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Exploring Alternative Homework Assignment Strategies in Mechanics of Materials

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WIP: Exploring Alternative Homework Assignment Strategies In Mechanics of Materials

Abstract

Teaching methods are constantly changing as the field learns more about effective practices supported by the science of learning. The available learning tools and other factors such as the learners themselves can shift within institutions making exploration of new methods important as faculty work to address the needs of their students. There is a lot of literature that supports that faculty must evaluate how they are teaching to see if it is effective, that is why this study at the University of Maine in the department of Mechanical Engineering focuses on investigating the intervention of a different type of assessment into a mechanics of materials course. This alternative assignment is called the knowledge check. Which is a structured prompt or series of prompts relevant to the topic being examined in the course which learners respond to in the form of a video submission. This video has the learner speak over a slide(s) which combined with their oral explanation answer the provided prompt(s).

The methodological approach to an assignment also incorporates techniques shown in the science of learning to be effective which are difficult to leverage in a traditional written assignment in an engineering course such as:

- Student self-elaboration and self-explanation of examples
- Retrieval of knowledge (sometimes referred to as reflection) which can be leveraged to access the forward testing effect and has been shown to improve student learning even with limited classroom time
- Multilateral scaffolding through development of multimodal skills such as oral presentation which are essential in all future careers students must be prepared for when they graduate college
- Presentations to enhance student learning

The knowledge check assignment as a method of assessment incorporates both examination of the direct topic of the unit being covered as well as development of essential soft skills which are critical in all professionals. It also leverages a method of soft skills development relevant to the modern landscape of technical communication, the video conference, by providing a scaffolded landscape for students to practice presenting slides digitally in the form of a video also removing the anxiety and pressure of in-person presentations making this an accessible option for lower-level collegiate students and a diverse array of learners in general. It also represents a low barrier to entry change for faculty to implement which is of value as it allows for inclusion without a complete course redesign.

The potential effectiveness of this alternative assignment was studied in two Fall 2025 sections of MEE 251 Solid Mechanics. One section is being assessed using the traditional methods I have used to date while the other section is taught in the same way also by myself but is being assessed using a combination of traditional assignments and knowledge check assignments. The effectiveness of the intervention of the knowledge check assignment is being examined using surveys throughout the semester and grades on individual assignments and the course overall. The results of this study as well as lessons learned will be presented and discussed.

Introduction

In the fast paced, highly digital, and rapidly changing twenty-first century we live in as a college instructor in the department of Mechanical Engineering at the University of Maine I am constantly working to find teaching methods which are effective for the diverse learners currently in front of me. Part of this relies on a constant relationship with literature and the science of learning, but it also relies on the instructor to be inventive and willing to change. Sometimes that change of necessity requires investigating new assignment types, such as the knowledge check, a unique video presentation assignment approach to student's conveying their solution to engineering problems, which is the subject of this research [1].

The knowledge check assignment is a structured prompt or series of prompts developed from a solid mechanics problem which would typically be assigned as a traditional written homework assignment where the student would turn in their handwritten calculations and final answer for assessment. Instead of that the student now responds to the prompts by turning in a video submission of themselves voicing over a series of informative slides to communicate the same information in a different modality which is more supportive of diverse student populations.

This methodological approach to an assignment taps into different techniques shown by literature on the science of learning to be effective for student learning and retention as well as allows for a low-stakes place for them to develop essential soft-skills often overlooked in higher education STEM courses. Some of these techniques are outlined in the bullet list below:

- Student self-elaboration [2] and self-explanation of examples [3]
- Retrieval of knowledge (sometimes referred to as reflection) leveraged to improve student learning even with limited classroom time [4, 5, 6]
- Multilateral scaffolding through development of multimodal skills [7]
- Presentations to enhance student learning [8]
- Low-stakes assignments to develop essential skills
- Engagement with relevant modern technology and modes of technical communication

I began this research with the following three research questions which tie directly to the background and rationale outlined in this introduction.

1. Does the intervention (addition of the knowledge check assignment) have an impact on student learning.
2. Does the intervention (addition of the knowledge check assignment) have an impact on student experience, as indicated by semester surveys.
3. Does the intervention (addition of the knowledge check) change learner satisfaction with the course based on survey responses?

