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EDGD Calendar of Events

Future ASEE Engineering Design Graphics Division Midyear Conferences

EDGD Midyear Conference – To be discussed at the ASEE Annual Conference

Future ASEE Annual Conferences

Year	Dates	Location	Program Chair	
2025	June 22-25	Montreal, Canada	Tracy Hammond	*hammond@cse.tamu.edu*
2026	June 21 - 24	Charlotte, North Carolina		

If you're interested in serving as the Division's program chair for any of the future ASEE annual conferences, please contact the Director of Programs, Erik Schettig

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Message from the Editor

Nancy E. Study, *EDGJ* Editor

Penn State Behrend

In my last letter from the editor, I asked several questions of our readers related to the increasingly small number of submissions to the *Journal* despite multiple and varied efforts to create interest and increase submissions. These questions were, first, where do we go from here? Are we still relevant? Should the *Journal*, and the Division, expand their scope? Will it help to actively recruit potential authors at conferences now that things are returning to in-person meetings post-Covid?

Since then, based on feedback, we have expanded the scope of the *Journal* with an increasing list of accepted relevant topics in the emails sent to list-servs. We have attended EDGD sessions at the Annual Conference and encouraged presenters to consider the *Journal* as a place to publish their work. As a member of the ASEE Committee on Scholarly Publications, I have staffed a booth at the Annual Conference, shared brochures for our *Journa*l with Conference attendees, and have appeared on ASEE TV in my role as *Journa*l editor and a CSP Committee member. We have had discussions at the Division business meetings at the Annual Conferences and while there has been feedback indicating feelings of disappointment in the possibility of ending *Journal* publication, and statements about the importance of publishing in the *EDG Journal* to the careers of many of the senior colleagues attending the meeting, this has had very limited impact on submissions. As a result of the lack of regular publication, we are no longer indexed by ERIC. It would take a significant increase in the number of published articles over several years to earn that status back.

We will have what may be the final discussion of the future of the *Journal* at the Division's business meeting this coming summer at the Annual Conference. We invite all EDGD conference attendees to join us at the business meeting to exchange ideas with the EDGD executive committee on the future of our *Journal*. If you are not attending the conference, feel free to email me any suggestions you have to offer.

As always, I thank Judy Birchman for her able assistance in doing the copy-editing, Bob Chin, even though he is retired, for the ongoing technical and moral support, the staff at East Carolina University who host the *Journal*, and all of my reviewers for their timely feedback. Hope to see you all in Montreal.

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Investigating the Impact of an Engineering-based Junior-level Computer Aided Design (CAD) course in Engineering Education

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Abstract

In order to provide a high-quality introductory 3D modeling and design course to mechanical engineering students, a unique and well-balanced course was developed. This course was designed to help students understand the methods required to optimize a mechanical product design. It covered a variety of theoretical topics as well as associated practical graphical/modeling techniques within a 5-credit, 10-week frame. This paper describes the new mechanical engineering curriculum at a quarter system institution as well as some of the practical considerations in this design course and what we have learned after presenting this course for three-year implementation and stabilization. In the Future Work section, a collaborative teaching model based on a cross-institutional group project for this course is proposed to further improve engineering education while meeting industrial demands without overloading engineering undergraduate curricula.

Introduction

Computer-aided design (CAD) is taught in almost all mechanical engineering programs. In addition, to become a successful engineer, the engineer must be involved in all stages of the design process. However, today's young engineers place too much emphasis on learning the software itself and fail to realize that even the best design software is useless without knowledge. A preliminary survey was conducted among local public and private universities in the state of Washington to better understand the current status of computer-aided design (CAD) courses as shown in Table 1. University of Washington Seattle and Washington State University Vancouver offer one introductory 100-level engineering graphics course for freshmen and the approximated total contact times for these courses are 2,000 minutes and 3,220 minutes, respectively. Another three programs offer two separate courses but their emphasis, credit hours, course setup, and even the contact times vary significantly. Considering both academics systems and teaching options, the total contact times vary significantly from a minimum of 2,000 minutes (UW Seattle) to a maximum of 10,080 minutes (WSU Pullman).

