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Optimization of Student Learning Outcomes Using an Hours of Instructional Activity Tool

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Adapting to multiple modalities in delivering a quality engineering education has exposed the many opportunities to research and implement teaching methods that will ultimately increase student accessibility and student outcomes. Using many different perspectives including those of peers, future employers of the engineering students, and the students themselves and integrating these into the planning and delivering relevant teaching for innovative and motivated learning.

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Introduction

Time is an essential resource needed for successful student outcomes and effective instruction in higher education. The effects of varying student workload on learning, teaching effectiveness, and student outcomes studied from the perspective of the instructor, students, or administration has led to several key findings. Workload defined as time spent outside of the classroom is difficult to measure due to inherent variations in methodology and potential inaccuracies in the data collection. Yet, in their study, Gallardo, Geraldo, and Castano (2016) have found that "good learning requires a large time investment." The credit hour, the one unit of measure intended to standardize instruction and workload, contributes to the variation observed in studies aimed at correlating workload to student success. Unnthorsson and Oddsson (2015) showed that the workload assigned by instructors and realized by students can depend on the type of the course; thus, refuting the standard measure of the credit hour. Findings from several major longitudinal studies conducted over the past fifteen years Souto-Iglesias, A., & Maria, T. (2018). suggest several considerations of workload including planning of the time to complete assignments and the type of work assigned outside of the classroom that can be undertaken by instructors and administration in order to improve student outcomes (Unnthorson et al.), (Souto-Iglesias & Maria, 2018). The U.S. credit hour and its European counterpart along with inherent ambiguity have provided the basis for time equivalencies presented to instructors as guidelines, recommendations, and requirements. Instructors who strictly adhere to these guidelines may have received student feedback indicating poor teaching effectiveness due to excessive workloads. Students who either underestimate the time necessary in order to gain the respective competencies or fail to reach their personal expectations due to frustrations resulting from (perceived) excessive workload are not aware of the requirements for a "new kind of thinking or a new set of technical languages" associated with engineering courses (Unnthorson et al.). The students apply the same learning styles that they have used in secondary education courses. Research from one of these longitudinal studies has found, however, no connection between workload versus grades, workload versus favorable instructor ratings, and grades versus favorable instructor ratings (Souto-Iglesia & Maria). However, in its conclusion, the authors state that: "Considering the importance of requiring reasonable amounts of work from our students, it is therefore interesting to investigate in which extent this equivalence (credit hour and

associated workload) is realistic." The authors concluded that workload can be accurately measured with a combination of quantitative and qualitative methods. The discussion for optimal and appropriate workload is further complicated when considering engineering education along with professional certification. While the findings of a study conducted by the Vice President of Undergraduate Education (VPUE) at Stanford University as reported by Carls in 2018 showed that "it would not be possible or desirable for the university to attempt to enforce a strict unit of credit as the variation in the value of a credit is a necessary feature of the system," the Accreditation Board for Engineering and Technology (ABET) requires that strict standards in coursework be met for accreditation. Carls continued by quoting Martha Cyert, senior associate vice provost of undergraduate education, in order to make her claim on the flaws in the credit hour system. Cyert stated: "One of our main findings was how difficult it is to get reliable data." The investigators for VPUE stated to offer the best education possible is to "understand what students are experiencing; this may lead to a universal change in course evaluation that better assesses how much time students spend on a course per week."

The researcher, through an IRB-approved study, intends to answer the following research questions in support of addressing some of the discussion and concerns above. The approach not only includes a methodology to accurately quantify the workload from the perspective of both the instructor and student, but an assessment of actively involving the students in the planning of the workload which may lead to improved student outcomes.

- Does an increased awareness of the credit hour, time equivalencies and allocation, and workload along with (student) self-directed workload tracking change the perception of the student in terms of the instructor, instruction, and learning objectives of the specific course?
- Does an increased awareness of the ABET accreditation requirements and other corresponding Senate/administrative policies provide student motivation to both understand the instructor's method for assigning work and complete the work in the manner intended?
- Can student-driven pedagogy in terms of participation in the planning of assignments and the corresponding estimates of the time to complete lead to increased student outcomes?

