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Students' Richpeace CAD Patternmaking Performance Using Digital Flipbooks: A Pretest–Posttest Study

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ABSTRACT

CAD Richpeace patternmaking requires students to perform sequential technical procedures, yet previous Richpeace learning media have been evaluated mainly in terms of feasibility and student responses rather than changes in actual practical performance. This study examined changes in students' CAD Richpeace patternmaking performance following digital flipbook-supported learning. A quantitative pre-experimental one-group pretest–posttest design was conducted with 95 second- and fourth-semester female students in the Fashion Education Study Program at Universitas Negeri Medan. Total sampling was employed, whereby all 95 students in the accessible population were included as participants. The intervention was conducted once a week for four consecutive weeks, comprising four 60-minute learning sessions. Students' performance was assessed using 15 indicators covering basic CAD operations, bodice, sleeve, and skirt pattern construction, dart manipulation, and pattern grading. Data were analyzed using descriptive statistics, the Shapiro–Wilk test, the Wilcoxon signed-rank test, normalized gain (N-Gain), and effect size. The mean performance score increased from 40.40 (SD = 6.62) at pretest to 57.76 (SD = 6.28) at posttest. The pretest–posttest difference was statistically significant ($p < 0.001$), with a large within-participant effect size ($r = 0.87$), while the mean N-Gain was 0.517 and categorized as moderate. These findings indicate that digital flipbook-supported learning was associated with higher CAD Richpeace patternmaking performance and may serve as a structured supplementary resource for practical fashion education. However, because the intervention also involved lecturer demonstrations and laboratory practice and did not include a comparison group, the observed improvement should not be attributed solely to the digital flipbook.

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INTRODUCTION

Digital transformation has increased the importance of technology-related competence in technical and vocational education and training (TVET). Current TVET development emphasizes the alignment of occupational competence with increasingly digital workplaces [1]-[4]. This transition is particularly relevant to fashion education, where Computer-Aided Design (CAD) is used for garment pattern construction, modification, grading, and production. Consequently, CAD competence in fashion

education requires more than familiarity with software functions; students must be able to translate patternmaking knowledge into accurate digital procedures and executable pattern outputs.

The development of CAD patternmaking competence involves both cognitive understanding and psychomotor performance. Ernawati et al. [5], studying 83 Fashion Design Education students, reported that students categorized as having good cognitive and psychomotor competence achieved CAD patternmaking outcome means of approximately 84, whereas those in the low categories obtained a mean of approximately 55; the differences were statistically significant ($p = 0.0005$). Kulsum [6] similarly reported improvement among 34 vocational fashion students learning pattern grading with a CAD Pattern System, with the mean knowledge score increasing by 17.0 points and the skills score increasing by 1.03 points across classroom-action-research cycles. These findings indicate that digital patternmaking instruction needs to support not only conceptual understanding but also students' ability to execute technical procedures accurately.

International research has also highlighted the educational relevance of CAD-based patternmaking in apparel education. Baytar [7] examined the recurrent use of virtual prototypes in apparel CAD patternmaking and reported development in students' software interaction, visualization, and problem-solving skills. Papachristou et al. [8] further examined CAD environments for garment development, emphasizing the relevance of suitable digital tools for supporting apparel-related design and pattern-development learning. Together, these studies reinforce the importance of combining digital technologies with structured opportunities for practical patternmaking performance.

Richpeace is one of the CAD applications used for digital garment patternmaking and grading. Previous studies have examined Richpeace through several instructional approaches, but the outcomes measured have varied considerably. Studies on the Richpeace Digital Grading System have described its implementation and students' levels of understanding and skills [9], [10]. Development studies have focused primarily on media feasibility and expert validation; for example, Richpeace grading media received material- and media-validation scores of 84.8% and 87.72%, respectively [11], while a Richpeace e-module received corresponding feasibility ratings of 97.02% and 93.63% [12]. Video- and screencast-based approaches have also been developed for CAD and Richpeace learning [13], [14], [15]. Notably, the screencast study in [13] reported a significant pretest–posttest increase among 26 learners completing a peplum-skirt patternmaking task.

Although video tutorials and screencasts can demonstrate dynamic software procedures, a digital flipbook provides a different form of procedural support. Its page-based structure enables learners to control the pace of information, remain on a particular procedural step while performing the corresponding operation in Richpeace, and return directly to a specific instruction without repeatedly locating a segment on a video timeline. Written explanations and screenshots can also remain visible while students work in the CAD environment. Therefore, the digital flipbook in this study was positioned not as a replacement for lecturer demonstration or video-based resources, but as a structured side-by-side reference during hands-on patternmaking practice.

Evidence from broader educational settings suggests that digital flipbooks can support learning outcomes and engagement when information is presented in a structured and accessible format [16]–[20]. The design of the present digital flipbook was informed by multimedia learning principles [21]. The multimedia principle was reflected in the combination of concise verbal explanations with relevant screenshots and illustrations; spatial contiguity was supported by presenting procedural instructions together with their corresponding visual information; and segmenting was implemented by organizing complex CAD procedures into sequential, learner-controlled pages. These features are particularly relevant to CAD patternmaking because students must coordinate written instructions, software tools, measurements, construction points, pattern lines, and successive procedural decisions while completing practical tasks.