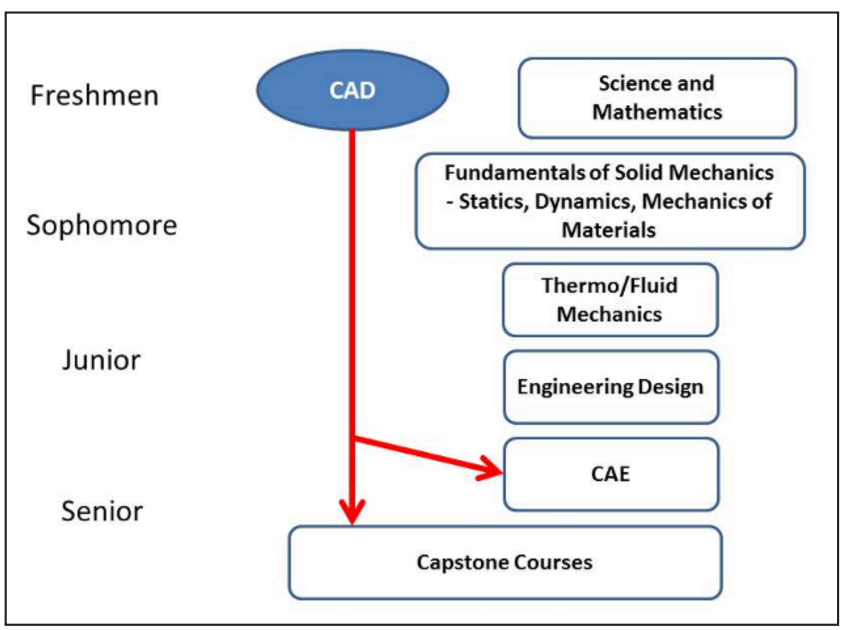
Based on the preliminary study and references, the author concludes that there have been two popular choices for teaching CAD in mechanical engineering programs in the U.S: 1) introductory topics, involving 2D drafting and 3D solid modeling, integrated into a 100-level freehand sketching and computer aided design course, or 2) two consecutive courses, a 100-level introduction to engineering graphics course followed by a 200-level course devoted exclusively to CAD and advanced analysis techniques (Jerz 2001, Ye 2004, Sacks 2010, Deniz 2018, Berselli 2020).

In the first choice listed above, the CAD experience is too often addressed as an isolated subject and this course may not serve as part of the foundation for engineering mechanics courses (see Figure 1). Furthermore, students do not use their CAD software or knowledge until they take any relevant elective courses in their senior year or capstone design courses unless they participate in undergraduate research. Based on the preliminary study and relevant references (Field 2004, Kim 2014, Ullah 2018, Woo 2020), few programs regularly employ CAD as a problem-solving tool to teach engineering ideas and concepts in fundamental mechanics courses.

Table 1
Summary of CAD courses in Pacific Northwest (PNW) mechanical engineering programs.

School Name	Academic system	Course name	Credit hours	Offered in	Total Lecture/Lab Time (Min)	Software
University of Washington, Seattle	Quarter	ME 123: Introduction to Visualization and Computer-Aided Design	4	Freshman	2,000	SolidWorks + Autodesk Fusion 360
Seattle University	Quarter	MEGR 1050: Engineering Graphics and Design	3	Freshman	1,500	SolidWorks
		MEGR 1810: Innovative Design	2	Freshman	1,800	SolidWorks
Washington State University, Vancouver	Semester	MECH 103: Engineering Graphics	3	Freshman	3,220	SolidWorks
Washington State University, Pullman	Semester	ME 116: CAD & Visualization	2	Freshman	5,040	SolidWorks
		ME 216: Integrated CAD Design	2	Sophomore	5,040	SolidWorks
Eastern Washington University	Quarter	METC 102: Introduction to Engineering Graphics	4	Freshman	2,000	NA
		MENG 217: 3D Parametric Computer Aided Design	4	Sophomore	2,000	SolidWorks
University of Washington, Bothell	Quarter	B ME 315: Introduction to 3D Modeling, Design, and Analysis	5	Junior	2,400	SolidWorks

