcomes, adding a student reflection section, and developing an evaluation plan for learning activities beyond face-to-face instruction. The experts also noted that the allocated time did not provide sufficient flexibility for PjBL. These recommendations served as the basis for product revisions.

**Table 1. Expert Validation Results**

| Product | 1st Validator | 2nd Validator | Average | Category |
|---|---|---|---|---|
| User guide | 94% | 99% | 96% | Very valid |
| Teaching module | 97% | 94% | 95,5% | Very valid |

Table 2 summarizes the results of the student response questionnaires. The median final scores were 93.3 for the individual trial, 88 for the small-group trial, and 89 for the large-group trial, all of which were classified as highly practical. Students were able to follow the module instructions independently, read the design brief, and begin developing ideas without direct assistance from the teacher. During the large-group trial, students began to demonstrate greater independence after the third and fourth sessions. The highest-scoring items were related to the ease of understanding the work procedures, the visual appeal of the module, and the integration of theory and practice. In contrast, lower-scoring items were related to the perceived lack of time allocated for developing the GSM.

**Table 2. Results of the student response questionnaire**

| Trial Stage | Students number | Final score median | Category |
|---|---|---|---|
| Individual | 3 | 93,3 | Very practical |
| Small group | 6 | 88 | Very practical |
| Large group | 31 | 89 | Very practical |

Pretest scores ranged from 17 to 47, with a mean of 30.55 (SD = 8.71), whereas posttest scores ranged from 67 to 97, with a mean of 86.48 (SD = 6.74). The 55.94-point increase in the mean score was statistically significant based on a paired-samples t-test, $t(30) = 41.87$, $p < 0.001$, with a pretest–posttest correlation of 0.56 ($p = 0.001$). The mean N-Gain was 0.81, indicating a high level of improvement. At the individual level, 28 of the 31 students achieved a high N-Gain category, while the remaining three achieved a moderate category (Table 3 and Figure 1).

**Table 3. Summary of Pretest and Post Test Result (n = 31)**

| Measurement | Value |
|---|---|
| Pretest average | 30,55 ±8,71 |
| Post test average | 86,48 ±6,74 |
| Average difference | 55,94 |
| Paired sample t-test | t(30) = 41,87; p < 0,001 |
| N-Gain average (category) | 0,81 (high) |

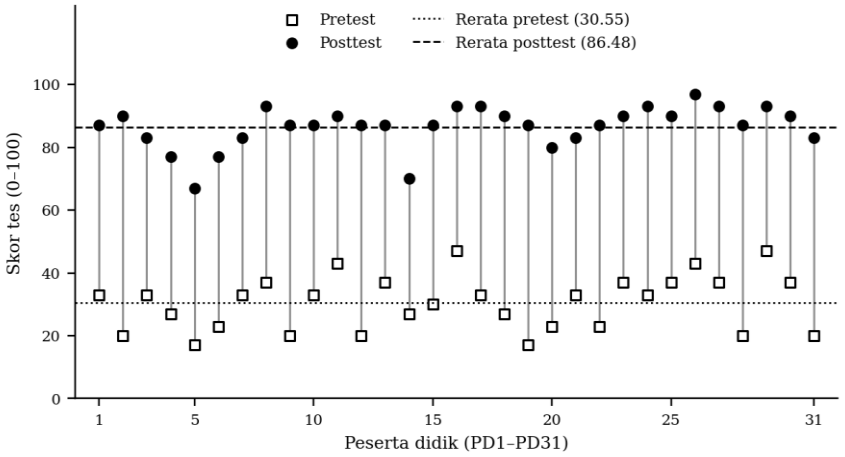



**Figure 2. Pretest and Post Test Score of Each Students (n = 31)**

In the large-group trial, Brand Guidelines or GSM project scores ranged from 75 to 85, with a mean of 81.7 (SD = 2.25) and a median of 82. A total of 27 out of 31 students (87.1%) met the mastery criterion of 80. The large-group student response questionnaire yielded a mean score of 88.7.

