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Enhancing design skills in art and design education

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Introduction: In art and design education, design-based learning (DBL) is crucial for students' design skills enhancement. Moreover, students' motivation plays a significant role in their creative performance in design education. Therefore, this study aimed to explore the impact of students' DBL and motivation on their design skills development in art and design education.

Methods: Notably, 207 University students participated in the current experimental research. With the help of nonrandom sampling, the experimental group (102) and the control group (105) were divided. The experimental group was given the treatment with DBL and the control group with the traditional instructions.

Results and discussion: The findings showed that experimental students who were treated by the DBL performed better in design skills assessment than those who were given traditional instructions. However, no gender difference was found in the analysis of covariance in the design skills assessment. Students' motivation, such as intrinsic motivation, achievement motivation, and failure-avoidance motivation also have significant impacts on their design skills development. These research findings encouraged educators to be able to use the DBL technique in their design skills instructions.

KEYWORDS

design-based learning, design skills, motivation, art and design education, experimental research

1 Introduction

Challenges in art and design education emphasize hands-on learning as the most effective means of mastering the principles and skills necessary for addressing complex issues. Consequently, there has been growing interest in problem-based learning (PBL) and project-oriented learning (PjBL) (Aley et al., 2024; Árki et al., 2022). Criticisms of PBL and PjBL include students struggling to bridge interdisciplinary subjects with their specific areas of expertise and overlooking the contributions of various fields to complex issues, along with a lack of grasp of fundamental disciplinary principles. Design-based learning (DBL) has evolved from these active learning approaches, incorporating learner-centered pedagogical principles (Jia et al., 2023). DBL is an instructional method grounded in constructivist principles, encouraging students to engage in authentic problem-solving experiences through design activities. Research has demonstrated effectiveness in cultivating design proficiency (Gómez Puente et al., 2015).

Design-based learning is increasingly recognized as an effective and motivating approach for cultivating 21st-century skills (Taconis et al., 2018). Design skills encompass a range of competencies such as research, communication, product creation, presentation, and reflective skills (Kadyirov et al., 2024). The research underscores the significance of motivation in fostering the development of design skills within the field of art and design. DBL has been shown to positively impact motivation in art and design education by engaging students in authentic, hands-on learning experiences (Oo et al., 2024).

The full extent of DBL that attributes within university-level art and design education remains inadequately examined. Consequently, it becomes imperative to empirically investigate DBL as an educational paradigm and its impact on students' outcomes to better understand its suitability for design disciplines. Hence, this study seeks to investigate how implementing of our DBL framework in the design process enhances the efficacy of knowledge acquisition, motivation, and design skill development among students.

2 Literature review

2.1 Design skills

Scientific findings emphasize the diverse spectrum of design skills, which include research capabilities, problem-solving, user-centered design, effective visual and verbal communication, technical proficiency, and presentation skills (Clemente et al., 2024; Kosslyn et al., 2006; Lachance et al., 2020; McKenney and Brand-Gruwel, 2023). By mastering these skills, designers can create innovative solutions that address user needs, enhance user experiences, and drive positive outcomes in various domains. In the current study, design skills are generally comprised of five sub-skills; research skills, communication skills, product-creation skills, reflective skills, and presentation skills.

Research skills, encompassing competencies such as information literacy and critical analysis, serve as the bedrock for navigating the extensive array of information resources. These skills empower individuals to sift through various sources, assess their reliability, and combine insights to make well-informed judgments (Rajvanshi and Mittal, 2021).

Communication skills, which include verbal, written, and nonverbal components, facilitate effective interaction, collaboration, and the exchange of knowledge, constituting the cornerstone of successful interpersonal relationships and teamwork (Krishnan et al., 2019).

Skills related to product creation, such as technical expertise, prototyping, and market research, are indispensable for conceiving and developing innovative and viable products. Design thinking advocates a human-centered approach to problem-solving, emphasizing empathy, ingenuity, and iterative refinement. Prototyping and market research validate concepts and ensure alignment with user preferences and market demand (Vagal et al., 2020).

Reflective skills, encompassing metacognition and self-evaluation, play a pivotal role in personal and professional growth by fostering deep learning, critical thinking, and ethical decision-making (Miciak et al., 2021). Metacognition enables individuals to monitor and regulate their cognitive processes, enhancing their capacity to learn from experience, while self-reflection promotes introspection and self-awareness, enabling individuals to identify strengths, weaknesses, and areas for improvement (Latha Lavanya, 2019).

Presentation skills are essential for effectively conveying ideas, engaging audiences, and persuasively conveying information. These competencies encompass not only clear articulation and confident delivery but also compelling storytelling techniques and audience-centric design, enabling presenters to capture attention, inspire action, and achieve their communication objectives (Curran-Everett, 2019).