Methodology:

It may be worthwhile to initially investigate the method to which instructors plan assignments and work to be completed outside of the classroom. These plans can be standardized against the Equivalent Learning Activities (ELA) measurement which would assign a time equivalency or time allocation that the instructor estimates for the students to complete the particular assignment outside of class or the classroom. Some of these methods for planning assignments and relevant workload may be based on intuition on the part of the instructor, level of experience, an established differential between instructor time to complete the assignment versus the approximated time for the student, and published time equivalencies provided by the university. One large, public university located in the northeastern United States provides a Senate policy that states two hours of ELA should be assigned per one hour of Equivalent Instruction Activity (EIA) defined as classroom teaching, lecturing, or time spent in the classroom where the instructor is leading the activity. Both ELA and EIA hours are directly applicable to course credit hours. The large university provides a Senate policy that states 45 hours of EIA instruction along with 90 hours of ELA work outside the classroom are required for a 3-credit course taught over the course of 15 weeks. The researcher will survey students on the topic of workload, specifically asking for the time allocation estimated to be spent on the course in order to be successful. The results of initial estimates provided by the students of time necessary prior to the start of the semester will be recorded and compared with results for the subsequent follow-up to the first question. Students will be informed of any relevant university policy that addresses workload, the ABET recommendation (if applicable) for the specific course, and the instructor's method for planning the time necessary to meet the demand of the intended workload and thus, the learning objective. Students will be questioned as to whether this information changes the initial estimates on the time necessary to be successful in the course. The responses will be recorded and compared against the initial results.

Instructors will select several assignments based on its necessity in developing competency and skill for a particular topic. (Instructors will be requested to provide the learning objective to which the assignment is based.) The instructors will estimate the time necessary for the student to complete the assignment using the intended method and will note the method to which the estimate was made. Students will estimate the time necessary to complete the assignment providing a basis of reasoning for the estimate. The students will be asked to track

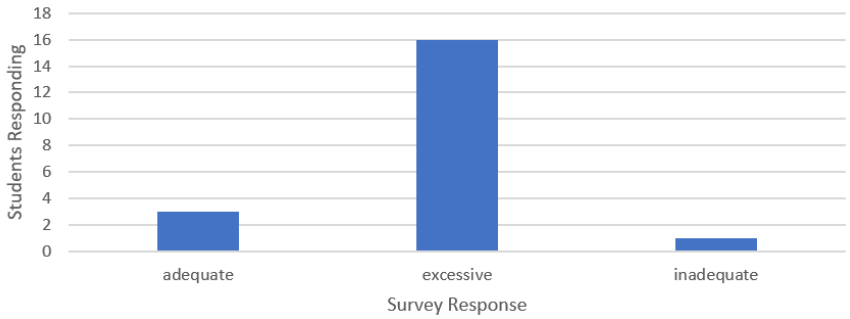
the time necessary to complete the assignment and to respond to a question as to whether the task of keeping time provided any motivation in completing the assignment. Results for the estimated and actual time necessary to complete the assignment will be recorded as well as the responses to the method of planning used by the instructor and whether the tracking of time provided motivation to the student.

The final research question will be investigated with a qualitative approach where students will be surveyed and interviewed on the subject of student-driven pedagogy. Specifically, students will be questioned as to whether students have preferences as to the desired amount of time for ELAs required and to which type of assignments are assigned by the instructor. This last segment is intended to provide instructors information on the benefit of the frequency and type of assignment.

Results of Initial Study:

Twenty students were surveyed after completing Engineering Mechanics Statics during the fall 2020 semester as a method of alternate assessment administered by the instructor as directed by the administration due to the delivery mode of the instruction. This course historically had been taught as an in-person class; the delivery mode for the fall 2020 semester was synchronous remote. The instructor provided the online lectures that were of the same length and frequency as lectures offered in the classroom. Students were actively engaged in questioning through the chat feature. The assignments assigned by the instructor were very similar to the previous semesters; this included assignment type, frequency, and grading rubric. Tests and exams were given at the same frequency throughout the semester as in previous semesters with the number of questions similar to previous tests. Survey results for the fall 2020 semester showed that eighty percent of the students found the workload excessive. (Figure One) The instructor was curious as to why the majority of the students thought the workload excessive during this semester versus others in the past even though the same planning of assignments and tests along with the same methodology of planning based on past experiences along with suggested time equivalencies provided by the university were used.