## DISCUSSION

The main finding of this study is that the Design Thinking and Computational Thinking phases can be paired across six stages of Project-Based Learning, allowing each project stage to serve a dual purpose: understanding user needs while structuring students' reasoning processes. This mapping goes beyond simply adding steps to the learning process. Decomposition, for instance, operationalizes empathy by requiring students not only to collect information about the business, but also to break it down into brand values, target audiences, and product characteristics (Zulfa & Andriyani, 2023). Abstraction guides ideation by filtering visual ideas based on the design brief and competitor analysis (Supiarmo et al., 2022), while algorithm design ensures that prototyping follows an explicit sequence of tasks, consistent with the view of computational thinking as a scaffold for direct instruction (Lee et al., 2024). This structure addresses the initial concern that PjBL tends to prioritize the final product, as each stage requires students to demonstrate their thinking processes rather than merely submit a finished product.

The high validity scores (96% and 95.5%) indicate that the experts considered the syntax theoretically consistent, feasible for face-to-face implementation, and aligned with the workflow of industry and the professional world. The experts' recommendations focused on strengthening the existing structure rather than changing it, including adding visual examples, explaining the relationship between design thinking and computational thinking from the outset, and incorporating a reflection section. Practicality was also rated very highly across all three trial stages. The increase in student independence after the third and fourth sessions suggests that the module functioned not merely as reading material but also as a practical guide that students used to take notes, check the sequence of tasks, and evaluate their own work. This is particularly important in PjBL, which requires students to manage their own work processes. However, the item concerning the time

allocated for developing the GSM received a lower score, consistent with the experts' comments on time allocation. This suggests that the practicality of the instructional product depends, in part, on providing a sufficiently flexible schedule.

The testing and revision stage and the presentation and reflection stage need particular attention because they represent the points at which design thinking and computational thinking intersect most closely. During the testing stage, students evaluate their prototypes against user needs and refine them based on feedback. This process reflects the core of the test stage in design thinking (Ardhianto & Moniaga, 2020) and the concept of iteration in computational thinking. Classroom observations indicated that students were able to evaluate their design outcomes, revise them based on feedback from teachers and peers, and reflect on the challenges they encountered and the lessons they learned during the presentation. These iterative and reflective abilities are among the higher-order thinking skills targeted in 21st-century learning.

The increase in the mean score from 30.55 to 86.48, with an N-Gain of 0.81, indicates a substantial improvement in test scores for conceptual and procedural understanding. This finding is consistent with reports that PjBL incorporating design thinking improves critical thinking skills (Riti et al., 2021) and that PjBL employing a computational thinking approach improves learning outcomes in informatics (Botutihe et al., 2024). However, the subjects, educational levels, and outcome measures differ, meaning that the magnitude of improvement cannot be directly compared. A distinctive feature of the present instructional design is the integration of both approaches within a single syntax. Concepts such as the distinction between brand identity and brand image, the function of a creative brief, and the role of color in design can be developed through empathy and competitor analysis. Meanwhile, procedural knowledge, such as organizing the contents of brand guidelines, selecting color palettes, and creating stylescapes, is developed through the prototyping and iteration stages. Since test scores were analyzed as a combined measure, this study could not determine the extent of improvement in the conceptual and procedural dimensions separately. Dimension-specific analysis therefore remains an area for future research.

The improvement in test scores should be interpreted with caution. The one-group pretest–posttest design lacked a comparison group. Therefore, the observed improvement cannot be attributed entirely to the integration of design thinking and computational thinking. Some of the improvement may have resulted from PjBL itself, the close alignment between the test content and the instructional material, or students' familiarity with taking the same test. The low initial mean score (30.55) is also understandable, as students had not studied brand guidelines before the instructional design was implemented. This left considerable room for improvement and makes the N-Gain difficult to compare with those reported in other studies. Class XI VCD 2, which served as the comparison class, was also not analyzed in this article. Future research should compare this instructional design with conventional PjBL to isolate the specific contribution of integrating design thinking and computational thinking. In addition, the test demonstrated low reliability, with KR-20 coefficients of 0.09 for the pretest and 0.19 for the posttest. The low pretest scores and the clustering of posttest scores toward the higher end of the scale resulted in limited variation among students, potentially contributing to the low internal consistency of the test items. The observed score improvement should therefore be interpreted cautiously, and future studies should refine and pilot-test the items before administering the test.

The mean project score of 81.7, with 87.1% of students meeting the mastery criterion of 80, indicates that most students were able to apply the sequence of tasks from design brief analysis and mood board development to GSM preparation. The narrow score range (75–85) may indicate that a structured workflow helped students with varying ability levels achieve relatively consistent product

quality. However, this limited variation may also indicate that the assessment was not sufficiently discriminative in evaluating the creative quality of students' work. Assessment by industry practitioners could complement teacher assessments in future research. The finding that students engaged in projects involving real clients is also consistent with the principles of link and match between vocational education and industry (Ahmanda et al., 2022), as well as reports that PjBL fosters collaboration (Fisdausyi & Riswanto, 2023).