2.2 The importance of motivation in design skills development

Motivation plays a pivotal role in the development of design skills, influencing various facets of the creative process and contributing significantly to the overall success and productivity of designers (Takashima and Senoo, 2020). Within the realm of research, motivation is crucial for investigating research activities and sustaining effort over time. Ho and Lee (2024) suggest that motivation influences individuals' readiness to undertake research projects, persist amidst challenges, and invest time and effort in honing research skills.

In product creation skills development, motivation similarly influences various aspects of the creative process, driving designers to initiate the product creation process and generate innovative ideas. Motivated designers are more inclined to engage in iterative design processes, solicit feedback, and refine prototypes based on user input and design criteria, ultimately leading to the production of higher-quality products (Li et al., 2024).

In communication skills development, motivation influences various facets of the learning process, contributing to improved communication proficiency. Motivated learners demonstrate a greater willingness to engage in communicative tasks, seek practice opportunities, and interact with course materials, leading to enhanced communication skills (Tanaka, 2024).

In reflective skills development, motivation plays a significant role in promoting individuals' willingness to engage in reflective practices and facilitating deeper learning and personal growth. Motivated individuals are more inclined to engage in self-reflection, seek opportunities for introspection, and actively participate in activities that promote reflective learning. Setting specific, challenging reflective goals and maintaining a sense of purpose and accountability have been shown to enhance motivation and focus in reflective practices, leading to deeper insights and learning outcomes (Tarakanov et al., 2020).

In presentation skills development within the design domain, motivation significantly influences designers' ability to effectively communicate ideas, engage stakeholders, and convey the value of their design solutions. Motivated designers, by setting specific, challenging presentation goals and maintaining a sense of purpose and accountability, enhance their motivation and focus, leading to greater skill development and performance improvement in design presentations (Takashima and Senoo, 2020).

2.3 Design-based learning

Design-based learning represents an educational methodology that integrates principles of design thinking into the learning process, with a focus on hands-on, experiential tasks where students confront genuine design dilemmas (Ladachart et al., 2023). DBL fosters active involvement, critical analysis, and problem-solving abilities by immersing students in authentic design endeavors. It highlights iterative design procedures, cooperation, and ingenuity, enabling students to apply theoretical understanding to practical scenarios and cultivate proficiencies pertinent to professional design work (Coorey, 2021).

Design-based learning places a strong emphasis on strategic planning and decision-making and navigates students to generate ideas, hands-on experiences, solutions, testing, and effective communication (Árki et al., 2022). Within the realm of art and design education, DBL draws upon pedagogical principles rooted in problem-based reasoning and project-oriented methodologies (Clemente et al., 2024).

The design elements integrated into our DBL framework originate from art-project activities conducted within university design classrooms. This framework has been formulated based on a systematic classification of design elements derived from practices observed in the costume and fashion design industry (Oo et al., 2024). These activities encompass various tasks, including exploring graphic representation, form, and the aesthetic aspects of scene costumes. This approach immerses students in authentic design tasks, fostering motivation and critical thinking. Additionally, DBL instills in students the ability to acquire and apply knowledge, and skills and encourages reflection during the construction processes (Azizan and Abu Shamsi, 2022).

The teacher's role within this framework is to facilitate learning by inspiring and sharing experiences related to addressing design-related challenges while students engage in DBL art projects. Throughout these assignments, students accumulate and apply knowledge while actively participating in artistic endeavors. Consequently, teachers pose probing questions to deepen students' understanding of design tasks, provide continuous feedback on technical design progress to enhance domain expertise and empower students by placing them at the forefront of the activity (Kadyirov et al., 2024). Acting as consultants, teachers prompt students to articulate engineering concepts during discussions and presentations, fostering reflective practices to elucidate the rationale behind technical design decisions.

The collaborative nature of learning is evident in tasks that require students to provide feedback on each other's plans or experimental outcomes and to present prototypes or final products collectively (Oo et al., 2024). This approach immerses students in authentic design tasks, fostering motivation, and critical thinking. While distinguishing DBL from similar methods may present challenges, it can be understood as an educational approach that involves students in addressing real-world design challenges while prompting them to reflect on their learning journey (Kasliwal et al., 2023). Regarding assessment, the utilization of self-created diagnostic instruments, along with observation and expert evaluation methods, enables the comprehensive evaluation of various aspects, including the level of knowledge, motivation, development of design skills, and the quality of the final product of the design activity.