Figure 1. *A simplified representation of conventional mechanical engineering curricula (Option 1).*



The second choice, utilizing the CAD courses as smoothly integrated parts in a mechanical engineering curriculum, may be an ideal solution to address the above issue and it allows students to gain sufficient confidence and design proficiency with CAD. However, meeting the requirements from the university and engineering accreditation as well as industrial demands for both breadth and depth may easily overload mechanical engineering undergraduate curricula.

In this study, the author presents an example 3D modeling course that may overcome these challenges. The author's hypothesis is that the proposed course would successfully employ CAD as a problem-solving tool and help engineering undergraduate students execute a design project with enough engineering mechanics background. This approach would provide students mini-capstone experience in their junior year and also minimize the disparity of skill that arises from traditional CAD courses which significantly differ from the real-world situations that mechanical engineering graduates encounter in the industry.

Methods

Proposed Design of the Course

One possible option for this program on the quarter system to relieve some overload and provide more problem-solving experience to students was to eliminate the stand-alone CAD class and incorporate it into a junior level design course (Table 1, last row, UW Bothell).

This course's education objectives are as follows:

- Formulate and communicate design ideas using paper-based drawing and CAD.
- Apply solid and surface modeling techniques in engineering design.
- Create, analyze, refine, and document engineering designs using CAD SW.
- Execute a design project and document and communicate results as part of a design team.

The general structure of the course was split into two parts to accommodate the course objectives (Table 2).

3D Modeling and 2D Drafting Basics (First portion of course): The course contents related to manual mechanical drafting are minimized and they concisely incorporated technical fundamentals and communication skills required for machining parts, such as documentation basics, drawing standards, dimensions, fastening methods, and other general drawing requirements as well as interpersonal communication methods.

Analysis and Design (Second portion of course): This portion exploits the role of solid modeling as an integral part of the engineering analysis process. Basic mechanics knowledge acquired through ME pre-major courses are carefully embedded in the course design. The topics include general design process, finite element analysis background, linkage system design, and rapid prototyping. An example to, and actions on the section is on position analysis of a linkage mechanism (crank-slider). It starts with a conceptual introduction to linkage analyses (Robert L. Norton, 2012). Formulas are derived and numerical calculation verification was performed in Excel (Figure 2). This result is compared to the theoretical calculation. Students learn that there are multiple approaches to optimizing the design of a system and the computer technology is not the only skill worth learning for solving these real-world problems.

Prototyping had a massive impact on the objectives of the course and the iterative process inherent in rapid prototyping was a great example of a product design/development cycle. In addition, building mechanisms or structural products was a multi-person and collaborative effort. Prototyping students' concepts can be an effective way for them to realize their ideas and learn how to work as a team. *The Collaboratory (also referred to as Makerspace)* housed in the School of STEM is a space where students can freely collaborate, study, and explore. The students of the course

Table 2

Sample 10-week structure and detailed topics.

Week	Topics
1	Introduction to 3D design Engineering drawing standards
2	Basic Part Modeling - SolidWorks Ex 1,2, and 3 (Pin, Base, Pulley)
3	Creation of Assembly Model - SolidWorks Ex 4 (assemblies) Mechanical 2D Drawings - SolidWorks Ex5 (2D drawing: Support Top)
4	3D Modeling and Rapid Prototyping Team Project Proposal Presentation
5	Midterm 1 Simulation and Analysis 1 - SolidWorks Ex6 (SolidWorks Motion: double pendulum)
6	Simulation and Analysis 2 - SolidWorks Ex 7 (Static Stress Analysis 1)
7	Simulation and Analysis 3 - FEA Background - SolidWorks Ex 8 (Static Stress Analysis 2)
8	Gear basics - SolidWorks Ex 9 (Spur Gear Dynamics) Mold Design - SolidWorks Ex 10 (Plastic Mold)
9	Midterm 2 Team Project Interactive Session 1
10	Team Project Interactive Session 2 Team Project Presentations

