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Effectiveness of Blended/Hybrid Cad Instruction (Online + Physical Hands-On) In Engineering Education

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ABSTRACT

The purpose of this research is to evaluate how blended or hybrid learning of CAD instruction serves the students of Manufacturing Engineering better. In engineering programs, with the acceleration of digital transformation in the post-pandemic era, online lectures and virtual demonstrations are increasingly combined with face-to-face laboratory activities to support design-based learning. This study used a descriptive comparative research approach and compared two groups: students who were enrolled purely in face-to-face CAD classes versus those enrolled in hybrid/blended classes. Academic statistics regarding student engagement, motivation, and satisfaction were collected using measurements of student performance combined with a student engagement survey. Hybrid learners performed marginally better than traditional learners on their course assessments and more significantly on final assessments and design projects. Student engagement measurements were consistently greater among hybrid students when compared with traditional students, indicating that the hybrid learning model, which integrates multimedia and flexible instructional approaches into the learning environment, enhances motivational and participatory aspects of learning. Feedback from surveys corroborates the impact of digital resources on students' ability to learn at their own pace and also notes issues related to internet connectivity and software limitations. Results provide strong support for the implementation of hybrid instructional formats in skills-based engineering courses (CAD). Hybrid instructional formats were noted to enhance cognitive and affective (motivational) learning outcomes of CAD.

Keywords - Blended learning, CAD instruction, Engineering education, Hybrid learning, Student engagement

INTRODUCTION

The rapid digital transformation of education has transformed the delivery of engineering courses, particularly in the following years after the COVID-19 pandemic. Traditionally, students required direct supervision from their instructors, but at this time classes can be conducted through different modalities such as synchronous, asynchronous, and including the online and face to face formats or blended learning. In this evolving environment, Computer Aided Design (CAD) education plays an important role for imparting engineering design skills that are both practical and technologically grounded. Future engineers have to excel in technical skills and can cope up to the emerging educational environments. They have to understand the impact of hybrid or mixed modalities on Computer Aided Design (CAD) education [1][7].

In the post-pandemic era, the researcher's claims that CAD learning is improved through interactive and visual teaching methods that foster experiential understanding. Studies suggest that online CAD courses can maintain student satisfaction and potentially match the effectiveness of traditional teaching techniques when designed properly and aimed at promoting active engagement [1]. Pando Cerra et al. (2023) shown that problem-based and self-assessment tools contributes to students' skills and motivation in CAD online learning environments [2]. Hybrid teaching has shown the capacity to improve the accessibility and consistency of engineering programs while facilitating various learning modalities [3][8][9].

In addition to the progress in online and hybrid education research, there are limited concrete evidences exists about the impact of hybrid or blended learning set up on teaching Computer Aided Design specifically on how it affects the learning outcomes in hands-on, design-intensive courses. Most studies have analyzed online or remote instruction alone, without assessing how the integration of online lectures and physical laboratory work influences skill development, digital literacy, and overall student performance in Computer Aided Design subjects.

Addressing this gap is critical for establishing evidence-based instructional approaches that equips our students for the progressively digital and collaborative engineering environment. Blended Computer aided design instruction offers potential benefits such as flexibility, engagement, and applied learning but its effectiveness requires to be systematically evaluate. Understanding this can guide the universities and instructors in optimizing post-pandemic instructional approaches that combine the efficiency of digital tools with the irreplaceable experiences of face to face classes [3][8].

This study aims to evaluate the effectiveness of blended or hybrid learning strategies in instructing Manufacturing Engineering students in Computer aided design, focusing on their impact on learning outcomes, engagement, and skills development. This study examines the impact of integrating online lectures, virtual demonstrations, and face to face laboratory designing activities on students' performance and satisfaction in Computer aided design education.

RELATED LITERATURE

A. Online and Hybrid Teaching in CAD Education

Dagman and Wärmefjord (2022) examined online CAD teaching during the pandemic. They found that students generally adjusted well. Many rated online delivery the same as or better than traditional instruction. However, some students had difficulty with limited feedback and fewer chances for real-time questions and answers [1]. Their findings indicate that while online teaching improves access, hybrid models might balance engagement and feedback quality better.

Li et al. (2025) stressed that the success of hybrid teaching relies on support from institutions, teacher flexibility, and students’ digital skills. Their study pointed out that the teaching field—which includes teacher knowledge and technology use—greatly affects positive feelings about hybrid education [3].