2.4 Review of related findings

Studies have investigated the efficacy of DBL as an educational approach to integrating design tasks into the curriculum, in enhancing design competencies. Research by Guaman-Quintanilla et al. (2023) revealed that students immersed in DBL environments exhibited marked improvements in problem-solving capabilities, creativity, and design-thinking skills compared to conventional instructional methods. Additionally, Günzel and Brehm (2024) and Rokooei and Hall (2018) conducted research comparing the effectiveness of various instructional approaches such as studio-based learning and project-based learning. The experimental group employing inquiry methods demonstrated superior outcomes in skill acquisition than the control group. Moreover, Aggarwal (2018) explored the utilization of technology-enhanced learning environments in design education and their impact on students' design proficiencies. They found that technology proved to be effective in fostering the development of design skills. Research conducted by Zhan et al. (2023) explored the impact of integrating experimental design tasks into science education. After the treatment, the experimental group showed a significant difference in design skills compared to the control group. Additionally, two longitudinal inquiry-based projects were conducted by the same authors. Researchers changed "step-by-step" instructions into practical activities that required some stages to be designed. Results showed significant improvement in the experimental group, the control group did not show notable progress in skills development (Zhan et al., 2023). Xiang and Liu (2018) conducted comparative research investigating variations in the development of design skills among different groups and design fields, including industrial design, graphic design, and architecture. Findings indicated that groups subjected to interventions emerged as leaders in acquiring and applying skills.

A study conducted by He and Wong (2021) investigated the differences between genders in design cognition, encompassing problem-solving methodologies, idea-generation tactics, and decision-making procedures. Their research showed how male and female designers perceive, understand, and react to design challenges, offering insights into potential cognitive distinctions that could impact the development of design skills. Moreover, another study (Santos et al., 2024) stated that male students generally report higher confidence in technical and analytical skills, while female students exhibit greater confidence in communication and teamwork skills. One study examined the influence of gender stereotypes on design performance and self-assurance. Results investigated how exposure to gender-typical images and settings in design education and professional environments affects women's confidence, drive, and accomplishments in design-related assignments (Cheryan et al., 2017). Jacoby and van Ael (2021) explored methods for fostering gender equality in design education. They investigated the efficacy of teaching methods, mentorship initiatives, and diversity programs in mitigating gender inequalities and bolstering the enhancement of design skills among female learners. Another research studied the significance of representation and role models in shaping perceptions of design as a profession and career option among both male and female students. Findings examined how gender-balanced curriculums, diverse faculty representation, and the visibility of female designers influence and empower aspiring designers (Ro and Knight, 2016). Dandridge et al. (2019) alongside Bailey et al. (2020) investigated the intersectionality of gender with other identity factors, such as race, ethnicity, and socioeconomic status, in shaping individuals' sense of design identity and encounters. These studies underscored the importance of acknowledging and addressing multiple facets of identity to advance diversity and inclusivity in design education and practice.

2.5 The rationale of the study

Educational methodologies like project-based learning, PBL, and DBL have been discussed in the literature (Aggarwal, 2018; Guaman-Quintanilla et al., 2023; Günzel and Brehm, 2024; Xiang and Liu, 2018; Zhan et al., 2023), yet there remains a gap in understanding their relative effectiveness in nurturing design skills. While studies have identified gender differences in the development of design skills (Bailey et al., 2020; Dandridge et al., 2019; Jacoby and van Ael, 2021; Ro and Knight, 2016), there is still a need for comprehensive research that explores these differences across diverse design disciplines and educational contexts. Addressing these research gaps has the potential to deepen our understanding of domain-specific knowledge, motivation, and the development of design skills. Therefore, this study aimed to explore the effects of students' DBL on their design skills development. Additionally, we also investigated the relationship between students' motivation and their design skills development. Therefore, we addressed the following research questions in the current study.

> RQ1: Is there a noteworthy difference in the progression of design skills between the experimental group with DBL and the control group without DBL?

> RQ2: Are there significant differences in the development of design skills between different genders?

> RQ3: How do students' motivation predict the development of their design skills?

> RQ4: What are the predictions of variables such as group, gender, and motivation on students' design skills development?

3 Materials and methods

3.1 Participants

This research was conducted in Russia, specifically in the Republic of Tatarstan, involving 207 students in the field of Russian art and design education. The participants were selected from Kazan Federal University and Kazan State Institute of Culture using a non-random sampling method known as purposive sampling. The study focused on third-year bachelor students aged between 19 and 23 years old. The sample was randomly divided into two groups: a control group consisting of 102 students and an experimental group consisting of 105 students. In the control group, there were 27 (26.5%) boys and 75 (73.5%) girls, while in the experimental group, there were 29 (27.6%) boys and 76 (72.4%) girls. Both groups exhibited similar backgrounds, levels of knowledge, and skills.