3D Modeling and 2D Drafting Basics (Weeks 1–4)

Analysis and Design (Weeks 5–8)

Team Projects (Weeks 9–10)

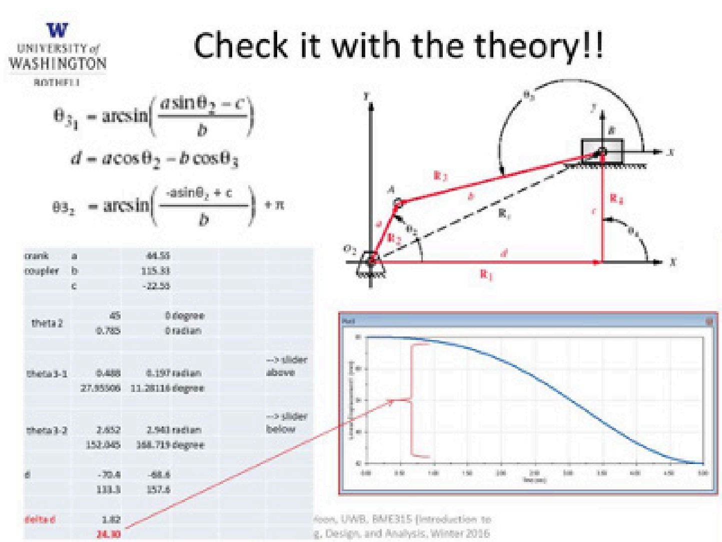
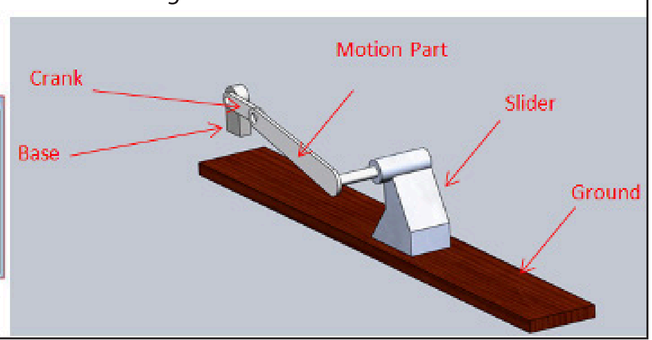


Figure 2. *An offset four-bar crank-slider linkage demonstration example (top) an example lecture notes on position analysis with the vector loop method and Excel calculation results on the horizontal displacement of the slider compared to the SolidWorks Motion analysis plot, and (bottom) a four-bar crank-slider linkage assembly modelled using SolidWorks.*



work in teams and were encouraged, but not required to make prototypes for their final projects. *The Collaboratory's* creative and supportive environment, including two universal laser cutter systems, twelve 3D printers (of various kinds), two 3D scanners, four computers equipped with the same SolidWorks license, and hand tools encourages student groups to improve their design concept quickly.

Method of Assessing Course Projects

This course was offered in Winter 2015, Summer 2015, Winter 2016, Autumn 2017, Winter 2018, Spring 2019, and Winter 2020. The first modifications of the course were made right after the Winter 2015 quarter. The summary of the first updates to, and actions on the course is presented below.

Update course equivalency requirements reasonably: The guidelines for course transfer equivalency were carefully studied and determined by the mechanical engineering program faculty. Any regular engineering graphics, CAD, and engineering visualization courses with more than 4 credits were given an official course equivalency after the instructor's permission if it included both 3D solid modeling and engineering design concepts.