The study discussed in this conference paper presents the current state of the work in progress (WIP) research I have done at the University of Maine, an example of the new assignment type being used is discussed and provided, and plans for continued research are briefly outlined.

Fall 2025 Investigation

In the Fall 2025 semester at the University of Maine this research was conducted in two sections of MEE 251 Solid Mechanics (often called strength of materials or mechanics of materials). The research was designed in the form of a typical intervention, where one section was assessed using the traditional methods used to date while the other section was taught in the same way by the same instructor but is being assessed using a combination of traditional assignments and knowledge check assignments. This approach was used to investigate the potential effectiveness of the intervention of the knowledge check assignment.

In this section of the paper the knowledge check assignments used will be discussed, followed by an examination of some of the data collected in the research which includes assignment scores, overall course final grades, survey responses, and comments from student evaluations of teaching. In Fall 2025 the study focused on three specific homework assignments out of the many given throughout the course. These assignments intentionally covered a range of the critical topics contained in a solid mechanics course as outlined below. The third knowledge check assignment is given on the last page of this paper as an example for reference purposes.

Homework Assignment	Section 1	Section 2	Assignment Topic
1	Worksheet 1	Knowledge Check 1	Statically indeterminate system of axially loaded bars
2	Worksheet 2	Knowledge Check 2	Power transmission and torsion of a circular shaft
3	Worksheet 3	Knowledge Check 3	Normal and shear stress analysis of a beam in bending

The scores for these three assignments for section one without the intervention of the knowledge check are outlined in Table 1 below along with the overall homework subtotal score for all students who chose to participate in the research.

Table 1: Section 1 (no intervention) worksheet assignment scores and homework subtotal

	Worksheet 1		**Worksheet 2**		**Worksheet 3**		**Worksheet Subtotal**	**Homework Subtotal**
	Score	*%*	*Score*	*%*	*Score*	*%*	*Calculated Score*	*Calculated Score*
Mean (Average)	8.73	87.3%	8.24	82.4%	8.27	82.7%	84.1%	94.9%
Standard Deviation	2.75		2.84		3.23		2.93	0.08
Coefficient of Variation	0.31		0.34		0.39		0.35	0.08

The scores for the three assignments for section two with the intervention of the knowledge check are outlined in Table 2 on the following page along with the overall homework subtotal score for all students who chose to participate in the research.

Table 2: Section 2 (intervention) knowledge check assignment scores and homework subtotal

	Knowledge Check 1		**Knowledge Check 2**		**Knowledge Check 3**		**Knowledge Check Subtotal**	**Homework Subtotal**
	Score	*%*	*Score*	*%*	*Score*	*%*	*Calculated Score*	*Calculated Score*
Mean (Average)	7.50	75.0%	7.03	70.3%	7.92	79.2%	74.8%	92.0%
Standard Deviation	2.49		2.75		3.00		2.75	0.09
Coefficient of Variation	0.33		0.39		0.38		0.37	0.10

Comparing the data from the two sections shown in Tables 1 and 2 it is observed that the subtotal average score for the knowledge check assignments in the intervention section was 9.3 % lower than that for the section with worksheets intended to emulate the more traditional way problems are assigned in the course. However, the overall combined subtotal of all homework assignments in the course was only 2.9 % lower for the intervention section. From this limited pool of data, I cannot draw any specific conclusions but is encouraged to see the overall scores in the two sections are at least similar indicating that the intervention did not strongly influence the overall score in that category in a strong way.

This difference in scores could be attributed to a number of factors. I have outlined some which may have been factors based on my experience so far in the following bullet list.

- Necessary differences in the rubrics used to assess two different types of assignments
- The unfamiliar nature of this type of assignment for those enrolled in a sophomore course
- Differences in the students enrolled in the two different sections of the course that were a part of this phase of the research investigation
- Additional skills necessary to create PowerPoint presentations and videos

Further reviewing the performance of the students who participated in the study this time with regard to exam scores and overall course grade it was found that there were minimal differences between the two sections with section 1 achieving an average prelim exam subtotal of 83.0 % and final exam score of 78.5 % compared to 78.1 % and 76.7 % respectively for section 2 with the intervention showing the two sections performed similar to one another. The overall course grade for the two sections was likewise close in nature with section 1 achieving a 90.8 % and section 2 an 87.7 %.