3.2 Instruments

3.2.1 The motivation questionnaire

It is a self-developed survey comprising 20 statements designed to assess participants' inclinations toward motivation (n = 20). Respondents indicate their level of agreement or disagreement with each statement using a 5-point Likert scale. Although there are different types of motivational scales, the reason for the self-development of this questionnaire is to choose the most relevant motivational items for students' design tasks and skills. This instrument has already been validated in our pilot study with 193 students (Kadyirov et al., 2024), with acceptable reliabilities (Cronbach's α = 0.71, average variance extracted, AVE = 0.52, and composite reliability, CR = 0.87). Some items are presented as an example, "*I can work more efficiently on a task when given specific instructions and guidance, as opposed to more general directives,*" "*If something did not work out for me, I would do my best to cope with it and then move on to something that could work out well.*"

3.2.2 The control and final diagnostic sheets

It is a custom-designed tool utilized to gauge students' design skills development throughout the *Art-project Work Assignments and Requirements (ARAW)* treatment process (Oo et al., 2024). It consists of a total of 30 items, comprising 5 diagnostic sheets (25 items) aimed at assessing various design skills (including research, communication, product creation, presentation, and reflective skills), along with 1 sheet dedicated to expert evaluation of the art-project activity's outcome (5 items). The control and final diagnostic sheets (CFDS) was devised to evaluate the advancement of design skills at different phases of ARAW completion and to appraise the attributes of the final product. Its internal consistency reliability is 0.90, AVE = 0.51, and CR = 0.77. For clarity, some sample items of CFDS are described for clarity (Table 1).

3.3 Procedure

The two groups were randomly selected into the experimental and control groups. Both groups received the pre-tests of CFDS for the assessment of their initial design skills. The MCQ questionnaire also investigated their motivation.

TABLE 1 Control diagnostics of the communication skills.

Criterion	Indicator	Method	Points
1. The ability to listen and understand others	Listens and responds adequately to the students and teacher	Observation	
2. The ability to perform a monolog	Freely shares information in an understandable form with the audience	Observation	
3. The ability to evaluate emotional behavior	Understands not only his/her emotional state but also the interlocutor	Observation	
4. The ability to participate in discussion	Participates in discussions, defends his/her opinion, respects the opinions of others	Observation	
5. The ability to work in collaboration	Knows his/her role in the team working processes	Observation	

During the experimental phase, students in the experimental group engaged in the actual design process by completing three art-project assignments from the ARAW (2. Draw a sketch of the stage costume; 3. Design a model of the stage costume; and 4. Manufacture the stage costume). They worked in groups of three, systematically addressing project requirements, sketching, analyzing materials, creating models, and manufacturing costumes. The teacher provided assistance and guidance as needed, with skill assessment (research, reflective, communication, and product-creation skills) and feedback conducted using CFDS. The control group likewise undertook comparable project assignments in groups of three, with the teacher maintaining full control, as in the previous phase. The teacher conducted lectures on sketching, model creation, material selection, and costume sewing, guiding students through each step. The teacher led the activities, and students followed his instructions closely. Design skills assessment during this phase utilized the CFDS. This phase extended over the longest duration, spanning 8 weeks (with three lessons per week, each lasting 90 min) (Árki et al., 2021).

Then, experimental students presented and defended their art projects (5. Present and defend the art project work), with the assessment including expert evaluation and final diagnostics using CFDS. They were free to choose presentation formats and materials, discussing their methodologies, challenges faced, and acquired skills. Assessment of the art projects was an essential element within this DBL framework, integral to the completion of the project. This evaluation comprised an expert evaluation of the art project's outcome, along with a final assessment of research, presentation, communication, product creation, and reflective skills using the CFDS. These evaluations were conducted by the teacher to ensure the thoroughness and quality of the student's work. The control group followed a structured plan of presentation provided by the teacher, costumes and design skills were assessed using the post-test CFDS. This stage spanned 4 weeks, with classes held three times a week, each lasting 90 min. As a post-test, the students from both groups had to present their works in the class under the observation of the experts. For clarity, the whole procedure of the study for both experimental and control groups is presented in Figure 1.

4 Findings

4.1 Differences in design skills achievement between control and experimental groups

To examine the impact of PBL on the development of students' design skills, we initially assessed the initial conditions of both control and experimental groups. By utilizing the independent sample t-test, we compared both groups, revealing no significant difference ($p > 0.05$) between the experimental and control groups. The non-significant initial status of both the experimental and control groups is presented in Table 2.

Subsequently, to examine the difference in students' design skills attainment between the control and experimental groups, an analysis of covariance (ANCOVA) was employed. Initially, an analysis was conducted to verify the assumption of homogeneity of regression slopes. The results ($R^2 = 0.27$, $p = 0.957$) demonstrated that there was no interaction between factors (control and experimental groups) and the covariates (pre-test scores), indicating the fulfillment of the assumption of homogeneity of regression. In the ANCOVA (Table 3), a significant difference was observed between the groups (control and experimental), $F(1, 205) = 73.17$, $p < 0.001$. Table 4 displays the means and standard deviations for the control and experimental groups concerning design skills achievement, both before and after accounting for the impact of pre-test achievement. As evident from the table, the experimental group exposed to the DBL exhibited higher achievement ($M = 4.19$, SD = 0.42) compared to the control group without the DBL ($M = 3.71$, SD = 0.40).