Figure One:
Fall 2020
Engineering Mechanics Statics
Workload



The same group of engineering mechanics students were surveyed prior to the start of Engineering Dynamics course scheduled for the spring 2021 semester as to their approximation on how much time and effort would be required to be successful in Engineering Dynamics. The results are presented in Table One; the students were then provided with the information on the Senate policy stating that 135 hours of Equivalent Instructional Activities and Learning Activities are the expectation/requirements of the university.

Table One:

Student Response to Workload or Expected Number of Hours per Week Spent Outside the Classroom Working Towards Success in Engineering Dynamics

Student Responding	Number of Hours per Week
1	5
2	6
3	6
4	5
5	4
6	3
7	5
8	4
9	4
10	4
11	3
12	3
13	3
14	3
15	6
16	6
17	7
18	7
19	6
20	5
	Avgerage 4.75

Students were then asked to respond as to whether this knowledge changes their perspective on assigned workload and other time-dependent attributes of the course. The question asked was whether the students considered the 135 total hours of course time a reasonable or excessive amount of time needed in order to be successful. According to the results from Table One, students would have completed 116 Hours of Instructional Activity (HIA) which is the sum of Equivalent Instructional Activity hours and the Equivalent Learning Activity hours using the average 4.75 ELA hours per week for the 15-week semester. Figure Two shows

the response to the question comparing the university policy requirement to the students' own estimation.

The students were then asked to estimate the amount of time they anticipated spending on the various types of assignments. These were recorded in Table Two. The instructor used the HIA Estimator Tool to plan the semester and at the same time asked the students to record the amount of time they spent on a particular task. These results were added to Table Two which displays the published time equivalency incorporated into the course plan by the instructor along with the estimates provided by the students and the input from the students on the actual time the tasks took to complete.

Three different assignments were tracked in terms of how much time the students estimated that it would take to complete, the instructor's estimate on how much time would be needed to complete the assignment based on a published equivalency, and the actual time that the student took to complete the assignment. The first assignment involved watching a 12-minute video and taking notes on the content. The subject of the video was general planar motion: relative motion analysis. The students estimated 30 minutes to watch the video and complete a set of notes. The instructor used a 30 minute per page of notes equivalency provided by the university and estimated the task would take one hour as two full pages of notes were anticipated to be written. The average amount of time that the students needed to complete this task was 45 minutes. The second assignment was in the form of a case study where students were to analyze attributes of general planar motion in a crank-piston system. Students were to graph the velocity of piston and acceleration of piston versus angular displacement of the crank for two complete revolutions using an absolute motion analysis. The students were to determine which part of the curves corresponded to the four strokes of the power cycle. The students were to investigate the effect on the motion as a function of the crank diameter and the length of the connecting rod. Next, the students were to graph the angular and tangent velocity and acceleration of the connecting rod versus the piston velocity and the crank angular velocity. The effects of the length of the connecting rod and crank diameter were to be determined as well. The students were expected to submit a file that contained the relationships and equalities that were used to produce the two graphs and the evidence that allowed the students to determine the effect of dimensions on the motion. The students anticipated two hours to complete this assignment once learning the instructions. The instructor anticipated this assignment to take three hours to

complete based on published time equivalencies along with past experience. The students completed this task indicating on the file the amount of time each of the components of the assignment took; the average completion time was 3.3 hours. The final assignment's instructions to the students were to utilize the Conceptual Dynamics website in reviewing Chapter 6, Kinetics of a Rigid Body, sections IV, Kinetic Moments, V, Mass Moments, VIII, Center of Mass References, and IX, General Planar Motion. The students were then assigned four worksheets, one from each section. The students anticipated that this assignment would take two hours to complete. The instructor based on the time equivalency and past experience estimated three hours to complete this activity. The students handed in the four worksheets indicating the average time to complete the assignment was 2.6 hours.