Despite these developments, the literature reviewed for this study provides limited evidence of broad pretest–posttest assessment of executed CAD Richpeace performance across multiple practical competency domains within the same study. Much of the existing Richpeace literature has emphasized media feasibility, expert judgement, student responses, descriptive understanding, or performance on relatively specific patternmaking tasks [9]–[15]. Such evidence is useful for evaluating learning resources, but favorable feasibility ratings or learner perceptions do not necessarily indicate that students can accurately execute a broad range of CAD patternmaking procedures. In fashion education, this distinction is important because practical competence requires students to demonstrate software operation, garment-pattern construction, dart manipulation, and digital grading rather than merely report positive perceptions of the learning media.

Accordingly, this study examined changes in students' CAD Richpeace patternmaking performance following digital flipbook-supported learning using a 15-indicator performance assessment. Two research questions were addressed: RQ1: To what extent does students' overall CAD Richpeace patternmaking performance change from pretest to posttest following digital flipbook-supported learning? RQ2: How is the observed improvement distributed across the 15 assessed CAD Richpeace competencies? For the inferential analysis of RQ1, the null hypothesis (H0) stated that there was no statistically significant difference between students' pretest and posttest CAD Richpeace patternmaking performance, whereas the alternative hypothesis (H1) stated that a statistically significant difference existed between the two measurements. Through this approach, the study extends previous Richpeace learning-media research by focusing on measurable practical performance across multiple CAD competency domains rather than relying primarily on feasibility ratings or learner perceptions.

METHOD

A. Research Design

This study employed a quantitative pre-experimental one-group pretest–posttest design to examine changes in students' CAD Richpeace patternmaking performance following digital flipbook-supported learning. The same participants completed performance assessments before and after the learning intervention. A separate control group was not included because all students enrolled in the course were required to receive the same instructional material as part of the regular curriculum. Withholding the digital flipbook-supported learning from a subset of students would have created unequal access to the planned course content. Therefore, the findings were interpreted as within-participant changes occurring during the intervention period rather than as evidence that the digital flipbook alone caused the observed improvement. Data were analyzed using IBM SPSS Statistics Version 25. The research design is presented in Table 1.

Table 1. Research Design

Group	Pretest	Intervention	Posttest	Primary Comparison
One experimental group (n = 95)	O1: CAD Richpeace patternmaking performance	X: Digital flipbook-supported CAD Richpeace learning	O2: CAD Richpeace patternmaking performance	O2-O1; normalized gain; effect size

B. Participants and Research Setting

Ninety-five female students enrolled in the Fashion Education Study Program at Universitas Negeri Medan participated in the study. Total sampling was employed because all 95 students in the accessible population were included. The participants consisted of 50 second-semester students and 45 fourth-semester students. Information on participants' age was not collected.

The second-semester students had basic prior exposure to CAD Richpeace, whereas the fourth-semester students had more extensive prior experience with the software. Prior proficiency was not independently

measured; therefore, differences between the two semester groups were considered as a potential source of heterogeneity when interpreting the combined results.

Data collection was conducted from February to April 2026. The digital flipbook-supported learning intervention was implemented once a week for four consecutive weeks, comprising four 60-minute sessions conducted in the computer laboratory.

Table 2. OPERATIONAL DEFINITION OF STUDY VARIABLES

Variable	Role	Operational Definition	Measurement	Output
Digital flipbook-supported learning	Intervention	Structured digital learning support presenting CAD Richpeace content through sequential pages, textual explanations, screenshots, illustrations, and procedural guidance, used alongside lecturer demonstration and laboratory practice.	Implemented between pretest and posttest.	Exposure to the flipbook-supported learning intervention.
CAD Richpeace patternmaking performance	Outcome	Students' practical ability to operate CAD Richpeace tools and perform digital pattern construction, modification, dart manipulation, and grading.	15 performance indicators, each scored 1-5; total score 15-75.	Pretest score, posttest score, gain, and effect size.

C. Digital Flipbook-Supported Learning Intervention

The digital flipbook was developed from the instructional book Pola Digital & Grading Busana dengan CAD Richpeace, authored by Qothrun Nada Ma'ruf Batu Bara, Ulfa Annida Damanik, and Novialdi Ashari and published by CV Gapura Pustaka in 2026 [22]. Two authors of the present study, Qothrun Nada Ma'ruf Batubara and Ulfa Annida Damanik, were also co-authors of the source instructional material. The content was reorganized into a sequential digital flipbook format to support CAD Richpeace learning, while retaining the instructional sequence from basic software operation to garment-pattern construction and grading.

The basic software-operation component introduced tools including Intelligent Pen, Rectangle, Point, Eraser, Forfex, Snipe Curve, Add Seam, Grain Line, and Text. Students then progressed from basic tool operation to practical garment-pattern construction and modification activities. The learning material combined concise textual explanations, numerical measurements, software screenshots, illustrations, and sequential procedural instructions.

For example, the bodice-pattern section begins with entering body measurements using the Text tool and establishing a basic construction frame using the Rectangle tool before students proceed to construction points, lines, curves, darts, and completed pattern pieces. More advanced sections include dart manipulation and digital grading based on predetermined size increments and grading parameters. The page-based structure enabled students to revisit particular procedures while simultaneously operating CAD Richpeace. Instructions and their corresponding visual examples were presented together, while complex procedures were divided into sequential steps. The digital flipbook therefore functioned as a structured procedural reference rather than as a replacement for lecturer instruction.

