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Smart Apps Creator-Supported Project-Based Learning for Developing Fashion Design Skills in a Vocational High School

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Abstract

Fashion design skills develop through repeated cycles of drawing, feedback, and revision, yet vocational instruction often relies on teacher demonstration and evaluation of the finished product. This quasi-experimental study compared Grade XI fashion design students taught through project-based learning (PjBL) supported by a Smart Apps Creator (SAC) application, with structured peer feedback, teacher guidance, and self-assessment, with students taught through direct instruction. Two intact classes (n = 24 each) at a vocational high school in Central Java, Indonesia, took part over eight meetings. Skills were measured with a practical drawing test scored by three raters using a six-aspect rubric (post-test ICC = .98). Pre-test scores did not differ (M = 50.06 vs. 50.64, p = .690). At post-test, the experimental class scored higher (M = 82.06, SD = 6.36) than the control class (M = 53.94, SD = 6.75), $t(46) = 14.86$, $p < .001$, $d = 4.29$; a supplementary ANCOVA controlling for pre-test scores gave the same result, $F(1, 45) = 219.01$, $p < .001$, partial $\eta^2 = .83$, although the pre-test showed negative internal consistency. The experimental class reached a "good" rating across all six aspects, whereas the control class remained at the "fair" level. Because the intervention combined several components, each condition comprised a single class taught by the same teacher, and the effect was unusually large, the results should be interpreted with caution. The findings suggest that SAC can serve as a practical scaffold for feedback-rich project work in vocational fashion design.

Keywords: Smart Apps Creator, project-based learning, formative feedback, fashion design skill, vocational high school, quasi-experimental design

1. Introduction

Technical and Vocational Education and Training (TVET) prepares learners for occupations that require both technical mastery and the ability to adapt to changing workplace demands (Yusop, Rasul, Mohamad Yasin, Hashim, & Jalaludin, 2022; Silor & Silor, 2025). In the Indonesian vocational high school (*Sekolah Menengah Kejuruan*, SMK) program in Fashion Design and Production, fashion drawing is a core competence. Students must be able to draw a well-proportioned fashion figure, choose a suitable pose, render the silhouette and details of a garment, and color the drawing to make the character of the fabric visible. These are procedural skills that develop gradually, through repeated attempts, comparison with a standard, and revision.

Assessment and instruction in many vocational settings, however, remain oriented towards the finished product. Students often receive a judgment on their final drawing but little guidance during the drawing process, limiting their opportunities to correct errors in proportion, pose, or coloring before these errors become habits (Gulikers, Bastiaens, & Kirschner, 2006; Boud & Falchikov, 2007; Wang, 2024). In Indonesia, the Merdeka Curriculum already requires teachers to carry out formative assessment during learning (Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi, 2022). The problem addressed in this study is therefore not whether formative assessment is a part of the vocational curriculum, but how it can be carried out systematically in practical subjects. An analysis of secondary school teachers' teaching modules showed that the amount and quality of planned formative assessment remain uneven in practice (Azis & Ayudia, 2024).

Three related concepts frame this study, and their relationship needs to be stated explicitly. Instruction is the overall

arrangement of learning activities. Project-based learning (PjBL) is one instructional model, in which students work over an extended period on an authentic task that leads to a tangible product (Krajcik & Shin, 2014; Kokotsaki, Menzies, & Wiggins, 2016). Formative assessment is a process embedded within instruction, in which evidence of learning is gathered and used to adjust teaching and learning while it is still in progress (Black & Wiliam, 2009; Carless, 2015). Feedback is the central component of formative assessment. It provides information that helps learners see the gap between their current performance and the intended goal and what to do next (Hattie & Timperley, 2007), ideally in a form that develops their ability to judge their own work (Nicol & Macfarlane-Dick, 2006; Carless & Boud, 2018). Although assessment and feedback are often discussed together, they are distinct processes (Winstone & Boud, 2022). In this study, PjBL is the instructional model, and structured feedback from peers, the teacher, and the students themselves is the formative assessment mechanism built into its project stages.