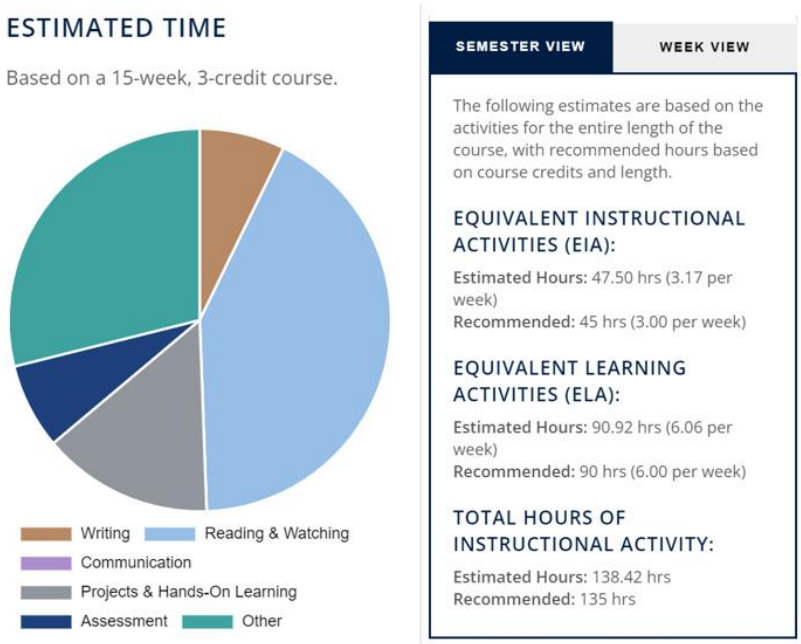
Table Two:

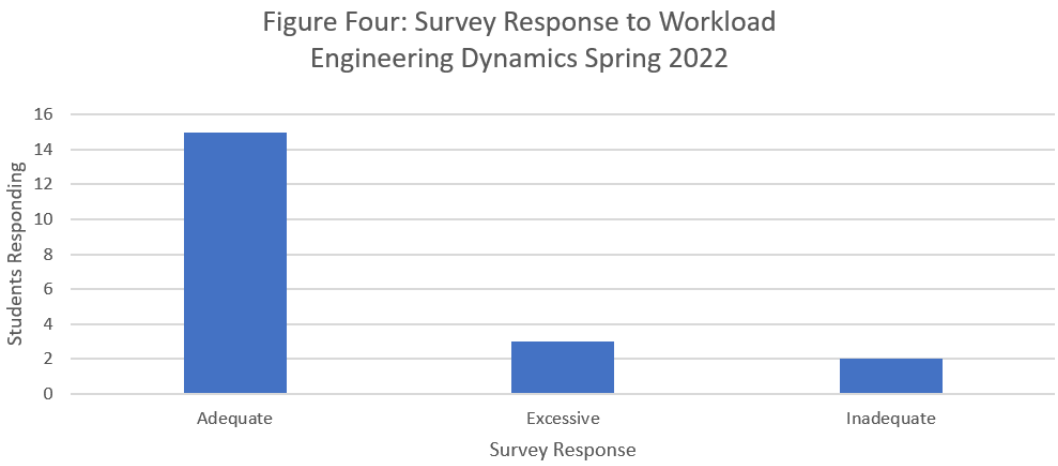
Time Equivalencies, Estimations and Actual Completion Times for Three Different Types of Assignments

Assignment Description	Instructor Estimate Based on Time Equivalency (Hours)	Student Estimation Time to Complete (Hours)	Actual Completion Time (Hours)
Video (12 minute) Notes on General Planar Motion-Relative Motion Analysis	1.0	0.5	0.75
Case study-crank and piston system including velocity and acceleration of piston versus angular displacement and effects of dimensions on motion	3.0	2.0	3.3
Conceptual Dynamics unit: General Planar Motion Kinetic Moment, Mass Moment, Center of Mass	3.0	2.0	2.6

