WIP: Industry-based Focus to Engineering Statics Instruction Using a Drafter/Checker Approach

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***Abstract*— This work in progress, innovative practice paper involves highlighting an engineering industry-norm strategy using a drafter/checker roles approach. Specifically, an undergraduate, engineering classroom is treated similarly to a company engineering design team. Active, collaborative learning with a student-centered experiential approach that emulates the engineering industry is the focus of the project that is used during a freshman engineering class at a large, public R1 and HSI university in the southern U.S. In the engineering design industry, drafters create engineering drawings and engineers serve as checkers and approvers of the engineering drawings. This strategy will be simulated in a freshman engineering mechanics class to prepare students for work in the engineering industry, namely for two statics homework assignments. Quantitative data analysis using a survey and comparing normalized homework scores for students in a control class without the drafter/checker methodology and a class taught by the same instructor that uses the drafter/checker approach were compared. The results indicate that the drafter/checker approach showed statistically higher homework scores for the treatment group in the particle statics assignment, but statistically similar outcomes compared with the control group for the rigid body statics assignment. Students expressed high satisfaction ratings using the drafter/checker method, especially for the communication and teamwork survey questions. Bringing ideas of working in industry into a freshman-level engineering class may serve to enhance students' preparedness to enter the engineering industry upon graduation and help reduce the industry-academia knowledge gap that many companies are experiencing today.**

Keywords*— industry-based teaching, drafter/checker approach, active learning, peer coding review

I. INTRODUCTION

Academia has seen an increasing high school-college readiness skills gap, especially in the STEM fields [3]. Further, there is an increasing academia-industry gap for engineering students entering industry upon graduation [10]. Engineering students around the world are not prepared to perform at industry-level expectations in several main areas, including communication, teamwork, critical thinking, and digital professionalism, among others [4], [11], [18]. Traditionally, students learn how to work as an engineer through senior-level capstone classes rather than earlier in the undergraduate curriculum. It is thought that if students are exposed to industry norms throughout their undergraduate curriculum, then they may be better prepared to enter the engineering industry and reduce the academia-industry skills gap. This is similar to being more fluent in a foreign language because you have practiced the language for four years (undergraduate years) instead of only one year (capstone class in senior year). It is also important to distinguish the different opinions of soft skills (essential skills) that are lacking entering the engineering industry and how the opinions of these skills change between industry, professors, and students [11].

Typically on an engineering drawing there is a drafter, checker, and approval role contained in the title block. The drafter creates the engineering computer-aided drafting drawing. Another team member serves as a checker to the drafter's work. An engineer usually serves the approval role. It is believed that using different levels of Bloom's Taxonomy [13] by drafting (understanding and applying levels) and checking (analyzing and evaluating levels) may contribute to increased learning [12].

II. LITERATURE REVIEW

A. Drafter/Checker Approach

No specific content was found in the literature review for using a drafter/checker approach in engineering education. The Felder et al. [5] article discussed assigning some homework in teams of three students and collecting one assignment per group as a recommended practice in engineering education. Significant improvement in course content mastery was seen on individual exams for a course using small team homework and in-class quizzes as compared to working individually on the homework and in-class quizzes in a senior-level design course [7]. There has been work comparing an academic peer review process for scholarly writing and applying it to a computer science class. In an academic peer review, the reviewer has extensive scholarly writing and editing experience. This does not relate to the freshman class environment in which the peer reviewer may or may not have content mastery of the subject matter they are reviewing.

B. Peer Coding Review

In the computer science realm, work has been done in the area of a peer coding review in which a student checks another student's program in order to find and correct errors in a computer program [9]. This seems to be the most similar concept to the drafter/checker approach out of the literature review studied. Studies from the code reviews suggested that the results from using code reviews in the classroom were similar to the benefits of these types of reviews in industry, namely increased quality, increased productivity, increased product knowledge sharing and increased communication. A recommendation of the code review journal article by Almeida [1] was to increase the number of code reviews and to use them primarily during the later part of a semester in order to increase student proficiency in performing the code inspections.

III. Research Questions

The motivation of this study prompted the following research questions:

1. What is the impact of employing the drafter/checker approach on students' content mastery of engineering statics concepts in a first-year engineering course?

2. How does the use of the drafter/checker approach affect student perception of engineering preparedness to enter the engineering industry for a freshman engineering class?

IV. Methods

A. Participants and Data Collection

A freshman general engineering class that teaches math and science fundamentals to solve engineering mechanics problems is the focus of the study. The instructor serves as a guide and coach throughout the student homework assignments, similar to an industry engineering design manager role. The research involves a freshman engineering mechanics class population using a drafter/checker approach (treatment group) in performing two homework assignments as compared to a control class taught by the same professor over different semesters. Collaborative, active learning methodologies will be employed in the research project through two homework assignments with the drafter/checker style. The students work two statics homework assignments in teams of two, with one student serving as the drafter to complete the homework assignment and the other student serving as the checker of the drafter's work. The roles are then reversed on the next homework assignment. Both students earn the same grade on each assignment, with the instructor serving as the approval role by grading the assignment. The topics of particle and rigid body statics are the content of the two homework assignments.