PjBL is well suited to vocational education because it situates learning in authentic tasks (Guo, Saab, Post, & Admiraal, 2020; Syahril et al., 2022). Studies have reported positive effects of PjBL on students' creativity and engagement (Basri, Salija, Baa, & Muhammad, 2024), as well as on critical thinking, creativity, communication, and collaboration when PjBL is combined with digital media (Maasawet, 2025). A project that unfolds in stages, such as sketching, detailing, and coloring a fashion drawing, also offers natural points at which students' work can be checked and improved (Al-Kamzari & Alias, 2025; Baartman & Gulikers, 2025). Whether these opportunities are used, however, depends on how the project is organized and what support students have at each stage.

Digital technologies can provide part of this support. In Krajcik and Shin's (2014) description of PjBL, learning technologies act as scaffolds that help students carry out tasks they could not yet manage alone. Digital tools can make examples, standards, and criteria available whenever students need them and can structure how students give and receive feedback (Shute, 2008; Núñez-Solís et al., 2026). Digital formative assessment has been associated with higher motivation and achievement in general education (Sofyan, 2025), but there is little evidence on how such tools support practical, procedural skills in vocational subjects.

Smart Apps Creator (SAC) is a commercial authoring tool that allows teachers to build interactive applications by arranging pages, media, and interactions without programming, and to export them as Android, iOS, Windows, or HTML5 applications (Medianetic, n.d.). Studies in Indonesia have used SAC to develop learning media for biology (Putra, Maasawet, & Masruhim, 2021; Maasawet, Candra, Putra, & Kolow, 2023), for vocational subjects (Ni'mah & Zutiasari, 2023), including light-vehicle electrical systems (Al Farouqi, Hadromi, & Widjanarko, 2025), and have reported that the media were judged valid and practical and were associated with improved learning outcomes. Most of these studies, however, were development studies in which SAC was used primarily to deliver content, effectiveness was assessed with single-group pretest–posttest comparisons, and outcomes were mostly cognitive. To our knowledge, no study has examined SAC as a scaffold for project work and feedback in a practical vocational subject, or measured its effect on practical skills with independent raters.

This study addresses that gap by comparing PjBL supported by an SAC application, in which students received structured peer feedback, teacher guidance, and self-assessment opportunities at each project stage, with the direct instruction routinely used at the school, in Grade XI fashion drawing. The research question was: Do students receiving SAC-supported PjBL demonstrate higher fashion design skills than those receiving direct instruction, after accounting for their initial skill level? It was hypothesized that the experimental class would achieve higher post-test scores. The study is intended to provide evidence on the practical value of SAC in vocational fashion design classrooms rather than to test each instructional component separately.

2. Method

2.1 Research Design

This study used a quasi-experimental nonequivalent control group design with a pre-test and post-test (Shadish, Cook, & Campbell, 2002). This design was chosen because students in Indonesian vocational high schools are organized in fixed classes, so random assignment of individual students was not possible (Murnane & Willett, 2010). Two intact classes were assigned to the experimental and control conditions.

Because the groups were not randomly formed, the design cannot rule out all alternative explanations for differences between them (Anglin, Liu, & Wong, 2024; Cham, Lee, & Migunov, 2024). To reduce these threats, baseline equivalence was assessed using demographic characteristics and pre-test scores, pre-test scores were used as a covariate in a supplementary analysis, and the drawings were scored by three raters, two of whom were from other schools, after student names had been replaced with codes.

2.2 Participants

Participants were all 48 Grade XI students in two intact Fashion Design and Production classes at a vocational high school

in Central Java, Indonesia, during the 2025/2026 academic year. One class (n = 24) was assigned to the experimental condition and the other (n = 24) to the control condition. No students were excluded. Gender, type of junior high school attended, and prior sewing or design experience were recorded with a brief identity questionnaire completed at the pre-test. Most participants were female, and most had no prior sewing or design experience outside school (Table 2).

Both classes were taught by the same fashion design teacher, who had more than five years of experience with project-based learning and was familiar with digital learning tools, which is an important condition for integrating technology into vocational teaching (Cattaneo, Antonietti, & Rauseo, 2022; Cattaneo et al., 2025). Having the same teacher teach both classes helped control for differences in teaching competence across classes, although the teacher knew which class received the intervention. The possible source of bias is addressed in the Limitation section.