Before implementation, the learning material was evaluated by three expert validators, all of whom judged it to be valid for instructional use. The learning material was subsequently used during the intervention. The intervention was conducted in a computer laboratory once a week for four consecutive weeks, resulting in four instructional sessions. Each session lasted approximately 60 minutes, giving a total scheduled intervention duration of approximately 240 minutes. During each session, the lecturer

demonstrated the relevant CAD Richpeace procedures and students subsequently practiced the procedures using the digital flipbook as a supporting reference.

Table 3. DIGITAL FLIPBOOK-SUPPORTED LEARNING COMPONENTS

Learning Component	**Main Content**	**Learning Function**	**Assessment Link**
Orientation / product interface	CAD Richpeace overview (Chapter I)	Introduces CAD Richpeace and familiarizes students with the digital learning environment.	Not scored
Software preparation	Installation and equipment requirements	Helps ensure that students can properly access and use the CAD Richpeace software environment.	Supporting prerequisite
Basic tool operation	Intelligent Pen, Rectangle, Point, Divider, Eraser, Forfex, Snipe Curve, Add Seam, Grain Line, Text	Develops basic operational fluency for digital patternmaking.	Indicators 1-6
Basic bodice construction	Front and back bodice pattern construction	Develops structured digital construction of the basic bodice.	Indicators 7-8
Sleeve construction	Basic sleeve pattern	Develops students' ability to construct digital sleeve patterns accurately.	Indicator 9
Skirt construction	Front and back skirt patterns	Develops students' ability to construct digital skirt patterns accurately.	Indicators 10-11
Dart manipulation and grading	Dart transfer/manipulation; size settings; grading of bodice, sleeve, and skirt	Develops advanced pattern modification and size-grading competence.	Indicators 12-15

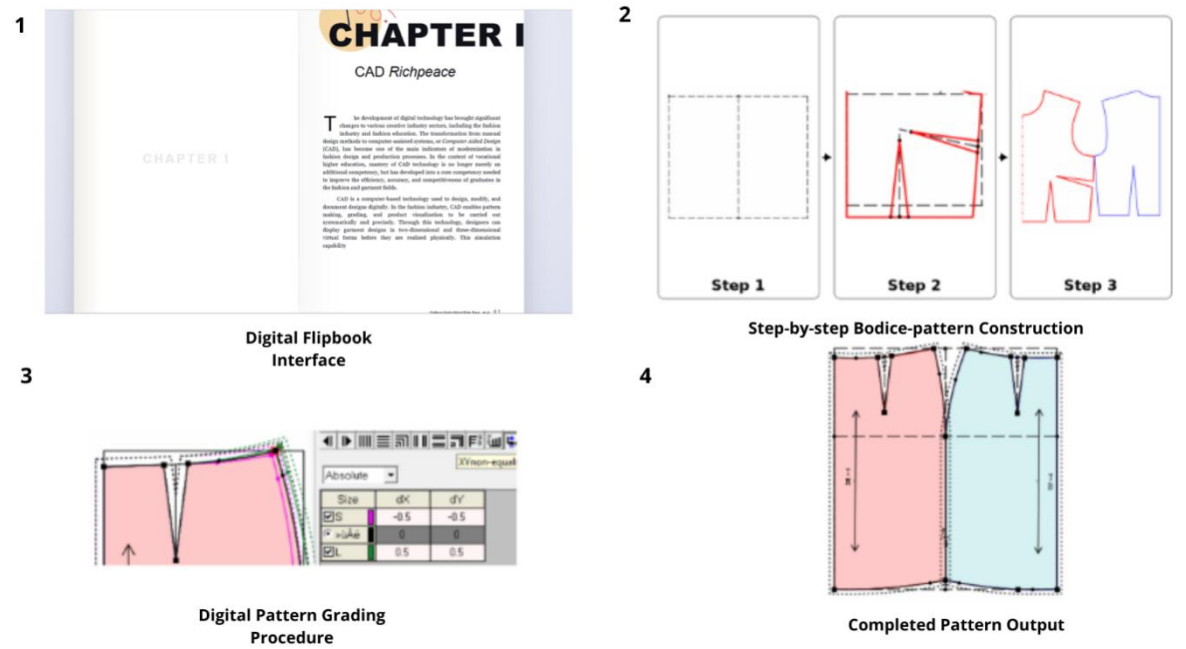


Figure 1. Examples of the digital flipbook-supported CAD Richpeace learning material: (A) digital flipbook interface, (B) step-by-step bodice-pattern construction, (C) digital pattern grading procedure, and (D) completed pattern output.

D. Research Instrument

Students' CAD Richpeace patternmaking performance was assessed using a performance-based instrument consisting of 15 indicators. The indicators were developed through direct alignment with the practical competencies represented in the instructional material and the CAD Richpeace procedures taught during the intervention. The assessed competencies covered basic software operation, bodice, sleeve, and skirt pattern construction, dart manipulation, and digital pattern grading.

The same 15 competency indicators were used at pretest and posttest. Each indicator was rated on a five-point performance scale, with higher scores representing more accurate, complete, independent, and consistent execution of the required CAD procedure. The total performance score ranged from 15 to 75.

The instrument was designed through content-to-assessment alignment between the instructional material and the practical CAD Richpeace competencies assessed in the study. However, a separate formal content-validity coefficient was not established for the 15-indicator performance instrument. Therefore, the instrument should be interpreted as a study-specific performance assessment, and future research should undertake formal content-validity testing before broader application.

The 15 performance indicators and their corresponding observable scoring focuses are presented in Table 4. The scoring focus for each indicator was used to guide the assessment of students' practical execution of the required CAD Richpeace procedures.