We also compared the differences in each factor of design skills development between two groups of control and experimental. Significant differences ($p < 0.001$) were found in all six factors of design skills assessment between control and experimental groups. Their significant differences are shown in Figure 2. Out of six factors (research skill, reflective skill, communication skill, production skill, presentation skill, and act project skill) of students' design skills development, it was also found that students highly achieved in (communication skill) development. Students from the experimental group outperformed those from the control group in all cases of design skills assessment.

4.2 Differences in design skills achievement between genders

Then, ANCOVA was also employed to examine whether males have higher achievement in design skills assessment than females after controlling their pre-test scores differences. Results indicate that after controlling differences in their pre-test scores, there is a significant difference between males and females, $F(1, 205) = 3.88$, $p = 0.050$ (Table 5). However, the variance or effect size ($\eta^2 = 0.02$)

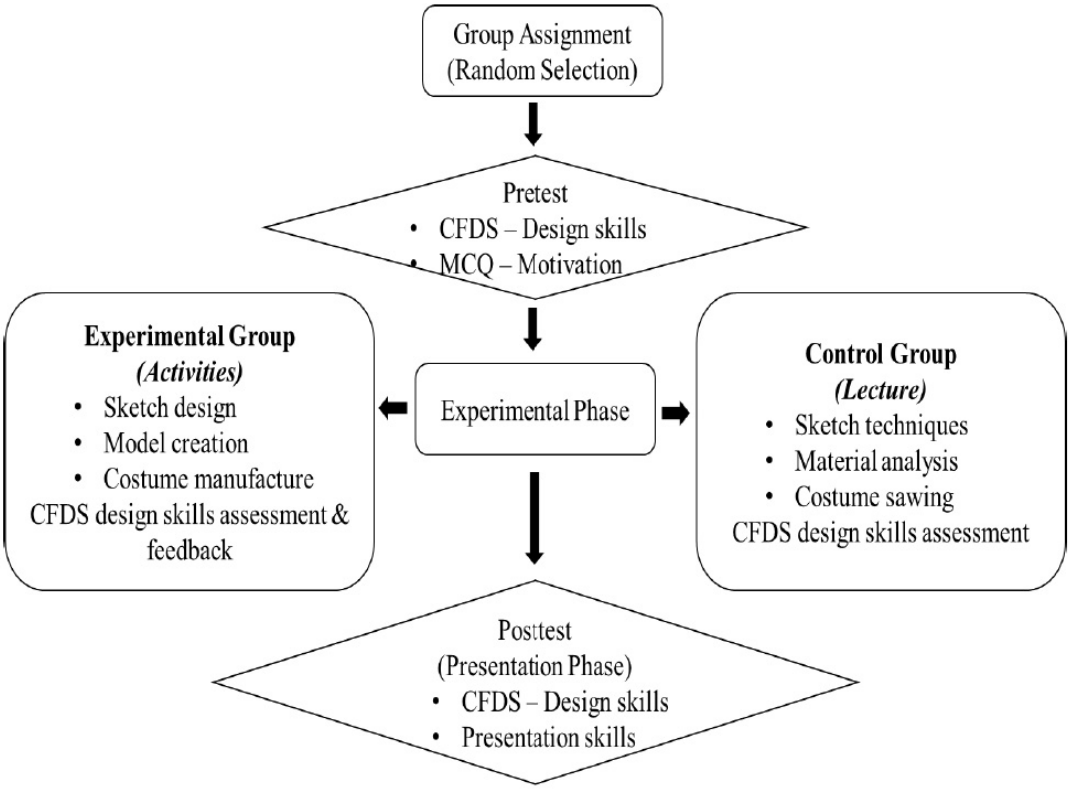

FIGURE 1
The procedure of the study for both experimental and control groups.

TABLE 2 Results from pre-test in design skills of control and experimental groups.

Groups	Number	Mean	SD	MD	Effect size (*d*)	df	Significant (*p*-value)
Control	102	2.44	0.55	0.03	0.04 (very low)	205	0.776
Experimental	105	2.41	0.55				

Not significant ($p > 0.05$).

TABLE 3 Analysis of covariance for students' achievement (post-test in design skills) as a function of groups, using pre-test scores as a covariate.

Source	df	Mean square	*F*-value	*p*-Value	Eta square (η^2)
Pre-test	1	0.16	0.93	0.337	0.01
Groups	1	12.32	73.17	0.000***	0.26
Error	204	0.17			

***$p < 0.001$, $\eta^2 = 0.1$ (not bad), 0.15 (big), 0.01 (small).

TABLE 4 Adjusted and unadjusted group means and variability for students' achievement (post-test) in design skills, between control and experimental groups.

Group	Number	Unadjusted		Adjusted	
		Mean	SD	Mean	SE
Control	102	3.71	0.40	3.71	0.04
Experimental	105	4.19	0.42	4.20	0.04

between genders was small. Therefore, no significant difference was found between male students ($M = 4.04$, SD = 0.35) and female students ($M = 3.93$, SD = 0.51) in their design skills development (Table 6).