2.3 Instructional Conditions

The study took place over eight meetings, each three lesson hours (24 lesson hours of 45 minutes). Meeting 1 was the pre-test and meeting 8 the post-test. In meetings 2 to 6, both classes studied the same content on casual womenswear in the same order: basic concepts and body proportion (8.5 head-lengths), figure pose, design elements and principles (including moodboards), silhouettes and garment parts, and coloring techniques. Meeting 7 was used to complete the drawings: students in the experimental class presented their projects, and the teacher of the control class reviewed and assessed the finished drawings. The classes differed in the instructional model, learning media, and feedback organization (Table 1).

Experimental condition. Instruction followed PjBL organized around the six design features described by Krajcik and Shin (2014): a driving question, learning goals, engagement in authentic practice, collaboration, learning technologies as scaffolds, and the creation of a tangible artefact. The driving question was: How can an attractive, well-proportioned casual-wear design that reflects fashion character be created with the support of interactive SAC media? Using SAC, the first author developed an Android application containing (a) content pages for each of the five content units, (b) an independent exercise after each unit, (c) a reference gallery and moodboard pages, (d) a Discussion and Feedback page with prompts for giving peer feedback, (e) a project guide with a stage-by-stage checklist, and (f) a self-assessment page based on the six aspects of the scoring rubric. Students worked on one individual project, a casual-wear fashion drawing, from meeting 2 to meeting 7.

Feedback was organized in repeated cycles across the project. The teacher commented on students' initial ideas (meeting 2) and draft concepts (meeting 3). Students exchanged peer feedback in small groups and pairs using the prompts in the application (meetings 3 to 5). The teacher monitored progress and gave individual guidance during sketching, detailing, and coloring (meetings 4 to 6). Then, students completed the self-assessment before presenting their finished drawings (meeting 7).

Control condition. The control class was taught with the direct instruction model typically used at the school, following the five phases described by Arends (2012): stating objectives and preparing students, demonstrating knowledge and skills, providing guided practice, checking understanding and providing feedback, and providing extended practice. In each meeting, the teacher explained the material to the whole class with PowerPoint slides and printed handouts, demonstrated the drawing steps on the board, and had students complete individual exercises on printed worksheets. From meeting 4, students worked on an individual casual-wear drawing assignment. The teacher gave feedback through question-and-answer checks, guidance during practice, written correction notes, and a review of selected finished drawings in front of the class (meeting 7). The control class did not use a driving question, project group work, structured peer feedback, self-assessment, or the SAC application.

Table 1. Experimental-Control Research Design

Group	Pre-test	Treatment	Post-test
Experimental	✓	SAC-supported PjBL with structured feedback	✓
Control	✓	Direct instruction	✓

2.4 Instrument and Scoring Procedure

Fashion design skill was measured with a practical fashion drawing test administered at pre-test and post-test. Students had 90 minutes to draw a casual womenswear design on a theme of their choice. The drawing had to include a fashion figure of 8.5 head-lengths, a pose suited to the design, complete garment details, and coloring that showed the fabric character. The post-test required a design different from the pre-test. Drawings were scored with an analytic rubric of six aspects (Appendix A): (1) body proportion, (2) figure pose, (3) garment design (silhouette and detail), (4) coloring technique, (5) creativity, and (6) neatness. Each aspect was rated on a four-point scale, from 1 (poor) to 4 (very good), using written descriptors for each level. The total score (6–24) was converted to a percentage of the maximum score (total ÷ 24 × 100), giving a possible range of 25–100.

All pre-test and post-test drawings from both classes were scored independently by three raters, including the class teacher and two fashion design teachers from other vocational schools. Before scoring, student names on the drawings were replaced with identification codes. Because the class teacher was one of the raters, however, coding might not have prevented this rater from recognizing some students' work. The raters first held a calibration session with sample drawings

to agree on the interpretation of the rubric descriptors and then scored all drawings separately, without seeing each other's scores. Each student's final score was the mean of the three raters' scores.