B. Project-Based and Problem-Based CAD Learning

Several studies support active learning methods like problem-based learning (PBL) and project-based learning (PjBL) in CAD education. Pando Cerra et al. (2023) showed that using interactive self-assessment tools (TrainCAD) in PBL settings significantly boosted student performance and motivation [2]. Similarly, Sola-Guirado et al. (2022) used PjBL in virtual CAD/CAM/CAE environments and confirmed that project-based hybrid learning effectively builds technical and professional skills in design and manufacturing settings [5].

C. Comparing Instructional Modalities and Student Outcomes

Jayasekaran and Anwar (2022) conducted a study comparing different teaching methods: Emergency Remote Instruction (ERI), online learning, and HyFlex (hybrid) in an AutoCAD design course. The study found that ERI initially improved performance because of its flexible format. However, the most notable improvement came in hybrid settings where students could switch between online learning and hands-on practice [6]. This result matches other research showing that hybrid teaching helps students retain information better, solve problems more effectively, and feel more satisfied in technical courses.

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METHODOLOGY

Research Design

The study employed a descriptive comparative research design to evaluate the effectiveness of hybrid or blended

computer aided design (CAD) instruction on the learning outcome, skills development, and engagement of Manufacturing Engineering Students.

The hybrid or blended instructional model integrated online lectures and virtual demo with a face to face laboratory activity classes.

The design focused on comparing student's experiences and performance in two type of instruction:

1. Fully face to face CAD classes – students taught entirely in face-to-face laboratory activity sessions.
2. Hybrid/Blended CAD classes – students taught through a combination of online lectures, virtual demonstrations, and face to face laboratory activities.

Participants

The study involved second (2^{nd}) and third (3^{rd}) year Manufacturing Engineering Students enrolled in CAD course at Bulacan State University (BulSU). The participants are divided into two (2) groups.

- Group A (Fully face to face CAD classes) = (N = 10)
- Group B (Hybrid or Blended CAD classes) = (N = 10)

Both groups followed the same course syllabus, assessment criteria, and learning objectives to ensure comparability. Student participation was voluntary, and their anonymity was maintained throughout the study.

Data Collection Instruments

1. Academic Performance Evaluation: The comparison of midterms and final project grades, laboratory activities and exercise, and quizzes.
2. Student Engagement Survey: A structured questionnaire to validate hybrid learning evaluation tools, measured motivation, satisfaction, and participation.

Data Analysis

Quantitative data from academic performance scores and student engagement surveys were analyzed using descriptive statistics, including mean and standard deviation, to compare trends between instructional modalities. Given the limited sample size and exploratory nature of the study, inferential statistical testing was not applied. Qualitative data from open-ended survey responses were analyzed using thematic coding to identify recurring patterns related to engagement, challenges, and perceived effectiveness of hybrid CAD instruction.

RESULT & DISCUSSION

The quantitative data gathered from the student engagement survey and performance scores were analyzed using descriptive statistics, specifically the mean and standard deviation, to determine the overall level of motivation, satisfaction, and participation among students enrolled in Full Face-to-Face and Blended/Hybrid CAD classes.

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Academic Performance Evaluation

TABLE 1 Academic Performance Evaluation

Mean							
	Activity	Quiz	Midterm	Finals	Exam	Project	Grade
Hybrid/Blended Learning	14.718	29.625	100.000	91.100	28.665	13.665	96.519
Full Face to Face Classes	14.363	29.775	100.900	87.900	28.320	13.185	95.504

Table 1 presents the mean scores of students from the two instructional modalities fully face-to-face and hybrid/blended CAD classes across four performance indicators: laboratory activities, quizzes, midterm, final exam, and final project. The results indicate that students under the hybrid setup achieved slightly higher overall performance ($\bar{x}$ = 96.519) than those in the face-to-face setup ($\bar{x}$ = 95.504). Among the components, the largest difference was noted in Final exam, where hybrid learners performed better ($\bar{x}$ = 91.100) compared to face-to-face learners ($\bar{x}$ = 87.900).

The result indicates that the traditional and online methods of teaching, along with the various flexible self-paced components of hybrid learning, worked together to develop the students´ design skills by offering more opportunities for practice and review. This, in fact, coincides with the conclusions of Jayasekaran and Anwar (2022) who claimed that hybrid AutoCAD instruction not only retains but also brings about mastery of skills by means of repeated exposure and flexibility in learning modes.