Develop a syllabus that explores multiple approaches and perspectives on the topic: Students learned that there were multiple approaches to optimizing the design of the system and they knew that the computer technology was not the only skill worth learning for solving these real-world problems. Conducting a final project was one of the newly implemented major approaches.

The students' final project performances were statistically analyzed comparing the outcomes before (Winter 2015) and after the improvement actions (1st cycle: Summer 2015 ~ Autumn 2017, 2nd cycle: Winter 2018 ~ Winter 2020). Results from classes since Spring 2020 were excluded from analysis because they were all conducted 100% remotely due to the Covid-19 pandemic. Project marks obtained from the given four offerings were analyzed. The breakdown of the final report and presentation are summarized in Table 3. The total number of students analyzed for this assessment is shown in Table 4.

Table 3

Breakdown of final project report and presentation assessments.

Final Report (20% out of total grade)			
Criteria		Scientific Rigor, Content, and Result Derivation	25%
		Professional Report Specs	25%
		Understandability and Writing	25%
		Creativity and Novelty	25%
Total			100%

Final Presentation (20% out of total grade)			
Criteria	**Group**	Organization of Presentation	20%
		Scientific Quality, Rigor	20%
		Use of Visual Aids	20%
		Time Management	20%
	Individual	Q & A	20%
Total			100%

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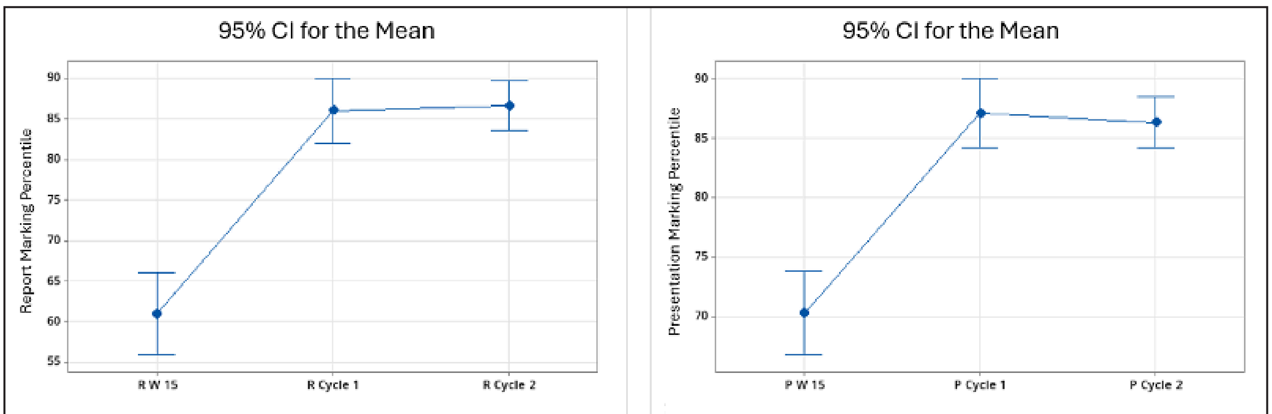
Table 4

Number of students in the years analyzed (each group consists of two to three students).

Year	*Winter 2015 (Before Improvement)*	*Summer 2015 – Autumn 2017 (cycle 1)*	*Winter 2018 – Winter 2020 (cycle 2)*
Number of Students (total)	24	34	65
Number of Groups (total)	8	13	22

Results

Figure 3 shows statistical summaries of the achievements in their final project before and after the course improvements (One-way ANOVA, Significance level: 0.05, Minitab). The differences between means for both presentation and report were statistically significant (P-value < 0.001). The Anderson-Darling test results indicated that they failed to reject the null hypothesis, implying that all of the data are from normally distributed populations. Also, Levene's test results among three groups proved that the variances were equal or very close to equal.