Inter-rater reliability was estimated with intraclass correlation coefficients based on a two-way random-effects model for absolute agreement (Koo & Li, 2016). ICCs were computed separately for the pre-test and post-test, using ratings for all 48 students. Agreement was excellent at post-test (ICC = .98, 95% CI [.96, .99], for the mean of three raters; ICC = .94, 95% CI [.90, .96], for a single rater) and moderate to good at pre-test (ICC = .78, 95% CI [.65, .87], for the mean of three raters; ICC = .55, 95% CI [.39, .69], for a single rater). Internal consistency of the six rubric aspects was good at post-test (Cronbach's α = .86) and across both occasions combined (α = .83), but was not acceptable at pre-test (α = −.60). To examine the negative pre-test value, item coding was checked (all scores ranged from 1 to 4 and no aspect was reverse-scored) and inter-aspect correlations were inspected. At pre-test, the six aspects were essentially uncorrelated (mean inter-aspect r = −.07, range −.30 to .24) and total scores varied little (SD = 1.19 on the 6–24 scale), whereas at post-test they were moderately to strongly correlated (mean r = .51). Because Cronbach's α assumes that the items reflect a single construct and depends on the variance of total scores, it is of limited use for a multidimensional rubric applied to the drawings of novices with very similar, low scores. Because the pre-test scores therefore did not form an internally consistent composite, their statistical utility as a covariate in the ANCOVA is limited; this is stated explicitly in the Limitations. The rubric is not described as reliable based on post-test statistics alone.

2.5 Data Analysis Techniques

Data were analyzed with IBM SPSS Statistics 26. Descriptive statistics (means, standard deviations, and ranges) were calculated for each group and occasion, and the demographic characteristics of the two classes were compared with Fisher's exact tests (with the Freeman–Halton extension for the 2 × 3 table), because some expected cell frequencies were small (Cohen, Manion, & Morrison, 2018).

Normality was checked with the Shapiro–Wilk test, which is appropriate for small samples (Ghasemi & Zahediasl, 2012), and homogeneity of variance with Levene's test (Field, 2024). Baseline equivalence was tested with an independent-samples *t*-test on pre-test scores.

The effect of the intervention was tested with an independent-samples *t*-test on post-test scores and checked with a supplementary one-way analysis of covariance (ANCOVA) on post-test scores with pre-test scores as the covariate, after checking the homogeneity of regression slopes, the normality and homogeneity of the residuals, linearity (by adding a quadratic pre-test term), and influential cases (Cook's distance) (Pallant, 2025; Mertler, Vannatta, & LaVenia, 2021). Effect sizes for the *t*-test were reported as Cohen's *d* and Hedges' *g*, calculated from the group means and pooled standard deviation, and partial η^2 for the ANCOVA, each with a 95% confidence interval. Learning gain was described with Hake's (1998) normalized gain, g = (post-test − pre-test) / (100 − pre-test), calculated for each student and classified as low ($g < 0.3$), medium ($0.3 \leq g \leq 0.7$), or high ($g > 0.7$). Because these categories were developed for conceptual tests, normalized gain was used only descriptively to express each student's improvement relative to the room for improvement. To show which components of fashion design skill changed, mean scores on the six rubric aspects were also compared between groups, with Holm's correction for six comparisons. The significance level was set at α = .05.

3. Results

No significant differences were observed between the two classes in the proportion of female students (79.2% vs. 62.5%; Fisher's exact test, $p = .341$), the type of junior high school attended ($p = 1.000$), or prior sewing or design experience (41.7% vs. 37.5%; $p = 1.000$) (Table 2). With samples of this size, non-significant differences do not demonstrate equivalence, but they indicate no marked imbalance between the classes on these characteristics.

Table 2. Students' Background Characteristics

Characteristics	Experimental Group (n = 24)	Control Group (n = 24)
Gender		
Female	19 (79.2%)	15 (62.5%)
Male	5 (20.8%)	9 (37.5%)
Total	24 (100%)	24 (100%)
Junior high school background		
Public junior high school	14 (58.3%)	13 (54.2%)
Private junior high school	6 (25.0%)	7 (29.2%)
Islamic junior high school	4 (16.7%)	4 (16.7%)
Total	24 (100%)	24 (100%)
Initial fashion design experience		
Have prior sewing/design experience	10 (41.7%)	9 (37.5%)
No prior experience	14 (58.3%)	15 (62.5%)
Total	24 (100%)	24 (100%)

Table 3 presents the descriptive statistics of fashion design skill scores, calculated as the mean of the three raters' scores.