Variability of Performance (Standard Deviation Analysis)

TABLE 2 Academic Performance Evaluation (Std)

Standard Deviation							
	Activity	Quiz	Midterm	Finals	Exam	Project	Grade
Hybrid/Blended Learning	0.131	0.395	0.000	2.961	0.444	0.444	0.975
Full Face to Face Classes	0.596	0.795	2.183	3.985	0.640	0.598	0.667

The standard deviation measures the dispersion or spread of the scores. A *lower* standard deviation indicates that students' scores were clustered more tightly around the mean, suggesting more consistent performance within the group.

1. Overall Percentage Grade: The Hybrid/Blended group has a slightly lower standard deviation with the value of 1.26 than the Face-to-Face group with 1.35. This suggests the Hybrid/Blended group's performance was slightly more consistent among its students.

2. Quizzes and Activities: The Hybrid/Blended group shows significantly less variability in Activity (SD = 0.131) and Quiz (SD = 0.395) scores. This is a notable finding: the blended learning environment appears to promote much more consistent performance in these frequent assessment types.

3. Midterm and Finals: The Face-to-Face group shows much higher variability in both Midterm (SD = 2.193) and Finals (SD = 3.985). This indicates that scores in the Face-to-Face class were more spread out some students scored very high, and others scored much lower.

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This result aligns with Li et al. (2025), who emphasized that well-supported hybrid instruction when coupled with digital literacy and teacher flexibility helps reduce performance gaps among students

Student Engagement Survey Results

TABLE 3 Student Engagement Survey Result

Category	Motivation	Satisfaction	Participation	Overall
Full Face to Face Mean	3.460	3.560	3.620	3.547
Blended/Hybrid Mean	3.820	3.780	3.960	3.853
Average Mean	3.640	3.670	3.790	3.700

Motivation

The Motivation scale consisting of Items 1–5 received a mean score of 3.82 (Blended/Hybrid Class) and 3.46 (Face-to-Face Class), which were both rated High. It means that students from both modes are interested in learning CAD, however the hybrid one may increase their interests to practice regularly and to comprehend difficult tasks through demonstrating online. The presence of digital tools, multimedia resources, and the self-paced nature of online learning may have contributed to higher motivation levels among hybrid learners.

This finding supports the notion of self-determined learning, where autonomy and accessibility foster greater intrinsic motivation (Deci & Ryan, 2000). The hybrid learning environment thus allows students to take greater control of their learning process, leading to improved engagement and interest in CAD activities.

Satisfaction

The mean for the Satisfaction (Items 6–10), was 3.78 for the Blended/Hybrid Class and that of the Face-to-Face class was 3.56, which is High on both scales. These findings suggest students from both learning environments are generally satisfied with the quality of teaching, assessment approach and resources. Yet hybrid learners reported rather greater satisfaction, which may be due to the balance struck between convenience and interactivity in this format.

Students perceived the use of user-friendly online tools and the flexible assessment mechanisms as key contributors to their positive learning experience. This aligns with the findings of Means et al. (2013), who noted that learners in blended environments often exhibit higher satisfaction due to the combination of technological engagement and face-to-face collaboration.

Participation

In the Participation (Par. 11.1-15) the Blended / Hybrid Class averaged 3.96, and the Face-to-Face Class 3.62, both High interpretation range scores. This indicates that students are for the most part active in both modes of instruction, but in the hybrid format their activities were more likely to be discussions, group work and connection with professors. By combining live and online classes there were many ways to interact. Students were able to work and cooperate well in this multiple format towards degree projects which met everyone's needs equally: part-virtual, Interactions for instance where work/discussing papers got done together.

The increased participation among hybrid learners may also reflect the impact of digital collaboration platforms, which encourage communication beyond class hours. This supports earlier studies by Bernard et al. (2014), highlighting that blended learning enhances peer collaboration, engagement, and learning outcomes compared to traditional classroom setups.

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Qualitative Analysis of Open-Ended Survey Responses

To complement the quantitative data, qualitative comments were obtained by asking students three open-ended questions (eras written in their own words) about their experiences, challenges, and suggestions for taking Hybrid CAD. Their narratives were thematically analyzed, and the patterns/themes emerging from the data were identified.

Concerning the 1st questions, students mentioned that e-lectures with in-hand lab tasks were helpful and supported their CAD concept learning. Material resources for learning purposes (including online course materials, such as video, slide and recorded lectures) facilitated self-study and revision. Many emphasized that the hybrid format had helped them learn self-regulation and flexibility, studying at their own tempo. In addition, the oral discussion on site and feedback in time combined to supplement learning and motivation.