Report

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	4213	2106.67	41.48	0.000
Error	40	2032	50.79		
Total	42	6245			

Factor	N	Mean	StDev	95% CI
R W 15	8	61.00	4.17	(55.91, 66.09)
R Cycle 1	13	86.06	7.72	(82.06, 90.05)
R Cycle 2	22	86.65	7.54	(83.58, 89.72)

Presentation

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	5175	2587.37	34.44	0.000
Error	120	9016	75.13		
Total	122	14190			

Factor	N	Mean	StDev	95% CI
P W 15	24	70.271	3.043	(66.768, 73.774)
P Cycle 1	34	87.13	9.54	(84.19, 90.08)
P Cycle 2	65	86.35	9.52	(84.22, 88.47)

Figure 3. *Students' performance. Interval plots and statistics of student individual and groups' final project outcomes comparing report (group) results (left), and presentation (individual) results (right) before and after the modifications (two cycles). Interval plots display mean symbols with 95% confidence interval bars.*

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After improving the curriculum, it was observed that student groups' spectrum and scope of projects were expanded, and the depth of their research deepened. When this course was first offered, most of the techniques used in their final projects were limited to static stress/strain analysis. However, after the improvement, students started analyzing mechanics topics drawn from a number of ideas shared during the class in their projects. Figure 4 shows an exemplary project, "Makerspace staff availability clock" which implemented with a variety of manufacturing techniques. In addition, three different analytical and computational analysis techniques were used in this project: rotational rigid body in dynamics, pendulum dynamics (analytical and computational), and compound gear train design (analytical) (Figure 4).

Course Evaluation and Feedback

While student course evaluations can be very difficult to interpret and cannot be an official tool for academic research, they are still used for continuous improvement, enabling instructors to revise courses and syllabi (Arreola & Aleamoni, 2000). Table 5 shows the average ratings of the evaluated course for Winter 2015 (before improvement), Cycle 1 (Summer 2015 ~ Autumn 2017), and Cycle 2 (Witner 2018 ~ Winter 2020). Overall, the average score on students' course evaluations was 2.88 out of 5 in Winter 2015. Specifically, the assessment in course content and teaching effectiveness was relatively low (2.7 and 2.8, respectively). After course improvement actions, scores on these two items went up, as shown in Table 5 (content: 2.7 to 4.1 and 4.0, teaching effectiveness: 2.8 to 4.2 and 4.3). For the Autumn 2017 quarter, seven out of eight total students answered positively on the course content (better than good). Also, six out of eight students indicated the effectiveness of teaching as over good (Good = 3, Very Good = 4, and Excellent = 5).