The examination of students' design skills assessment revealed variations across genders in various factors. Notably, significant differences were found in only two aspects; research skill ($p < 0.05$) and communication skill ($p < 0.05$). Conversely, no significant

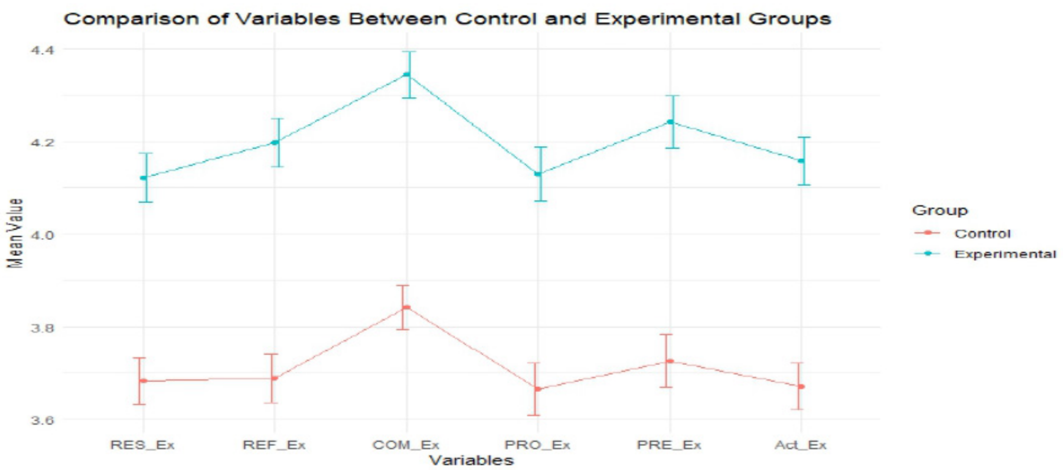

FIGURE 2
Comparisons of design skills assessment between control and experimental groups. RES_Ex, research skill; REF_Ex, effective skill; COM_Ex, communication skill; PRO_Ex, production skill; PRE_Ex, presentation skill; Act_Ex, act project skill.

TABLE 5 Analysis of covariance for students' achievement (post-test in design skills) as a function of groups, using pre-test scores as a covariate.

Source	df	Mean square	*F*-value	*p*-Value	Eta square (η^2)
Pre-test	1	0.43	1.92	0.158	0.01
Gender	1	0.87	3.88	0.050*	0.02
Error	33.48	0.16			

*$p < 0.05$, $\eta^2 = 0.1$ (not bad), 0.15 (big), 0.01 (small).

TABLE 6 Adjusted and unadjusted group means and differences in students' achievement (post-test) in design skills, between gender groups.

Group	Number	Unadjusted		Adjusted	
		Mean	SD	Mean	SE
Male	51	4.04	0.35	4.07	0.07
Female	156	3.93	0.51	3.91	0.04

differences were identified between genders regarding other factors in the design skills assessment, including reflective skill, product-creation skill, presentation skill, and act-project skill (Figure 3).

The possible reason may be that students do their projects outside the classroom which teacher's motivation and other external effects that can stimulate their extrinsic motivation were lost.

4.3 Students' motivation for the prediction of design skills improvement

For the investigation of students' motivation for their design skills improvement, we employed the AMOS software to develop a regression model. As an independent variable, information from students' motivation questionnaire was employed while teacher's assessment of their design skills improvement was used as the dependent variable. The model showed an acceptable model fit with the goodness of fit indices, such as Chi-square = 342.62, df = 211, SRMR = 0.06, CFI = 0.90, TLI = 0.90, and RMSEA = 0.07. It was found that students' intrinsic motivation ($\beta = 0.15$, $p < 0.001$), achievement motivation ($\beta = 0.22$, $p < 0.001$), and failure avoidance motivation ($\beta = 0.19$, $p < 0.001$), had significant positive effects on the prediction of their design skills development. However, the aspect of students' extrinsic motivation was found no significant predicting effect on their design skills development (Figure 4).

4.4 Investigating the predicting effects of variables (group, gender, and motivation) on design skills development

The logistic regression analysis was conducted to investigate the predictive effects of three variables such as group, gender, and motivation on students' design skills development. When all three variables were considered together, group ($\beta = 0.51$, $p < 0.001$) and motivation ($\beta = 0.30$, $p < 0.01$) significantly predicted students' design skills development. However, genders have no predicting effects on students' design skills development. The analysis showed that the "pseudo" $\underline{R}^2$ estimates (0.23) indicated that approximately 23% of the variance in design skills development can be predicted from the linear combination of these three variables. However, the gender variable was found as a non-significant predictor of design skills development. The results are shown in Table 7.