Table 4. CAD RICHPEACE PATTERNMAKING PERFORMANCE INDICATORS

No.	Code	Performance Indicator	Observable Scoring Focus	Scale
1	Pre1/Post1	Accuracy in entering and organizing body measurements and pattern labels using the Text tool	Correctness of measurement entries, labels, placement, and organization	1–5
2	Pre2/Post2	Accuracy in creating the basic construction frame and guidelines using the Rectangle tool	Correct dimensions, placement, and structure of the construction frame and guidelines	1–5
3	Pre3/Post3	Accuracy in positioning construction points using the Point and Divider tools	Correct location, spacing, and division of construction points	1–5
4	Pre4/Post4	Accuracy in constructing straight and curved pattern lines using the Intelligent Pen tool	Correct connection, direction, and formation of straight and curved pattern lines	1–5
5	Pre5/Post5	Accuracy in modifying and refining pattern lines and curves using editing tools	Correct modification, smoothness, and refinement of pattern lines and curves	1–5
6	Pre6/Post6	Accuracy in extracting, cleaning, and completing pattern pieces using Eraser, Forfex, Snipe Curve, Add Seam, and Grain Line tools	Correct use of the required tools to extract, clean, refine, add seam allowance, and complete pattern pieces	1–5
7	Pre7/Post7	Accuracy in constructing the basic front bodice pattern	Correct construction sequence, dimensions, pattern lines, and completeness of the front bodice pattern	1–5
8	Pre8/Post8	Accuracy in constructing the basic back bodice pattern	Correct construction sequence, dimensions, pattern lines, and completeness of the back bodice pattern	1–5
9	Pre9/Post9	Accuracy in constructing the basic sleeve pattern	Correct dimensions, construction lines, sleeve curves, and completeness of the sleeve pattern	1–5
10	Pre10/Post10	Accuracy in constructing the basic front skirt pattern	Correct dimensions, construction lines, dart placement, and completeness of the front skirt pattern	1–5
11	Pre11/Post11	Accuracy in constructing the basic back skirt pattern	Correct dimensions, construction lines, dart placement, and completeness of the back skirt pattern	1–5
12	Pre12/Post12	Accuracy in performing dart manipulation while maintaining the original pattern dimensions and balance	Correct dart manipulation while maintaining the dimensions and balance of the original pattern	1–5
13	Pre13/Post13	Accuracy in setting standard sizes, measurement increments, and grading parameters	Correct entry of standard sizes, measurement increments, and grading parameters	1–5

14	Pre14/Post14	Accuracy and consistency in grading bodice and sleeve patterns across sizes	Correct and consistent grading increments for bodice and sleeve patterns across sizes	1–5
15	Pre15/Post15	Accuracy and consistency in grading front and back skirt patterns across sizes	Correct and consistent grading increments for front and back skirt patterns across sizes	1–5

Each indicator was scored on a five-point scale using the general performance criteria presented in Table 5.

E. Performance Scoring

A general five-point performance scale was applied across all 15 indicators. Scoring was based on the observable performance criteria specified for each indicator and considered the technical correctness of the CAD procedure, accuracy of numerical input, completeness of the resulting pattern, conformity with the required construction procedure, and the degree of assistance required during task completion. For grading-related indicators, scoring additionally considered the consistency of size increments and grading parameters across pattern sizes. No separate numerical tolerance limits were established beyond the procedural and performance criteria specified in the assessment framework.

Table 5. GENERAL PERFORMANCE SCORING RUBRIC

Score	Performance Level	General Criterion
1	Very poor	Unable to perform the task or performance is mostly incorrect.
2	Poor	Major errors are present and intensive guidance is required.
3	Adequate	Task is completed with some errors and/or occasional guidance.
4	Good	Task is performed correctly and independently with only minor errors.
5	Excellent	Task is performed accurately, independently, and consistently.

Students' CAD Richpeace performance was assessed through direct observation during the practical pretest and posttest tasks. All performances were scored live by the principal researcher using the same 15-indicator performance framework and five-point scoring criteria at both measurement occasions. The assessor was aware of whether each assessment represented the pretest or posttest occasion. Because scoring was conducted by a single assessor, formal inter-rater reliability could not be established, and blinded scoring was not implemented.

F. Data Collection Procedure

Data collection was conducted from February to April 2026 and consisted of a pretest, four consecutive weekly learning sessions, and a posttest. Before the intervention, participants completed practical CAD Richpeace tasks covering the 15 assessed competencies to establish their baseline performance.

During the four-week intervention, participants attended one 60-minute laboratory session each week. In each session, the lecturer first demonstrated the relevant CAD Richpeace procedures, after which students practiced the procedures while using the digital flipbook as a structured supplementary reference. The learning activities progressed from basic software operation to bodice, sleeve, and skirt pattern construction, dart manipulation, and digital pattern grading.

Following completion of the fourth intervention session, participants completed the posttest using the **same practical CAD Richpeace tasks administered at pretest**. The same 15-indicator performance framework, five-point scoring scale, and assessment criteria were used at both measurement occasions to support direct within-participant comparison. Because identical practical tasks were administered at pretest and posttest, familiarity with the assessment procedures may have contributed to posttest performance; this potential practice effect was considered when interpreting the findings.