Several discrepancies between the instructional design and its implementation should also be noted. First, procedural mastery was uneven. Some students still struggled with arranging logo grids, positioning visual applications, and developing product mockups during the brand guidelines preparation stage, possibly due to differences in their prior abilities. Second, during the small-group trial, which lasted only one session, students showed enthusiasm but had not yet fully understood the relationship between the design thinking and computational thinking stages. The findings from this trial are therefore indicative and reinforce the experts' recommendation that this relationship be explained from the outset. Third, time was particularly constrained during the revision and final presentation stages, as authentic design processes cannot always be compressed into a limited number of sessions. This is consistent with literature noting that each stage of design thinking requires sufficient time (Riti et al., 2021). Fourth, although the module was designed to support independent work, students still relied on teacher explanations and demonstrations when engaging in abstract reasoning and digital design techniques. Students in VCD programs, whose learning activities are largely visual and practice-oriented, tend to understand concepts more readily through concrete examples than through written instructions alone. Fifth, the study involved only two classes at one school and did not include summative evaluation, limiting the generalizability of the findings.

These findings have implications for VCD teachers. The resulting syntax can serve as a framework for designing other client-brief-based projects, provided that three adjustments are made. Teachers should provide visual examples and live demonstrations before students begin working independently, allocate additional time for revision and presentation, and explain the relationship between design thinking and computational thinking from the first session. At the theoretical level, this article offers an explicit mapping of PjBL, design thinking, and computational thinking that can be further tested in other vocational subjects. The instructional product can be disseminated to teachers through training sessions, workshops organized by vocational education practitioner communities, and Subject Teacher Working Group (MGMP) forums, allowing the design to be adapted to the specific conditions of individual classrooms.

## CONCLUSION

This study developed a project-based learning design that integrates Design Thinking and Computational Thinking into a six-stage instructional syntax for teaching the Applying Design Briefs element in vocational high school VCD programs. The resulting instructional products, comprising an implementation guide and a teaching module, were classified as highly valid (96% and 95.5%, respectively) and highly practical (median questionnaire scores of 88–93.3). Test scores increased from 30.55 to 86.48 ($p < 0.001$; N-Gain = 0.81), while the mean project score of 81.7 exceeded the mastery criterion of 80. These findings indicate that the instructional design is feasible and practical, and its implementation was accompanied by substantial improvements in conceptual and procedural understanding test scores. However, given the low reliability of the test items and the absence of an analyzed comparison group, the effectiveness of the instructional design cannot yet be established conclusively. Furthermore, since the design was evaluated using a one-group study conducted at a single school, the findings cannot be generalized. VCD teachers are encouraged to adapt this instructional design by allowing more flexible time allocations and providing technical

guidance on procedural aspects. Future researchers should evaluate the design using comparison classes in broader educational contexts, refine the test items and establish their reliability, analyze conceptual and procedural understanding separately, and develop supporting digital learning media.

## REFERENCES

Ahmanda, W., Maulana, A., Murtinugraha, R. E., & Arifah, S. (2022). Implementasi Program SMK Pusat Keunggulan dilihat dari konsep 8+i link and match. *Jurnal Pendidikan Teknik Bangunan, 2*(2), 59–74. https://doi.org/10.17509/jptb.v2i2.51290

Aprianto, M. T. P. (2023). Menggali potensi kreatif melalui design thinking: Meningkatkan keterampilan berpikir kreatif dalam proses pembelajaran abad 21. *Prosiding Seminar Nasional Ilmu Pendidikan, 2*(1). https://journals.fkip.unila.ac.id/index.php/psnip/article/view/192

Ardhianto, P., & Moniaga, C. (2020). Design thinking implementation in tourism map. *Proceedings of the 1st Conference of Visual Art, Design, and Social Humanities by Faculty of Art and Design*. https://doi.org/10.4108/eai.2-11-2019.2294884

Aristi Putri, I. G. A. A., Rahmat, F. N., Fitrianto, A., & Nugroho, D. S. (2023). Perancangan brand guideline sebagai strategi promosi produk Libong Coffee. *Jurnal Pengabdian Masyarakat Progresif Humanis Brainstorming, 6*(3), 825–832. https://doi.org/10.30591/japhb.v6i3.5171