Conclusion and Future Work

This present study explored a 5-credit 3D mod-

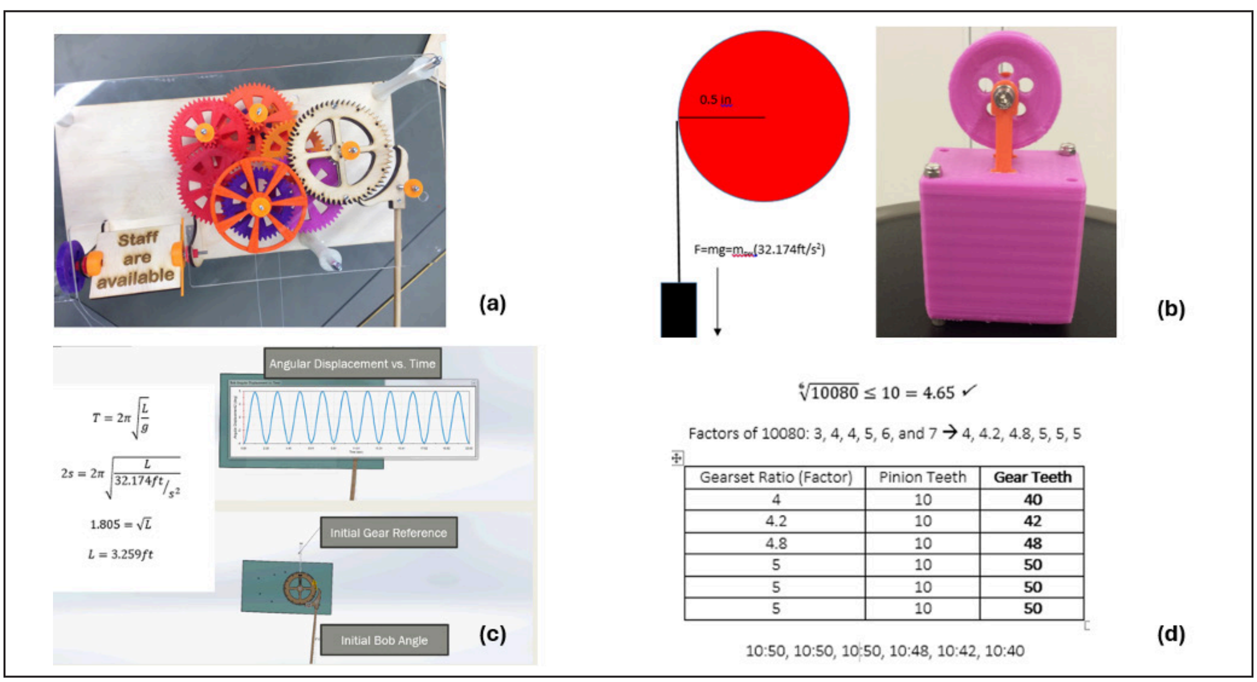

Figure 4. *(a) Prototyped mechanism, (b) analytical calculation of suspending mass, (c) SolidWorks Motion of pendulum kinematics and (d) compound gear train design.*

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Table 5 *Average student evaluation ratings. Likert scale is 0 to 5 with 5 being high.*

Items	*Winter 2015 (before improvement)*	*Summer 2015 - Autumn 2017 (cycle 1)*	*Winter 2018 – Winter 2020 (cycle 2)*
The course as a whole was:	2.8	4.1	3.9
The course content was:	2.7	4.1	4.0
The instructor's contribution to the course was:	3.2	4.3	4.1
The instructor's effectiveness in teaching the subject matter was:	2.8	4.2	4.2
Average	**2.88**	**4.18**	**4.02**
Student evaluation	**0.19**	**0.10**	**0.15**

eling and design course which was designed to help mechanical engineering students better understand the methods necessary to optimize a product design by providing various theoretical topics and associated practical modeling and analysis techniques. This work contributes to the mechanical engineering curriculum model by providing both theoretical and empirical insights into an outdated CAD course. CAD software can assist mechanical engineering students in actively engaging in engineering activities if it is thoughtfully developed for use and integrated into an engineering practice (Robertson 2009, Taleyarkhan 2016, Berselli 2020). The proposed upper-class engineering design course encourages more teacher-student interaction than traditional first-year engineering drawing 101 courses, which often have over 100 students with one faculty member and TA assistance. The author proposes a junior-level engineering design course for up to 30-40 students, taught entirely by faculty. This approach uses CAD as a problem-solving tool to assist engineering undergraduate students in completing a design assignment that requires a solid understanding of basic mechanics courses.

We waited three years to examine how the course had stabilized following the three phase-improvements and concluded that the study results are consistent with those of other studies. Results from classes since Winter 2020 were not considered in the analysis because they were all held entirely remotely owing to the Covid-19 pandemic.

Based on what we learned about the specific deficiencies from this study, the author proposes to revamp some of the additional activities within the updated CAD course using a cross-institutional joint team approach. For example, a realistic group project model in which students from a 4-year college partner with students from 2-year community colleges to work within their respective roles to support a shared project will be designed and added to the final project. The partnership will be between the course discussed in this paper and community colleges' Machining/Manufacturing Technology students to create shared projects. Specifically, we will work to analyze the effectiveness of this model, creating metrics and measurements that provide insight to the improved engineering learning environment. The author believes that by taking approach, the study's goals, problem-solving and realistic design project execution, can be improved while meeting the curriculum requirements and industrial demands without overburdening engineering undergraduate curricula.

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