Table 6. Data Collection and Intervention Timeline

Stage	Timing	Main Activity	Instrument / Learning Support	Output
Pretest	Before the intervention	Participants completed practical CAD Richpeace tasks covering the 15 performance indicators	15-indicator CAD Richpeace performance instrument	Pre1–Pre15; Total_Pre
Session 1	Week 1, 60 min	Lecturer demonstration followed by flipbook-supported laboratory practice	CAD Richpeace and digital flipbook	Learning exposure
Session 2	Week 2, 60 min	Lecturer demonstration followed by flipbook-supported laboratory practice	CAD Richpeace and digital flipbook	Learning exposure
Session 3	Week 3, 60 min	Lecturer demonstration followed by flipbook-supported laboratory practice	CAD Richpeace and digital flipbook	Learning exposure
Session 4	Week 4, 60 min	Lecturer demonstration followed by flipbook-supported laboratory practice	CAD Richpeace and digital flipbook	Learning exposure
Posttest	After Session 4	Participants completed the same practical CAD Richpeace tasks administered at pretest	Same 15-indicator CAD Richpeace performance instrument	Post1–Post15; Total_Post

G. Data Analysis

Data analysis was conducted using IBM SPSS Statistics Version 25. Descriptive statistics were used to summarize students' pretest and posttest performance. Because the total performance score ranged from 15 to 75, the analysis emphasized total raw scores and mean scores per indicator rather than percentages calculated directly from the maximum score. Descriptive statistics included the mean, standard deviation, median, interquartile range, minimum, and maximum.

The distribution of the paired difference scores (posttest − pretest) was examined using the Shapiro–Wilk test. Normality was assessed on the difference scores because the inferential analysis involved paired measurements from the same participants. Statistical significance was set at $\alpha = 0.05$. Because the paired difference scores did not satisfy the normality assumption, the Wilcoxon signed-rank test was used as the primary inferential analysis to determine whether students' posttest performance differed significantly from their pretest performance. The Wilcoxon analysis was reported using the standardized test statistic (Z), positive and negative ranks, and p-value.

Because the departure from normality was relatively mild and the study included 95 paired observations, a paired-samples t-test was additionally conducted as a sensitivity analysis to examine whether the substantive conclusion was robust to the choice of paired inferential test. The Wilcoxon signed-rank test remained the primary inferential analysis. Normalized gain (N-Gain) was calculated for each participant using: $g = (\text{Posttest} - \text{Pretest}) / (75 - \text{Pretest})$. where 75 represented the maximum possible total performance score. N-Gain values were interpreted as low ($g < 0.30$), moderate ($0.30 \leq g < 0.70$), and high ($g \geq 0.70$), following Hake [23]. The distribution of N-Gain scores was summarized using the mean, median, interquartile range, minimum, maximum, and frequency of participants within each gain category. The magnitude of the within-participant pretest–posttest difference was estimated from the Wilcoxon signed-rank test using: $r = |Z| / \sqrt{N}$. where *Z* represented the standardized Wilcoxon statistic and *N* represented the number of paired participants (N = 95). Effect-size values of approximately 0.10, 0.30, and 0.50 were interpreted as small, medium, and large, respectively, following Cohen [24]. The effect size represents the magnitude of the within-participant difference and should not be interpreted as an isolated causal effect of the digital flipbook-supported learning intervention.

Table 7. DATA ANALYSIS PROCEDURES

Analysis	Purpose	Variable / Input	Decision / Formula	Reported Output
Descriptive statistics	Summarize pretest and posttest performance	Total_Pre, Total_Post, and indicator scores	Mean, SD, median, IQR, minimum, and maximum	M, SD, Median, IQR, Min, Max
Normality test	Assess distribution of paired differences	Total_Post − Total_Pre	Shapiro–Wilk test on paired difference scores	W, p
Primary paired comparison	Test pretest–posttest performance difference	Total_Pre vs. Total_Post	Wilcoxon signed-rank test	Z, positive ranks, negative ranks, p

Sensitivity analysis	Examine robustness of the paired comparison	Total_Pre vs. Total_Post	Paired-samples t-test	Mean difference, t, df, p, 95% CI
Normalized gain	Quantify improvement relative to available score headroom	Pretest, posttest, maximum score = 75	g = (Post − Pre) / (75 − Pre)	Mean, median, IQR, range, gain category
Effect size	Estimate magnitude of within-participant change	Wilcoxon test result	r = |Z| / √N, N = 95	r and interpretation

RESULTS AND DISCUSSION

Results

A. Overall Change in CAD Richpeace Patternmaking Performance

All 95 students in the accessible population provided complete pretest and posttest performance data and were included in the paired analysis. No participant was excluded from the final analysis. As presented in Table 8, the mean total performance score increased from 40.40 (SD = 6.62) at pretest to 57.76 (SD = 6.28) at posttest. Because the performance instrument consisted of 15 indicators scored from 1 to 5, the corresponding mean score per indicator increased from 2.69 to 3.85. The mean within-participant increase was 17.36 points (SD = 2.62) on the 15–75 total-score scale, equivalent to an average increase of approximately 1.16 points per indicator.

Although the paired difference scores were not normally distributed, the mean difference and its 95% confidence interval are retained as complementary descriptive information because of the relatively large sample size (n = 95). The mean increase was 17.36 points (95% CI: 16.82–17.89). Non-parametric descriptive statistics showed a median pretest score of 40.00 (IQR = 36.00–44.00), a median posttest score of 58.00 (IQR = 53.00–62.00), and a median within-participant increase of 17.00 points (IQR = 16.00–19.00).