Table 3. Descriptive Statistics of Fashion Design Skill Scores (Percentage of Maximum Score; Mean of Three Raters)

Group	Score Type	Mean	SD
Experimental (n = 24)	Pre-test	50.06	4.73
	Post-test	82.06	6.36
Control (n = 24)	Pre-test	50.64	5.24
	Post-test	53.94	6.75

The two classes started from almost the same level (experimental M = 50.06, SD = 4.73; control M = 50.64, SD = 5.24), and an independent-samples t-test confirmed that the difference was not significant, $t(46) = -0.40$, $p = .690$, $d = -0.12$. At post-test, the mean of the experimental class was 82.06 (SD = 6.36), whereas the mean of the control class was 53.94 (SD = 6.75). No student reached the maximum score (highest post-test score = 91.67), suggesting that ceiling effects were unlikely.

Table 4. Shapiro–Wilk Test of Normality

Group and Test	Statistic (W)	p-value
Experimental, pre-test	0.972	.717
Experimental, post-test	0.960	.433
Control, pre-test	0.932	.108
Control, post-test	0.965	.547

The Shapiro–Wilk test indicated that pre-test and post-test scores in both classes were consistent with a normal distribution (all $p > .05$; see Table 4).

Table 5. Levene's Test of Homogeneity of Variance

Test	Levene's Statistic (F)	df	p-value
Pre-test	1.193	1, 46	.280
Post-test	0.040	1, 46	.842

Levene's test showed that variances were homogeneous at both pre-test and post-test (Table 5). The assumptions for parametric analysis were therefore considered satisfied.

Table 6. Independent-Samples t-Test Results for Pre-test and Post-test Scores

Test	t	df	Sig. (2-tailed)	Mean Difference	95% CI Lower	95% CI Upper
Pre-test (baseline)	−0.401	46	.690	−0.58	−3.48	2.32
Post-test	14.859	46	< .001	28.12	24.32	31.93

The experimental class scored significantly higher than the control class at post-test, $t(46) = 14.86$, $p < .001$, with a mean difference of 28.12 points, 95% CI [24.32, 31.93] (Table 6). The effect size was d = 4.29, 95% CI [3.24, 5.32] (Hedges' g = 4.22).

A supplementary ANCOVA with pre-test scores as the covariate gave the same result. The assumption of homogeneous regression slopes was met (group × pre-test interaction, $p = .204$). After adjustment for pre-test scores, the experimental class (adjusted M = 82.10) still scored higher than the control class (adjusted M = 53.89), $F(1, 45) = 219.01$, $p < .001$, and partial $\eta^2 = .83$. Pre-test scores did not significantly predict post-test scores ($p = .473$), which is consistent with the low internal consistency of the rubric at pre-test. Because the pre-test showed negative internal consistency, the ANCOVA is reported as a supplementary check rather than as the primary test of the group difference.

In practical terms, the mean aspect scores of the experimental class reached the "good" level of the rubric (above 3 on the 1–4 scale) at post-test, whereas those of the control class remained at the "fair" level (around 2; Table 8). The effect size was very large compared with effects usually reported for educational interventions and is interpreted with caution in the Discussion section.

Table 7. Normalized Gain (Hake) by Group

Group	N	Minimum	Maximum	Mean	Std. Deviation
Experimental	24	0.28	0.83	0.64	0.14
Control	24	−0.28	0.28	0.06	0.15

The mean normalized gain of the experimental class was in the medium category (g = 0.64, SD = 0.14); 16 students had medium gains, seven had high gains, and one had a low gain. The control class had a low mean normalized gain (g = 0.06, SD = 0.15), and all control students fell in the low category (Table 7).

Table 8 presents the mean scores on the six rubric aspects. In the experimental class, mean aspect scores rose from around level 2 ("fair") at pre-test to above level 3 ("good") at post-test, whereas in the control class they remained around level 2. The experimental class scored higher than the control class on every aspect at post-test (all $p < .001$ after Holm's

correction). The largest difference was observed in coloring technique (d = 2.32), followed by figure pose (d = 2.04) and creativity (d = 2.02), and the smallest was in neatness (d = 1.56).

Table 8. Mean Rubric Aspect Scores (1–4 Scale; Mean of Three Raters)

Aspect	Exp. Pre-test	Exp. Post-test	Control Pre-test	Control Post-test	d (Post-test)
Body proportion	1.99	3.35	2.06	2.32	1.79
Figure pose	2.12	3.31	2.08	2.14	2.04
Garment design	1.89	3.22	1.99	2.18	1.89
Coloring technique	1.72	3.25	2.12	1.92	2.32
Creativity	2.10	3.31	1.92	2.11	2.02
Neatness	2.19	3.26	1.99	2.28	1.56

Note. d = Cohen's d for the post-test difference between groups; all post-test differences $p < .001$.