Astuti, P., Qohar, A., & Hidayanto, E. (2019). Proses berpikir siswa dalam menyelesaikan soal higher order thinking skills berdasarkan pemahaman konseptual dan prosedural. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan, 4*(1), 117. https://doi.org/10.17977/jptpp.v4i1.11910

Bacquet, J. N. (2020). Implications of summative and formative assessment in Japan – A review of the current literature. *International Journal of Education and Literacy Studies, 8*(2), 28. https://doi.org/10.7575/aiac.ijels.v.8n.2p.28

Bell, S. (2010). Project-based learning for the 21st century: Skills for the future. *The Clearing House, 83*(2), 39–43. https://doi.org/10.1080/00098650903505415

Botutihe, A. N., Manggopa, H. K., & Liando, O. E. S. (2024). Model pembelajaran berbasis proyek dengan pendekatan computational thinking untuk meningkatkan hasil belajar informatika di SMA. *Journal of Education Method and Technology (JEMTech)*, 38–45.

Chang, S. L. (2006). The systematic design of instruction. *Educational Technology Research and Development, 54*(4), 417–420. https://doi.org/10.1007/s11423-006-9606-0

Csizmadia, A., Curzon, P., Dorling, M., Humphreys, S., Ng, T., Selby, C., & Woollard, J. (2015). *Computational thinking: A guide for teachers*. Computing at School. http://eprints.soton.ac.uk/id/eprint/424545

Deayantika, N. N. C. S., Setiadi, D., Lestari, T. A., & Artayasa, I. P. (2025). Pengaruh model project based learning berbantuan media animasi interaktif terhadap computational thinking siswa. *Journal of Classroom Action Research, 7*(2), 737–743.

Fisdausyi, M. F., & Riswanto, A. (2023). Peran pembelajaran berbasis proyek dalam meningkatkan keterampilan sosial mahasiswa. *Jurnal Konseling Pendidikan Islam, 4*(1), 144–151. https://doi.org/10.32806/jkpi.v4i1.302

Habets, O., Stoffers, J., Van der Heijden, B., & Peters, P. (2020). Am I fit for tomorrow's labor market? The effect of graduates' skills development during higher education for the 21st century's labor market. *Sustainability, 12*(18), 7746. https://doi.org/10.3390/su12187746

Harpe, S. E. (2015). How to analyze Likert and other rating scale data. *Currents in Pharmacy Teaching and Learning, 7*(6), 836–850. https://doi.org/10.1016/j.cptl.2015.08.001

Indarta, Y., Jalinus, N., Abdullah, R., & Samala, A. D. (2021). 21st century skills: TVET dan tantangan abad 21. *Edukatif: Jurnal Ilmu Pendidikan, 3*(6), 4340–4348. https://doi.org/10.31004/edukatif.v3i6.1458

Jalinus, N., Nabawi, R. A., & Mardin, A. (2017). The seven steps of project based learning model to enhance productive competences of vocational students. *Proceedings of the International Conference on Technology and Vocational Teachers (ICTVT 2017)*. https://doi.org/10.2991/ictvt-17.2017.43

Joshi, A., Kale, S., Chandel, S., & Pal, D. (2015). Likert scale: Explored and explained. *British Journal of Applied Science & Technology, 7*(4), 396–403. https://doi.org/10.9734/bjast/2015/14975

Lee, H. Y., Wu, T. T., Lin, C. J., Wang, W. S., & Huang, Y. M. (2024). Integrating computational thinking into scaffolding learning: An innovative approach to enhance science, technology, engineering, and mathematics hands-on learning. *Journal of Educational Computing Research, 62*(2), 431–467. https://doi.org/10.1177/07356331231211916

Manjunath, A. A., Sohan, M. C., Anala, M. R., & Subramanya, K. N. (2023). Design thinking approach to simplify monetary transactions for the people with visual impairment. *British Journal of Visual Impairment, 41*(2), 265–285. https://doi.org/10.1177/02646196211032492

Nirmayani, L. H., & Dewi, N. P. C. P. (2021). Model pembelajaran berbasis proyek (project based learning) sesuai pembelajaran abad 21 bermuatan Tri Kaya Parisudha. *Jurnal Pedagogi dan Pembelajaran, 4*(3), 378. https://doi.org/10.23887/jp2.v4i3.39891

Nurhopipah, A., Nugroho, I. A., & Suhaman, J. (2021). Pembelajaran pemrograman berbasis proyek untuk mengembangkan kemampuan computational thinking anak. *Jurnal Pengabdian kepada Masyarakat, 27*(1), 6. https://doi.org/10.24114/jpkm.v27i1.21291

Pratiwi, M. N. D., Wedi, A., & Praherdhiono, H. (2018). Media pembelajaran standar lembar balik ilmu pengetahuan alam sekolah dasar. *Jurnal Kajian Teknologi Pendidikan, 1*(3), 195–204.