Table 8. DESCRIPTIVE STATISTICS OF PRETEST AND POSTTEST PERFORMANCE

Measure	N	Mean	SD	Median	IQR	Min	Max	Mean per indicator
Pretest	95	40.40	6.62	40.00	36.00–44.00	26	58	2.69
Posttest	95	57.76	6.28	58.00	53.00–62.00	43	70	3.85
Difference	95	17.36	2.62	17.00	16.00–19.00	11	23	1.16

All 95 participants obtained higher posttest than pretest total scores, with individual increases ranging from 11 to 23 points. Thus, the direction of change was consistent across the analyzed participants. However, because performance was scored live by a single assessor who was aware of the measurement occasion, this uniform direction of change should be interpreted cautiously and should not be regarded as evidence that the learning intervention alone produced the observed increase.

B. Normality and Paired Comparison of Pretest and Posttest Performance

Because the pretest and posttest measurements were obtained from the same participants, normality was examined for the paired difference scores rather than for the pretest and posttest distributions separately. The Shapiro–Wilk test indicated a statistically significant but relatively mild departure from normality ($W = 0.968$, $p = 0.020$). Accordingly, the Wilcoxon signed-rank test was retained as the primary inferential analysis.

The Wilcoxon signed-rank test showed that posttest performance was significantly higher than pretest performance ($Z = -8.487$, $p < 0.001$). There were 95 positive differences, no negative differences, and no ties, with a positive rank sum of 4560.00 and a negative rank sum of 0.00.

The corresponding effect size was calculated as $r = |Z| / \sqrt{N}$, where N represented the 95 paired participants. The resulting effect size was $r = 0.87$, exceeding Cohen's 0.50 benchmark for a large effect. This value describes the magnitude of the within-participant pretest–posttest difference and should not be interpreted as an isolated estimate of the causal effect of the digital flipbook-supported learning intervention because the study did not include a comparison group.

Table 9. Normality and Paired-Comparison Results

Analysis	Statistic	N/df	p-value	Interpretation

Shapiro–Wilk test of difference scores	W = 0.968	95	0.020	Difference scores deviate from normality
Wilcoxon signed-rank test	Z = −8.487; T+ = 4560; T− = 0	95	< 0.001	Posttest performance significantly higher than pretest
Effect size	r = 0.87	95	—	Large within-participant effect
Paired-samples t-test, sensitivity analysis	t = 64.645	df = 94	< 0.001	Same substantive conclusion

As a sensitivity analysis, a paired-samples t-test was also conducted because the departure from normality was relatively mild and the sample size was 95. The analysis produced the same substantive conclusion, $t(94) = 64.645$, $p < 0.001$, with a mean difference of 17.36 points (95% CI: 16.82–17.89). Therefore, the finding of higher posttest performance was not dependent on the choice between the Wilcoxon signed-rank test and the paired-samples t-test.

C. Normalized Gain of CAD Richpeace Performance

Normalized gain was calculated for each participant to describe the amount of improvement relative to the maximum attainable score. The mean N-Gain was 0.517 (SD = 0.107), while the median was 0.512 (IQR = 0.451–0.571). Individual N-Gain values ranged from 0.273 to 0.800. Using Hake's criteria, two participants (2.1%) were classified in the low-gain category, 86 (90.5%) in the moderate-gain category, and seven (7.4%) in the high-gain category. Thus, the distribution was strongly concentrated in the moderate-gain range.

Table 10. DISTRIBUTION OF N-GAIN CATEGORIES

N-Gain category	Criterion	Frequency	Percentage
Low	$g < 0.30$	2	2.1%
Moderate	$0.30 \leq g < 0.70$	86	90.5%
High	$g \geq 0.70$	7	7.4%
Total	—	**95**	**100%**

With n = 95, statistical significance can be attained even for comparatively small differences; therefore, N-Gain and effect size were reported to describe the magnitude of change rather than only its statistical detectability. The N-Gain distribution should also be interpreted in relation to participants' baseline scores because the maximum possible gain for each participant decreases as the pretest score approaches the maximum score of 75.

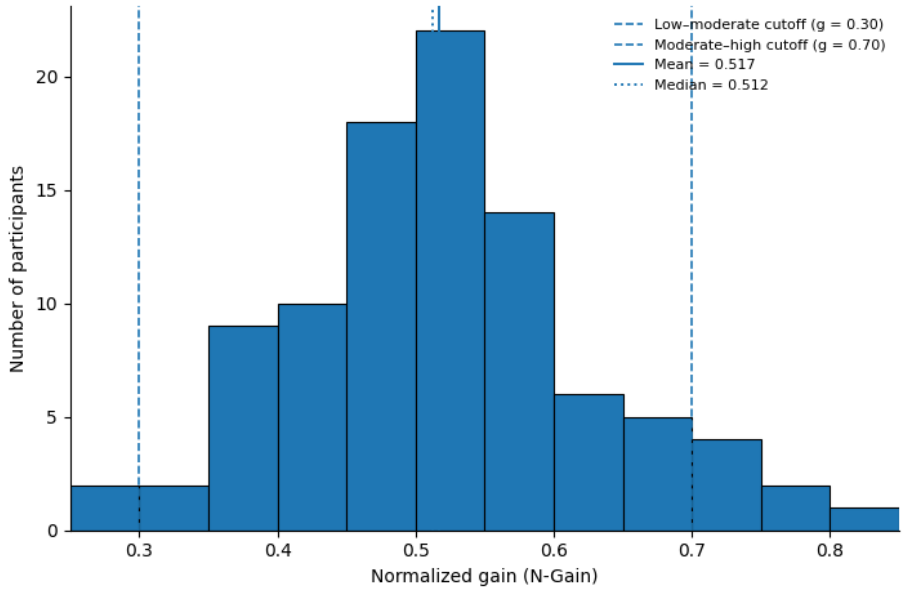


Figure 2. Distribution of participants' normalized gain (N-Gain) scores

The dashed vertical lines indicate the conventional N-Gain category thresholds (g = 0.30 and g = 0.70), while the solid and dotted lines represent the mean (0.517) and median (0.512), respectively.