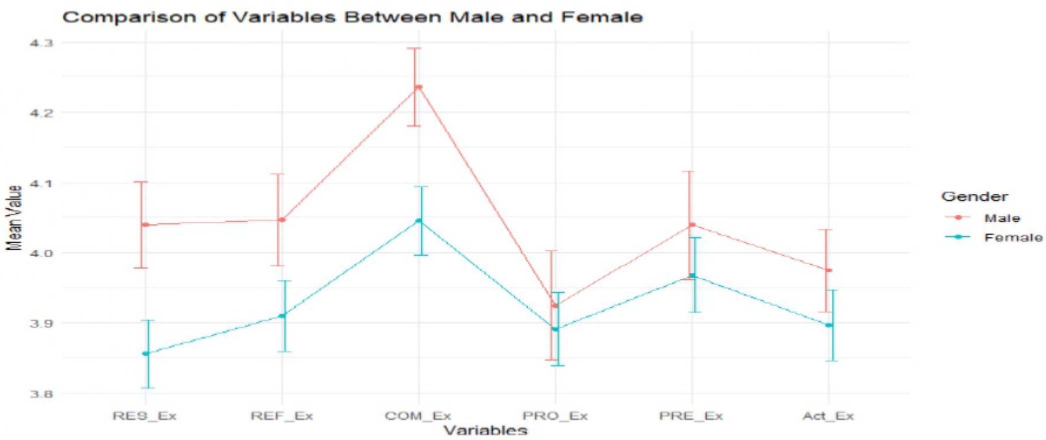

FIGURE 3
Comparisons of design skills assessment between genders. RES_Ex, research skill; REF_Ex, effective skill; COM_Ex, communication skill; PRO_Ex, production skill; PRE_Ex, presentation skill; Act_Ex, act project skill.

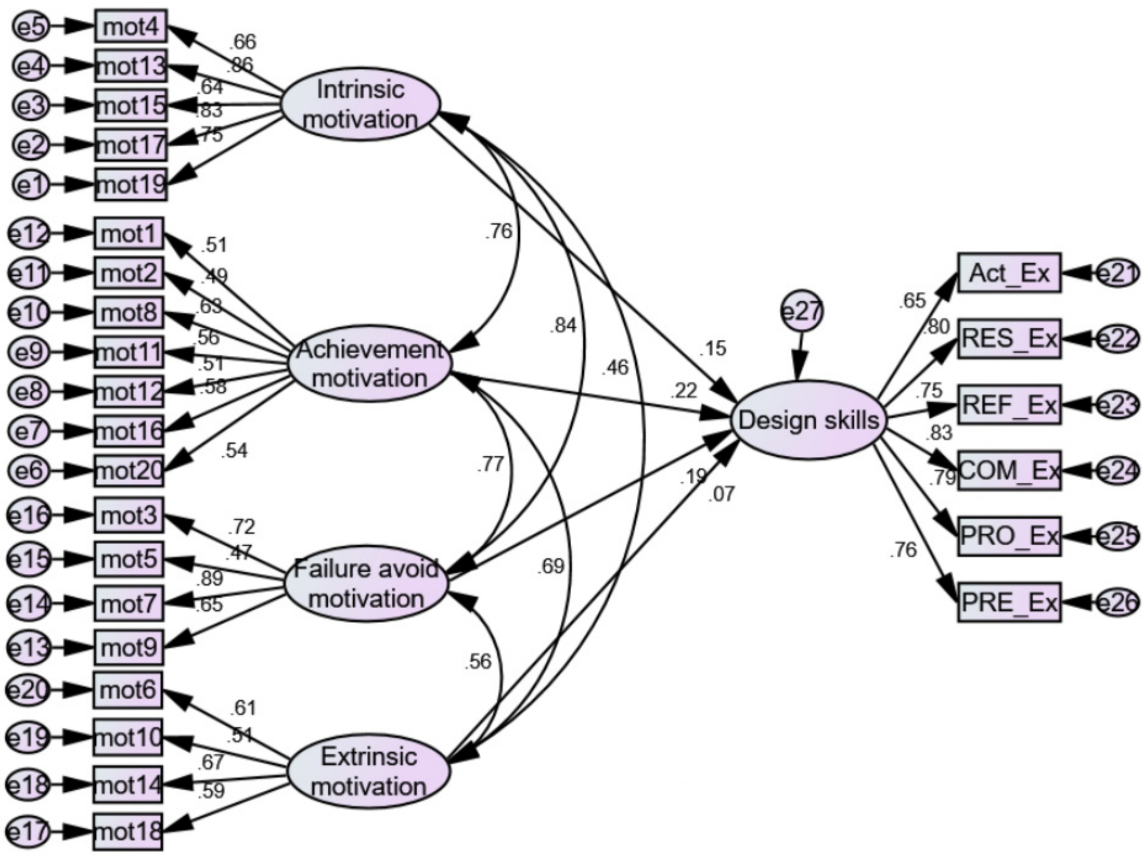

FIGURE 4
Predictive model of students' motivation for their design skills development.

5 Discussion

This study investigated the effects of students' DBL and motivation on their design skills development.