The students and instructor in the class use teamwork, collaboration, and communication skills in order to provide the content of the statics material, develop the homework answers, correct any mistakes, and provide feedback in the class, similar to an engineering design industry environment. Different skill sets are used to check someone else's work than to perform the work yourself, thus employing different levels of Bloom's Taxonomy in the approach to the homework assignments.

A retrospective comparison with two semesters of the same class, same professor, with similar homework problems and grading rubric was studied. During the Spring 2023 and the Spring 2024 semester, two homework assignments required students to work various particle and rigid body statics problems. The students were expected to show the detailed development of their engineering problem-solving solution including the problem statement, drawing a system (free body) diagram, showing the general sum of force/sum of moment equations, and clearly label their results. The two assignments are related statics concepts and provide students with a foundation to solve problems using a general engineering problem-solving methodology in the mechanics realm. To answer the first research question, the 2024 group with 27 student groups were exposed to the drafter/checker approach making it the treatment group while the 2023 group with 51 students were not exposed constituting the control group. In addition to the homework assignment, the 2024 group was asked to answer a survey in which 89% of the of students responded to the voluntary survey. The participant demographics for the 2024 treatment group survey are shown in Table I.

B. Instruments

This investigation used quantitative methods of inquiry. For the first research question, an independent samples t-test analysis was used to analyze student content mastery and effectiveness of active, collaborative learning via formal assessment by comparing homework grades for students in a control class and a class that uses the drafter/checker approach (treatment group). The rubrics for 2023 and for 2024 were different so the aspects most related to the drafter/checker learning objectives were normalized on both groups and then analyzed through an independent samples t-test.

For the second research question, a six-item-Likert-style instrument was developed by the research team and used to perform a frequency count analysis and analyze the data regarding student interest and familiarity with industry-based methodologies as well as satisfaction of learning the class statics concepts using the drafter/checker approach. Student perception of industry preparedness after using the drafter/checker approach was also surveyed. The instrument included demographic questions and two open-ended questions. For this manuscript, only the Likert-style questions were analyzed and are shown in Fig. 1.

V. Results

According to the independent samples t-tests (refer to Table II.), the treatment group showed better performance in the form of homework scores than the control group in the learning of particle statics ($t(76) = 2.631$, $p= 0.010$, Hedges' $g = 0.620$) but no difference from the control group in the

TABLE I. Survey Participant Demographics

Age Range	Female	Male
18 – 32 years	21.30%	78.70%

TABLE II. Quantitative Independent Samples t-test Results

Statistical Test used	Group	Cohort	n (students)	Activity 1	mean	standard deviation	*t*	*df*	*p*
Independent Samples t-test with equal variances assumed	Treatment: With Drafter/Cecker Technique	Spring 2024	27	HW Particle Statics	1.64	0.49	2.63	76	0.01
	Control	Spring 2023	51	HW Particle Statics	1.34	0.47			

Statistical Test used	Group	Cohort	n (students)	Activity 2	mean	standard deviation	*t*	*df*	*p*
Independent Samples t-test with equal variances not assumed because Levene's test for equal variance was	Treatment: With Drafter/Cecker Technique	Spring 2024	27	HW Rigid Body Statics	1.55	0.32	1.4	67.43	0.08
	Control	Spring 2023	51	HW Rigid Body	1.44	0.43			

learning of rigid body statics (t(67.431) = 1.395, p = 0.084, Hedges' g = 0.301). Equal variances were assumed for the particle statics data; however, equal variances were not assumed for the rigid body statics data because Levene's test for equal variance was statistically significant.

The frequency count analysis (refer to Fig. 1 and Fig. 2) provided the following results. The assertions where the students were more in agreement (adding agree and strongly agree) was with question 5 ("With the drafter/checker method for particle and rigid body concepts, I feel supported in learning teamwork skills in engineering.") and the assertion with less agreement (adding strongly disagree and disagree) was question 1 ("I feel that using the drafter/checker method enhanced my learning of particle and rigid body statics concepts.").

All questions had a more positive score (adding agree and strongly agree) than negative score (adding disagree and strongly disagree), except question 1 being exactly neutral. Question 5 had a +47.8% difference score (positive score minus negative score) and question 4 had a +42.6% difference score. The highest overall question score was for question 4 and question 5 with an average rating of 3.51 and 3.57, respectfully, out of a 5.00-point scale. Questions 4 and 5 surveyed the development of communication and teamwork

Rate your experience with the drafter/checker approach

Q01 I feel that using the drafter/checker method enhanced my learning of particle and rigid body statics concepts.