D. Changes Across the 15 Performance Indicators

Table 11 shows the mean pretest and posttest scores for all 15 performance indicators. A consistent pattern of improvement was observed across the assessed competencies. Mean increases ranged from 1.00 to 1.32 points on the five-point indicator scale, while indicator-level normalized gains ranged from 0.450 to 0.576. Therefore, rather than indicating a sharply differentiated pattern in which particular competencies improved substantially more than others, the results indicate relatively uniform improvement across the 15 assessed CAD Richpeace competencies.

Table 11. PRETEST–POSTTEST PERFORMANCE BY INDICATOR

No.	Performance indicator	Pre Mean	Post Mean	Δ	N-Gain
1	Text tool and measurement labels	2.65	3.82	1.17	0.498
2	Basic construction frame	2.71	3.75	1.04	0.454
3	Point and Divider tools	2.68	3.84	1.16	0.500
4	Intelligent Pen lines and curves	2.71	3.85	1.15	0.500
5	Editing and curve refinement	2.62	3.74	1.12	0.469
6	Pattern extraction and completion	2.84	3.84	1.00	0.463
7	Basic front bodice pattern	2.73	3.87	1.15	0.505
8	Basic back bodice pattern	2.68	3.85	1.17	0.505
9	Basic sleeve pattern	2.76	3.98	1.22	0.545
10	Basic front skirt pattern	2.62	3.79	1.17	0.491
11	Basic back skirt pattern	2.71	3.98	1.27	0.555
12	Dart manipulation	2.64	3.80	1.16	0.491
13	Size and grading parameter settings	2.59	3.67	1.08	0.450
14	Bodice and sleeve grading	2.75	3.94	1.19	0.528
15	Front and back skirt grading	2.72	4.03	1.32	0.576

Although numerical variation was observed across the 15 performance indicators, the differences in indicator-level gains were relatively small and were not subjected to inferential comparison. Therefore, the observed variation should not be interpreted as evidence that particular competencies improved significantly more or less than others. Instead, the indicator-level results demonstrate a broadly consistent pattern of improvement across the assessed CAD Richpeace competencies, including basic software operation, bodice, sleeve, and skirt pattern construction, dart manipulation, and digital pattern grading. This relatively uniform pattern suggests that the post-intervention improvement was distributed across multiple components of CAD Richpeace performance rather than being concentrated in only a small number of skills.

Discussion

The findings indicate that digital flipbook-supported learning **may support** the development of CAD Richpeace patternmaking performance. Students showed higher posttest scores across all 15 assessed competencies, with a moderate mean N-Gain and a large within-participant effect size. However, these findings should be interpreted as improvement occurring during the learning period rather than as evidence that the digital flipbook alone caused the improvement, because the intervention also involved lecturer demonstrations, laboratory practice, and repeated engagement with CAD Richpeace procedures.

The present study extends previous research on Richpeace-based learning by evaluating changes in practical performance rather than focusing primarily on media feasibility or learner responses. Previous Richpeace studies in the manuscript include the development of CAD Richpeace grading media, e-modules, screencasts, and video-based learning resources [11]–[15]. In contrast, the present study assessed performance through 15 indicators spanning basic software operation, bodice, sleeve, and skirt construction, dart manipulation, and digital grading. The intervention content was explicitly linked to these competency areas, from basic tool operation through advanced pattern modification and grading. Thus, the principal contribution of this study is the use of an indicator-level

performance assessment to document broadly distributed pretest–posttest changes in executed CAD Richpeace tasks.

One possible explanation for the observed improvement concerns the way procedural information was organized in the digital flipbook. The material combined written instructions, numerical examples, screenshots, and sequential practical steps. Rather than presenting an entire CAD procedure at once, complex patternmaking processes were divided into manageable stages that students could revisit while operating the software. This structure is consistent with the segmenting principle, while the placement of procedural explanations alongside corresponding screenshots is consistent with the spatial contiguity principle of multimedia learning [21]. The combination of verbal instructions and relevant visual representations also reflects the multimedia principle. These design features are particularly relevant to CAD patternmaking because students must coordinate software commands, body measurements, construction points, lines, curves, pattern components, and grading parameters during the same practical task.

The instructional material itself illustrates this procedural organization. For example, bodice construction begins with entering measurements using the Text tool and creating a construction frame with the Rectangle tool before proceeding to points, lines, curves, darts, and completed pattern components. The grading section similarly progresses from establishing standard size information to entering specific grading parameters for bodice, sleeve, and skirt patterns. Such organization may allow students to keep a particular procedural step available while carrying out the corresponding operation in CAD Richpeace. However, because students' cognitive processing was not directly measured in this study, this explanation should be regarded as a plausible interpretation rather than a confirmed learning mechanism.