Putra, B. S., Soepriyanto, Y., & Susilaningsih. (2022). Novel chat sebagai inovasi media pembelajaran sosiologi materi bentuk interaksi sosial. *JKTP: Jurnal Kajian Teknologi Pendidikan, 5*(1), 42–51. https://doi.org/10.17977/um038v5i12022p042

Rahayu, R., Iskandar, S., & Abidin, Y. (2022). Inovasi pembelajaran abad 21 dan penerapannya di Indonesia. *Jurnal Basicedu, 6*(2), 2099–2104. https://doi.org/10.31004/basicedu.v6i2.2082

Riti, Y. U. R., Degeng, I. N. S., & Sulton, S. (2021). Pengembangan model pembelajaran berbasis proyek dengan menerapkan metode design thinking untuk meningkatkan keterampilan berpikir kritis siswa dalam mata pelajaran kimia. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan, 6*(10), 1581. https://doi.org/10.17977/jptpp.v6i10.15056

Sari, D. F. (2023). Peningkatan mutu pendidikan kejuruan pada era pembelajaran abad ke-21 untuk menjawab tantangan industri 4.0. *Sang Acharya: Jurnal Profesi Guru, 4*(1), 71–79. https://doi.org/10.25078/sa.v4i1.3234

Satria, A. B. A., & Muntaha, A. A. (2022). Inovasi pendidikan abad 21: Penerapan design thinking dan pembelajaran berbasis proyek dalam pendidikan Indonesia. *Jurnal Pendidikan Dasar, 9*(2). https://doi.org/10.20961/jpd.v9i2.59940

Setyawan, M. D., & El Hakim, L. (2023). Pengembangan desain pembelajaran matematika menggunakan model Dick and Carey pada materi bangun ruang sisi datar. *Jurnal Pendidikan Indonesia, 4*(7), 709–721. https://doi.org/10.59141/japendi.v4i7.2036

Supiarmo, M. G., Sholikin, N. W., Harmonika, S., & Gaffar, A. (2022). Implementasi pembelajaran matematika realistik untuk meningkatkan kemampuan berpikir komputasional siswa. *Numeracy, 9*(1), 1–13. https://doi.org/10.46244/numeracy.v9i1.1750

Tentama, F., Sudarsono, B., & Ghozali, F. A. (2024). Implementasi pelatihan sikap kerja, pengetahuan kerja dan keterampilan kerja siswa SMK menuju dunia kerja. *BERNAS: Jurnal Pengabdian kepada Masyarakat, 5*(3), 2108–2114. https://doi.org/10.31949/jb.v5i3.9516

Vani, K. T., Ulfa, S., & Kuswandi, D. (2023). Desain pembelajaran proyek kolaborasi menggunakan model SECI untuk bidang studi IPS. *JKTP: Jurnal Kajian Teknologi Pendidikan, 6*(1), 37. https://doi.org/10.17977/um038v6i12023p037

Wati, P., Nusantara, T., & Utama, C. (2024). Efektivitas PjBL-STEM terhadap keterampilan berpikir kritis dan motivasi belajar siswa sekolah dasar. *Cetta: Jurnal Ilmu Pendidikan, 7*(2), 126–143.

Widodo, A. (2005). Taksonomi tujuan pembelajaran. *Didaktis, 4*(2), 61–69.

Yadav, A., Hong, H., & Stephenson, C. (2016). Computational thinking for all: Pedagogical approaches to embedding 21st century problem solving in K-12 classrooms. *TechTrends, 60*(6), 565–568. https://doi.org/10.1007/s11528-016-0087-7

Zulfa, F. N., & Andriyani, A. (2023). Computational thinking in solving arithmetic sequences problems for slow learners: Single subject research. *Jurnal Pendidikan Matematika (Kudus), 6*(1), 95. https://doi.org/10.21043/jpmk.v6i1.20406