These small differences could be a result of the small set of data currently associated with this work in progress research or another factor or factors – as discussed above the I need more data to be able to make statistically significant argument with confidence. However, I believe that this does not dimmish the potential of this concept especially considering that it is a form of assessment which is more supportive of the diverse array of learners currently enrolled in engineering programs at the college level.

With the quantitative data showing some minor differences in the performance of the two sections compared to one another the qualitative data taken through Google form surveys was examined. The results of two questions from the section two end-of-semester survey specifically relating to student impression of assignment effectiveness and the knowledge check specifically are shown in Figure 1 below as pie charts.

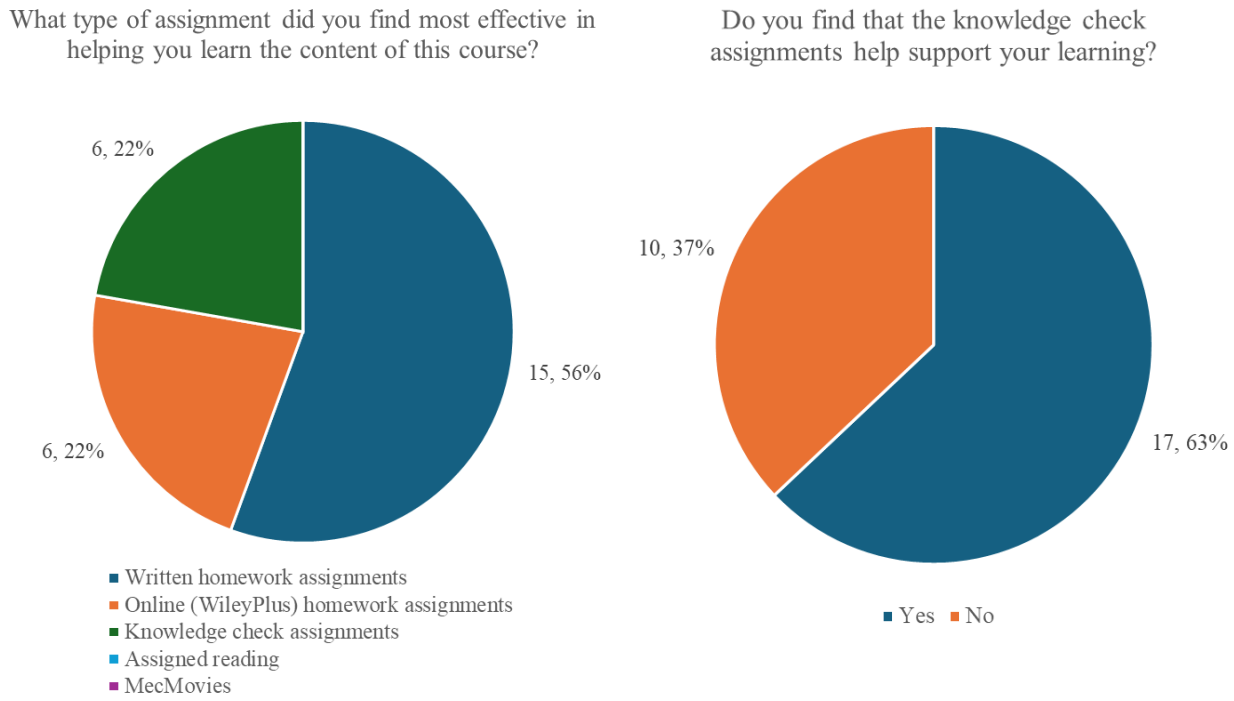

Figure 1: Section 2 (with intervention) end-of-semester survey results for two questions

Examining the contents of Figure 1 when section 2 was asked "What type of assignment did you find most effective in helping you learn the content of this course?" 22 % of respondents who participated in this research responded with "Knowledge check assignments" indicating that almost a quarter of respondents viewed the intervention assignment as having a positive impact on their education. Looking at the second pie chart in Figure 1, when section 2 was asked "Do you find that the knowledge check assignments help support your learning?" 63 % of respondents who participated in this research responded with "Yes." This further reinforces the positive student feedback on the intervention assignment as more than half of the survey results indicated that the students viewed the knowledge check as having supported their learning in the course.