4. Discussion

This study found that students who learned fashion drawing through PjBL supported by an SAC application achieved substantially higher practical skill scores than students who received direct instruction. The two classes began at the same level, and a supplementary analysis controlling for pre-test scores gave the same result, although the low reliability of the pre-test limits the value of that adjustment. The results are supported by the scoring procedure, where all drawings were scored by three raters, two of whom were from other schools, after student names had been replaced with codes, and agreement between the raters at post-test was excellent.

The pattern of gains across rubric aspects suggests how the intervention may have worked. The largest differences were in coloring technique, figure pose, and creativity, the aspects for which the SAC application provided worked examples, a reference gallery, and moodboard pages that students could return to while drawing. In the control class, examples were available mainly during the teacher's demonstration and in printed handouts. This is consistent with the role of learning technologies as scaffolds in PjBL (Krajcik & Shin, 2014). In this case, students could compare their own work with a visible standard whenever they needed it rather than only when the teacher was available.

The way feedback was organized is a second likely contributor to the observed improvement. In the experimental class, students received comments on their ideas and drafts, exchanged structured peer feedback, received individual guidance, and assessed their own work against the rubric before finishing. This repeated cycle of comparison and revision reflects what formative assessment theory describes as closing the gap between current and intended performance (Black & Wiliam, 2009; Hattie & Timperley, 2007). The self-assessment and peer-feedback activities also required students to make their own judgments about quality for themselves, which is central to developing self-regulation and feedback literacy (Nicol & Macfarlane-Dick, 2006; Carless & Boud, 2018). The control class also received teacher feedback, but it was less frequent, came from one source, and did not require students to evaluate their own work. The association between specific, actionable feedback and better outcomes is consistent with a recent review of students' perceptions of teacher feedback and its outcomes (Brandmo & Gamlem, 2025).

The effect size requires careful interpretation. A standardized difference of about four standard deviations is far larger than effects usually found in educational research, including studies of creative competencies in art and design education, where Kudria, Kravtsova, Ostapchuk, Kashyrtsev, and Krasylnykova (2026) reported effects of g = 1.20–1.56. Several features of this study may have contributed to the particular results. Most students had no prior drawing experience, so there was considerable room for improvement in a short period. The post-test task closely matched the project the experimental class had just completed, and the experimental condition combined several components that differed from the control condition at the same time. The teacher's awareness of which class received the intervention may also have increased the effort invested in that class. For these reasons, the effect size observed here should not be treated as an estimate of what SAC alone can achieve.

Compared with previous studies of SAC, which were mostly development studies that evaluated SAC as a medium for delivering content and measured cognitive outcomes with single-group designs (Putra et al., 2021; Maasawet et al., 2023; Ni'mah & Zutiasari, 2023; Al Farouqi et al., 2025), this study adds evidence from a controlled comparison in which practical skills were scored by independent raters. It suggests that SAC can be used not only to present material but also to structure the stages of a practical project and the feedback that accompanies them. For vocational teachers, the practical implication is that an application built with SAC can make standards, examples, and feedback prompts continuously available to students during project work, which is difficult to achieve with demonstrations and printed materials alone.

5. Conclusion

This study found that Grade XI vocational students who learned fashion drawing through project-based learning supported by a Smart Apps Creator application, with structured feedback from peers, the teacher, and self-assessment at each project

stage, achieved higher practical fashion design skills than students facilitated through direct instruction. The difference was observed on all six aspects of the scoring rubric. Because the two classes did not differ at pre-test, this comparison does not depend on the covariate adjustment, whose value is limited by the low reliability of the pre-test. The findings indicate that SAC can serve as a practical scaffold for iterative, feedback-rich project work in vocational fashion design.