Four research questions were addressed in the current study. The first research question was the investigation of the difference between the experimental which was given by the DBL and control groups given by the traditional teaching method. Students from the experimental group performed better than those from the control group in their design skills assessment. This finding aligns with other studies (Guaman-Quintanilla et al., 2023; Oo et al., 2024; Zhan et al., 2023),

TABLE 7 Logistic regression predicting design skills development.

Model	Unstandardized coefficients		Standardized coefficients	*t*-Value	Significant	Correlations			Collinearity statistics	
	B	SE	β			Zero-order	Partial	Part	Tolerance	CIF
Group	0.48	0.06	0.51	8.52	<0.001	0.51	0.51	0.51	0.99	1.01
Gender	0.08	0.09	0.08	0.92	>0.05	0.11	0.06	0.05	0.48	2.09
Motivation	0.20	0.06	0.30	4.34	<0.01	0.20	0.20	0.24	0.87	1.09

showing more achievement of the experimental group than the control group in the design skills works. The reason may be that students from the experimental group have to work the individual assignments, and their teacher plays just the role of a guide/model. Students have to work on assignments that require their research skills, technological or communication skills, reflective skills, and product-creation skills. Moreover, students can collaborate with others as they wish, and thus they have more motivation to work and are willing to create better design skills tasks.

The second research question was to examine the gender differences in students' design skills development. The finding showed no significant difference between genders regarding their design skills development. This finding is similar to the previous findings of the research (Jacoby and van Ael, 2021), but different from other studies (Demirbas and Demirkan, 2007; Ro and Knight, 2016), showing the better performance of female students than males in the design skills assessment. The possible reason may be that design skills are highly individual and can be influenced more by personal interest, motivation, and experience than by gender. Moreover, another possible reason may be that both genders in this research context have equal access to education and training opportunities in design skills development.

The effects of students' motivation on their design skills development were explored in the third research question of this study. The finding model showed that students' intrinsic motivation, achievement motivation, and failure-avoidance motivation had positive significant effects on their design skills development. However, no significant effect was found on the design skills development by their extrinsic motivation. The possible reason may be that design skills are complex with multifaceted natures such as critical thinking skills and technological skills. Extrinsic motivation has less significant effects in addressing the diverse range of abilities needed for effective designs. Moreover, in art and design education, students' intrinsic motivation, such as passion for creativity or problem-solving, is more important than their extrinsic motivation, such as teacher's and colleagues' daily motivation and rewards. Our research finding also aligns with another study (Kelly et al., 2020) that proves the importance of students' collaboration in motivational tasks in design skills performance.

In the fourth research question, we explored the role of predicting variables (groups, genders, and motivation) in students' design skills development. The regression analysis showed that two variables such as students' groups and motivation contributed significant and positive predicting effects on their design skills development. However, gender was found as a non-significant predictor in students' design skills development. The possible reason may be that no significant difference was found between genders in addressing the second research question. Moreover, design skills are highly individual, and there is substantial variation with each gender. There is also one study (Zhan et al., 2023) that is similar to our research findings.

As for practical implications, the study shows the effectiveness of DBL over traditional teaching methods in the assessment of students' design skills development, teachers should focus on the DBL which encourages students' research skills, communication skills, reflective skills, and product-creation skills. The study also highlights the importance of students' motivation especially intrinsic motivation, along with achievement and failure-avoidance motivation, in students' performance in design tasks. Therefore, educators should emphasize students' motivation in assessing their design skills development.

The study has some limitations. One limitation of the study is that our study relies on a single assessment tool for assessing students' design skills. The design skills assessment is complicated, and thus the use of a comprehensive set of assessment methods, such as portfolios, and peer evaluations is also important to provide more understanding of students' design skills. Moreover, the study's focus on a specific educational context may limit the generalizability of the findings. Future research should consider different educational settings and different types of research designs such as longitudinal studies and action research. Furthermore, investigating socio-economic factors of students' families can also give a better understanding of students' development in design skills.

6 Conclusion

To conclude, this study found that students from the experimental group who were given the DBL treatment performed better than those from the control group who were not given the DBL treatment. In this research context, no gender difference was found in the findings of the design skills assessment. Investigating students' motivation, students' intrinsic motivation, achievement motivation, and failure-avoidance motivation had significant positive impacts on their design skills development. Moreover, the predicting variables such as students' groups and motivation contributed as significant predictors to students' design skills development. Therefore, educators should emphasize the DBL, and students' motivation to enhance their design skills in the field of art and design education.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Institutional Review Board of the University of Szeged, Doctoral School of Education. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

TO: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Writing – original draft. TK: Conceptualization, Data curation, Investigation, Methodology, Writing – review & editing. LK: Conceptualization, Data curation, Investigation, Methodology, Software, Writing – review & editing. KJ: Conceptualization, Data curation, Funding acquisition, Methodology, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that no Generative AI was used in the creation of this manuscript.

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