The final component of this study was to ask the students whether the time and effort required to be successful in this course was excessive, adequate, or inadequate. This question was identically phrased to the question asked at the end of the fall 2020 semester. The instructor utilized the same distribution of Equivalent Instruction Activities (EIA), instructor-led activities including lecture. This number was a total of 45 hours for the semester. The Equivalent Learning Activities (ELA) which included homework assignments, preparation for semester tests and exams, reading, case studies, and take-home quizzes totaled 90 hours for the semester based on time equivalencies. Figure Three shows the output of the Hours of Instructional Activities Estimator used for the fall and spring semesters for the engineering mechanics courses. Figure Four shows the results for the student responses.

Figure Three:
Hours of Instructional Activity
Engineering Mechanics





Initial Findings:

The engineering mechanic students' average response to the survey question asked concerning the amount of time and effort required to be successful in a three-credit engineering mechanics course was 4.75 hours per week of ELA with approximations ranging from 3 to 7 hours per week. According to this university's Senate policy based on federal guidelines on the US credit hour (CFR, Title 34), the suggested time for ELA is 6 hours of work per week outside of the classroom; students underestimated the time necessary to comply with the policy and thus, the expectations of the university. However, the majority of the students, seventy percent, responded that they considered the 6 hours of work reasonable, while thirty percent of the students planned on grasping the material in a shorter time. The average student approximations to how much time a specific assignment would take to complete fell below the actual time to complete for all three considered assignments. The students' estimations ranged from thirty to sixty-five percent different than the actual completion time. The actual completion times compared to the instructor estimates based on time equivalencies differed from 10 to 25%. The last question showed students' perspective on the workload as adequate increased from 15% at the end of the fall semester to 75% at the end of the spring semester.

Conclusions and Limitations:

The study involved the same group of students and instructor and a consistent remote synchronous delivery for both the fall and spring course. Some of the gains realized in students considering the workload adequate as opposed to excessive may have resulted from the increase

in familiarity with a remote synchronous course delivery mode and the instructor as well. The instructor does emphasize that students were provided the information on how assignments were planned out by the instructor prior to the spring semester and therefore, prior to the gains realized in student perspective of the workload. Times reported to complete assignments were self-reported and are therefore subject to discrepancies. The instructor will consider the current, successful research on workload measurement using various methods for planned future research.

The findings indicate that students who are made aware of university expectations and guidelines on the workload planning for this engineering course are more agreeable to the work assigned by the instructor who is basing the workload on time equivalencies, policy, and accreditation.

Future Investigation

A fully interactive application, the HIA Estimator allows a user to input planned learning activities and then produces the Hours of Instructional Activity based on published time equivalencies. This Hours of Instructional Activities Estimator along with experience is presently used by the instructor. An IRB-approved study is planned where students will participate in the planning of assignments in the establishment of the workload using the HIA Estimator and in the recording of meaningful workload hours allowing the researcher to assess the relationship between student understanding and perspective of planning of assignments and workload and student learning outcomes and effectiveness of instructor and instruction. Students will be provided information on the guidance, recommendations, and requirements to meet ABET's credit hour certification and other university policy. The researcher will assess whether this information motivates the students in terms of understanding the instructor's method for assigning work and completing the work in the manner intended. This assessment will be completed using survey responses, interviews, and field notes. The final assessment will be that stemmed from this informal study. Students provided responses as to whether policy, guidelines, and time equivalencies are reasonable. A further consideration will allow students to provide responses as to preferences on time spent on assignments and on type of assignments assigned. The researcher anticipates finding whether active student involvement in the planning of a course can serve as student-driven pedagogy which produces increased student outcomes. Furthermore, this planned study may provide insight into the findings of Souto-Iglesias and Maria suggesting

that “reframing the existing academic credit by making the level of students’ effort rather than the contact hours as the foundation of the credit system where the focus is placed on the attained knowledge and skills of learners as a standardized measure of educational achievement based on taxonomies.”

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