Q02 With the drafter/checker method for particle and rigid body concepts, I feel supported in learning to become an engineer working in industry.

Q03 With the drafter/checker method for particle and rigid body concepts, I enjoy working on the assignments more than working the assignment individually.

Q04 With the drafter/checker method for particle and rigid body concepts, I feel supported in learning communications skills in engineering.

Q05 With the drafter/checker method for particle and rigid body concepts, I feel supported in learning teamwork skills in engineering.

Q06 I would like the drafter/checker method to be used in future ENGR216 classes.

Fig. 1. Student experience survey using the drafter/checker approach

skills using the drafter/checker approach. Question 2 also had a high positive difference score at +32.6%, which surveyed the students' perception of feeling supported in learning to become an engineer working in industry.

VI. CONCLUSIONS

Overall, the drafter/checker approach seems promising to help freshman engineering students learn and execute the expectations of working in industry. Higher statistically significant homework scores were shown when using the drafter/checker approach for the particle statics assignment, but equal scores were shown for the rigid body statics assignment. The student survey responses showed that the students felt an increase in their communication and teamwork skills using the drafter/checker approach as well as a positive experience learning to become an engineer working in industry. The analysis showed that students exposed to the treatment do perform better overall in homework scores and have increased teamwork and communication skills, even if they do not have the perception that they performed better

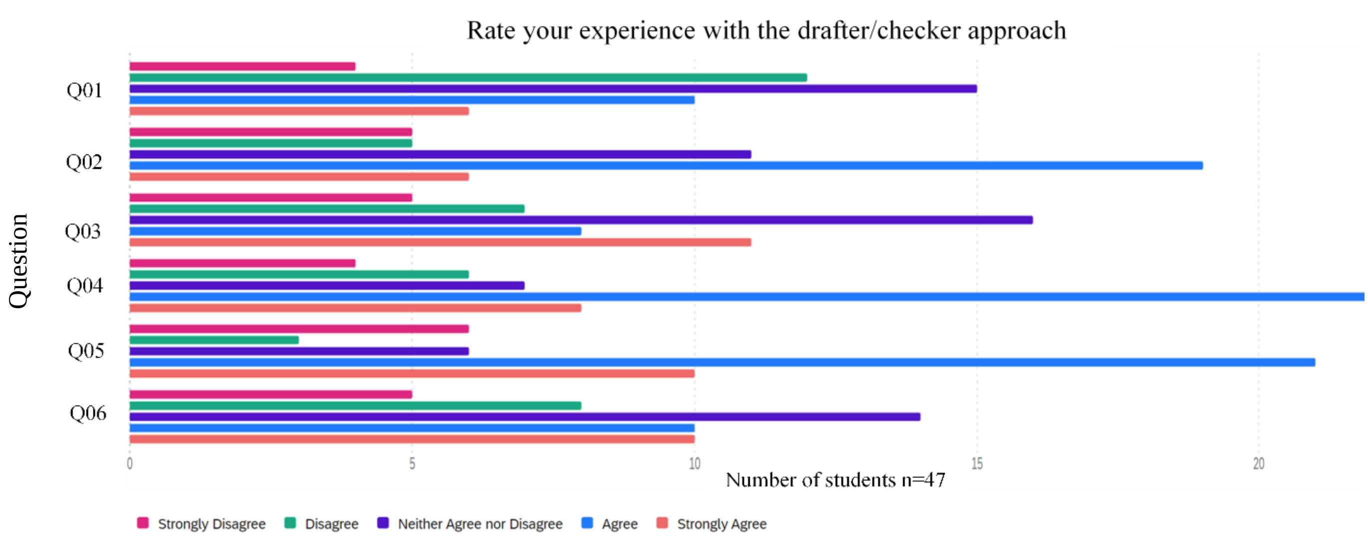

Fig. 2. Student experience survey results

using the treatment method. Using the drafter/checker approach in freshman engineering education may help to reduce the academia-industry gap, especially in the soft skills arena.

VII. Future Research

The focus for the Fall 2024 and Spring 2025 semesters will be to incorporate a reflection activity into the class in hopes of increasing the question 1 satisfaction level in the survey as that was the lowest survey score overall. A pre-survey will be added and compared with the port-survey results. Data will also be collected from a treatment and control group in the same semester with the same professor. The drafter/checker approach will also expand to a first-year engineering programming class. As students felt an improved sense of learning to become an engineer, increased communication, increased teamwork skills and higher homework scores using the drafter/checker approach as compared to the control group, the research will continue in an industry-based focus for engineering education.

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