The poor internet connection was the most common challenge mentioned in the answers to the 2nd question. Besides that, some students had limited access to CAD software (SolidWorks), and they reported that it was difficult for them to concentrate during the online classes. Few students also found it hard to manage their time between online and in-person sessions, and some of them talked about coordination and scheduling problems.

Students came up with a couple of ideas for making the learning process better which they had in the 3rd question. They suggested that schools should prepare offline or downloadable learning materials for those students who have a bad internet connection. Also, they proposed that the institution can provide student access to licensed software or give them permission to use the laboratory for longer hours so that they can practice more.

The qualitative part of the research shows that students consider hybrid CAD instruction as a productive learning method if it is supported by the necessary technological and pedagogical resources. Nevertheless, the achievement of this model is very much dependent on the availability of a stable internet connection and licensed software. These insights reinforce the quantitative data showing higher motivation, satisfaction, and participation among hybrid learners, underscoring the need for continuous digital and instructional support in engineering education.

Overall Discussion

TABLE 4 Student Engagement Survey Result (Overall)

	Overall	Full Face-to-Face	Blended/ Hybrid
Mean	3.700	3.547	3.853
Std Dev	1.001	0.971	1.018

The mean scores of all categories shows that Blended/Hybrid Class students rated consistently higher than Full Face-to-Face Class. The implementation of hybrid learning seems to better engage students, as it utilizes digital as well as face to face class. The high motivation, satisfaction and participation rates exhibited by the two groups further validate the positive effect of technology integration in Computer aided design teaching.

These findings suggest that hybrid/blended CAD modality fulfills students' need to quality of learning and it inspires their activeness in participation and desire for learning (motivation). This combination of face-to-face and online methods creates flexible and independent learning, proper time-pacing and improved levels of student engagement factors that are particularly important in skills-based and design oriented subjects such as Computer-Aided Design.

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In conclusion, the results confirm that Blended/Hybrid learning leads to higher level of engagement and better learning experiences for students versus traditional Face to face class. This is consistent with the emerging view in the engineering education literature that blended learning models are successful for enhancing cognitive as well as affective student learning outcomes.

Limitations of the Study

Although the findings of this study indicate positive effects of blended/hybrid CAD instruction on student performance and engagement, several limitations must be acknowledged. First, the sample size was relatively small (N = 20), which limits the statistical power of the analysis and the generalizability of the results beyond the study context. The participants were drawn from a single Manufacturing Engineering program at Bulacan State University, and therefore the findings may not fully represent outcomes across other engineering disciplines or institutions.

Second, external factors such as students' access to stable internet connectivity, availability of personal computing devices, and access to licensed CAD software (e.g., SolidWorks) were not fully controlled. These variables may have influenced individual learning experiences and performance outcomes, particularly in the hybrid learning environment.

Third, the study relied primarily on descriptive statistical methods to compare group performance and engagement levels. While this approach was appropriate given the exploratory nature and limited sample size, future studies are encouraged to employ inferential statistical techniques such as t-tests, ANOVA, or regression analysis to establish stronger causal relationships.

CONCLUSION

This study shows that blended or hybrid Computer-Aided Design (CAD) class set up is a better and more engaging learning modality for educating Manufacturing Engineering students compared to traditional face-to-face class set up. The results showed that students who used the hybrid system scored better on their academics overall, particularly on design projects and final assessments. Students learned the ideas better and become better at using technology by combining hands on laboratory activity, online and virtual lectures

The student engagement survey also showed that hybrid/blended learners were more motivated, satisfied, and involved. The results showed the importance to have a flexible, accessible and interactive learning environment. The study finds that the use of both digital learning tools and face to face classes improves the academic performance of the students This is the reason why hybrid/blended learning works well for teaching Computer aided design that require practical skills.

The findings indicate that blended or hybrid CAD instruction leads to higher engagement and improved learning experiences compared to traditional face-to-face instruction, these results should be interpreted within the scope of the study's limitations. The evidence supports the potential of hybrid learning as an effective instructional strategy for skills-based engineering courses. However, broader implementation should be accompanied by sufficient technological infrastructure and institutional support.

RECOMMENDATIONS

Based on the findings and limitations, future studies should aim to involve a larger and more diverse sample size across multiple engineering programs to strengthen the generalizability of the results. Researchers are encouraged to incorporate inferential statistical tests (such as t-tests or ANOVA) to provide stronger evidence of performance differences. Additionally, exploring variables such as students' digital literacy and learning styles could provide deeper insights. Practically, institutions implementing hybrid CAD instruction should develop structured support systems, including offline downloadable materials and extended laboratory access, to ensure equity for students with limited internet connectivity.

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