The findings can also be considered alongside other forms of digital support for CAD patternmaking. Previous studies cited in this manuscript have used screencast and video-based media to demonstrate patternmaking procedures [13], [14], [15]. Compared with a continuous video sequence, a paginated digital resource offers a different form of procedural access: learners can remain on a particular page, repeatedly inspect numerical values or tool locations, and move directly between specific procedural steps. Accordingly, the digital flipbook should not be interpreted as inherently superior to video or screencast instruction. Rather, it represents a complementary format that may be useful as a side-by-side reference while students operate CAD Richpeace.

This interpretation is also consistent with research on digital flipbooks in other educational settings. Previous studies cited in the manuscript reported associations between flipbook-based learning and improved learning outcomes [17], [18], while digital flipbooks have also been developed for vocational learning contexts [16]. The present study adds a more practice-oriented perspective by examining CAD Richpeace performance using a multi-indicator practical assessment rather than relying only on perceptions of the learning media. This performance-oriented emphasis also complements previous CAD patternmaking research that examined students' learning attitudes [25], by extending the focus toward the execution of practical CAD competencies.

From a practical perspective, the findings support positioning the digital flipbook as a supplementary instructional resource rather than as a replacement for lecturer demonstrations, guided practice, corrective feedback, and repeated software use. In this study, the flipbook was used alongside lecturer demonstration and laboratory practice, and the observed mean N-Gain of 0.517 reflects moderate within-participant improvement during this combined learning process. In an actual CAD Richpeace course, the material may be used as preparation before laboratory practice, as an in-laboratory procedural reference while students perform specific CAD procedures, and as a remediation resource when students need to repeat or review a procedure after experiencing difficulty.

The indicator-level findings further support this interpretation. Although numerical differences were observed among the 15 indicators, the range of normalized gains was relatively narrow and no inferential comparison among indicators was conducted. Therefore, the results do not support the conclusion that particular competencies were statistically more difficult or improved significantly more than others. Instead, the main pattern was broadly distributed improvement across basic tool operation, garment-pattern construction, dart manipulation, and grading. Future development of the learning material may nevertheless incorporate additional annotated examples, error-checking guidance, and short practice activities, but these improvements should be treated as instructional design

recommendations rather than conclusions derived from statistically significant differences among the indicators.

Several limitations should be considered. First, the one-group pretest–posttest design did not include a comparison group; therefore, alternative explanations such as lecturer demonstrations, repeated laboratory practice, testing effects, or students' natural learning progress cannot be separated from the contribution of the digital flipbook. Second, the same practical CAD Richpeace tasks were administered at pretest and posttest. Consequently, familiarity with the task procedures may have contributed to the higher posttest scores, and a practice or testing effect cannot be ruled out. Future studies should consider using equivalent but non-identical task forms to reduce this potential source of bias. Third, students' performance was scored live by the principal researcher during both the pretest and posttest. Because a single assessor conducted all scoring and was aware of the measurement occasion, blinded assessment and formal inter-rater reliability were not available. Consequently, potential assessor-related measurement bias cannot be completely excluded. Fourth, individual exposure to the digital flipbook was not systematically logged; consequently, the study cannot determine whether students who accessed or reviewed the material more frequently achieved greater gains. Fifth, the sample combined 50 second-semester students with basic prior CAD Richpeace experience and 45 fourth-semester students with more extensive prior CAD Richpeace experience. This heterogeneity may have influenced baseline performance and the amount of improvement available to individual students. Finally, the posttest assessed relatively immediate performance following the four-week intervention and did not examine long-term retention or transfer to new patternmaking tasks. Future research should therefore use a comparison or wait-list group, employ multiple or blinded assessors and establish scorer reliability, track students' use of the digital resource, analyze prior-experience groups separately, use equivalent but non-identical pretest and posttest tasks, and include delayed or transfer assessments.

CONCLUSION

This study examined changes in students' CAD Richpeace patternmaking performance following digital flipbook-supported learning using a one-group pretest–posttest design. Among 95 participants, the mean total performance score increased from 40.40 (SD = 6.62) at pretest to 57.76 (SD = 6.28) at posttest. The pretest–posttest difference was statistically significant ($p < 0.001$), with a large within-participant effect size ($r = 0.87$), while the mean N-Gain of 0.517 indicated a moderate level of improvement. Higher posttest performance was observed broadly across the 15 assessed competencies, including basic CAD operation, bodice, sleeve, and skirt pattern construction, dart manipulation, and digital grading.

The findings indicate that digital flipbook-supported learning was associated with higher CAD Richpeace patternmaking performance and may serve as a supplementary resource for procedural learning in fashion education. However, because the intervention also involved lecturer demonstrations and laboratory practice, used identical pretest and posttest tasks, relied on live scoring by a single non-blinded assessor, and did not include a comparison group, the observed changes should not be attributed solely to the digital flipbook. Future research should employ controlled or quasi-experimental designs, use equivalent but non-identical assessment tasks, involve multiple or blinded assessors with established scorer reliability, monitor students' actual use of the digital resource, and include delayed or transfer assessments to examine retention and generalization of performance.

AUTHOR CONTRIBUTIONS

Qothrun Nada Ma'ruf Batubara: Conceptualization, Methodology, Formal Analysis, Writing – Original Draft. Ulfa Annida Damanik: Conceptualization, Methodology, Formal Analysis, Writing – Original Draft. Yudhistira Anggraini: Writing – Review & Editing. Halimul Bahri: Writing – Review & Editing. All authors contributed to the revision of the manuscript and approved the final version.

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