Several limitations should be noted. First, the intervention was tested as a package of project-based learning, the SAC application, and structured formative feedback; therefore, the design cannot isolate the separate contribution of SAC. Second, the same teacher taught both classes. This held teaching competence constant, but the teacher's experience with technology-supported instruction and awareness of the purposes of the study may have led to greater enthusiasm in the experimental class, so an experimenter effect cannot be ruled out. Third, although the drawings were assessed by three raters and student names were replaced with codes, one of the raters was the class teacher, who might have recognized some students' work. Fourth, the negative Cronbach's alpha of the rubric at pre-test ($\alpha = -.60$) indicates that the baseline scores did not form an internally consistent measure. This limits the statistical utility of the pre-test scores as a covariate in the ANCOVA model, so the adjusted means should be interpreted with caution; the main comparison therefore rests on the post-test t-test, given that the two classes did not differ at pre-test. Fifth, each condition was represented by a single intact class in one school. The intervention effect, therefore, cannot be fully separated from other differences between the two classes, and the student-level analyses do not account for the assignment of students to conditions as whole classes. This also limits generalizability, and the eight-meeting duration does not show whether the gains are retained. Sixth, the post-test drawing task closely resembled the project completed by the experimental class, so the results may not generalize to other fashion design tasks or competencies. Finally, the effect size ($d = 4.29$) is an outlier relative to the effects typically reported for educational interventions and should be confirmed by replication before it is used to estimate the impact of similar programs.

Future studies should compare SAC-supported and non-SAC versions of the same project-based design to isolate the contribution of the application, involve several teachers and schools, use raters who are entirely external to the participating classes, and include a delayed post-test to examine retention.

AI Usage Disclosure

During the manuscript preparation and revision, the authors used an AI-assisted tool (Claude, Anthropic) for language editing, drafting revised text, and checking statistical calculations. The authors reviewed and verified all content and analyses and take full responsibility for the findings and conclusions presented in this article.

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Author contributions

Conceptualization, Hermia Anata Rahman and Muhammad Akhyar; methodology, Hermia Anata Rahman; validation, Hermia Anata Rahman, Muhammad Akhyar, and Sukarmin; formal analysis, Hermia Anata Rahman; investigation, Hermia Anata Rahman; resources, Muhammad Akhyar and Sukarmin; data curation, Hermia Anata Rahman; writing original draft preparation, Hermia Anata Rahman; writing review and editing, Muhammad Akhyar and Sukarmin; visualization, Hermia Anata Rahman; supervision, Muhammad Akhyar and Sukarmin; project administration, Hermia Anata Rahman; funding acquisition, not applicable. All authors have read and agreed to the published version of the manuscript.

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Obtained.

Ethics approval

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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Appendix A. Analytic Rubric for Scoring Fashion Design Skill

Each aspect was rated from 1 to 4. Total score = sum of six aspects (6–24); final score = total ÷ 24 × 100.

Aspect	4 (Very good)	3 (Good)	2 (Fair)	1 (Poor)
Body proportion	Proportions of head, shoulders, waist, hips, and legs fully match the fashion-figure standard (8.5 head-lengths).	Proportions match the standard, with a minor inconsistency in one body part.	Proportions do not match the standard in several body parts.	Proportions do not match the fashion-figure standard.
Figure pose	Pose is fluid, dynamic, and suits the character of the garment design.	Pose is fairly fluid and suits the design but is less dynamic.	Pose is stiff but still shows the garment design fairly clearly.	Pose is stiff and does not support the presentation of the design.
Garment design (silhouette and detail)	Silhouette and details (design lines, cuts, accessories) are complete, clear, and proportional.	Silhouette and details are fairly complete and clear.	Silhouette is drawn, but details are incomplete or unclear.	Silhouette and details are not clearly drawn.
Coloring technique	Coloring is neat, with smooth gradation, and shows the texture or character of the fabric.	Coloring is neat, with fairly good gradation; fabric character is fairly visible.	Coloring is less neat; gradation is not smooth.	Coloring is untidy and does not show the character of the fabric.
Creativity	The design shows an original, innovative idea and does not merely copy examples.	The design develops an idea from the examples provided.	The design mostly copies examples, with little development.	The design entirely copies examples, with no development of ideas.
Neatness	The drawing is very neat and clean, with no stray marks or erasure traces, and lines are firm.	The drawing is neat, with few erasure traces or slightly unfirm lines.	The drawing is fairly neat but has several stray marks or erasure traces.	The drawing is untidy, with many stray marks or erasure traces.