Although the quantitative data showed a small decrease in assignment scores and other numerical metrics for the intervention group it was encouraging to see that the qualitative metrics from students were positive in nature. Figure 1 on the previous page showed a sub-set of the end-of-semester survey questions given to section 2 with the intervention. These questions were chosen because they specifically relate to two important factors; 1, student satisfaction and impression of the effectiveness methods used in the course, and 2, student impression of the intervention assignment specifically.

Continued Research

Although the current review of course grades did not show any direct evidence of the benefit of this new assignment the current amount of data is limited as the research at this time has only been conducted on one semester. Based on the valuable skills being practiced by students, the positive feedback received in comments both on in-class surveys and student evaluations of teaching, and the inclusiveness of this type of assessment for a diverse away of learners I plan to continue this research in the Spring 2026 semester and beyond.

In the execution of the study and examining the data collected during the first semester I discovered a number of lessons learned, some actions related to these are outlined below as they relate to the continued path of this research effort.

- Wording of certain survey questions can be improved to further clarify the questions
- Focus of future research will be on implementation of the knowledge check assignment and how to improve it
- Instructor will provide more scaffolding for the first knowledge check since potentially unfamiliar skills are being exercised in this assignment
- Different assessment strategies will be explored to investigate ways to make the grading of this type of assignment scalable while ensuring equity of scores

Future iterations of this research may expand its use to other solid mechanics-related courses such as labs and technical electives where the potential benefit of reinforcing soft-skills, different modalities of technical communication, and alternative ways of learning may benefit students. As they not only learn the material of the current course but also prepare to be professionals in world which increasingly relies on digital forms of communication such as online video conferences over traditional methods such as letter reports and in-person meetings.

As this research continues, the investigator welcomes discussion and feedback from others.

References

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[4] P. C. Brown, Make It Stick: The Science of Successful Learning, Harvard University Press, 2014.

[5] K.-H. T. B. Oliver Kliegl, "When retrieval practice promotes new learning - The critical role of study material," *Journal of Memory and Language,* vol. 120, 2021.

[6] L. D. N. J. R. B. Pooja K. Agarwal, "Retriecal Practice Consistently Benefits Student Learning: a Systematic Review of Applied Research in Schools and Classrooms," *Educational Pyschological Review,* pp. 1409-1453, 14 March 2021.

[7] H. A. Lee Sze Seau, "Introducing a Responsive Multimodal Oral Presentation Pedagogy: Integrating TED Videos with Web 2.0, Collaborative Learning and Teacher Feedback," *RELC,* vol. 53, no. 3, 2020.

[8] M. W. Lynch, "Using conferences poster presentations as a tool for student learning and development," *Innovations in Education and Teaching International,* vol. 55, no. 6, pp. 633-639, 2018.

Example Knowledge Check Assignment

Your knowledge check submission is a single video where you present an explanation of the following problem in the *Assignment Prompt* as a voice over of a series of three to four slides.

Assignment Prompt:

For the beam given in Figure 1 on the right complete the following assuming a rectangular cross-section and that the beam is constructed of A36 steel.

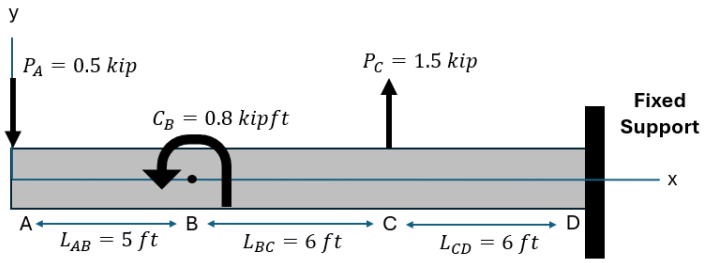

Figure 1: Cantilevered beam with external loading shown and a rectangular cross-section that is 4-inches tall and 2-inches wide.

- Construct the shear-force and bending moment diagrams
- Calculate the maximum normal stress induced by bending
- Calculate the maximum transverse shear stress

Assignment Requirements:

All submissions must adhere to the following requirements and be completed in full by the student as their own original work with citations where necessary.

- Must submit a video file in .mp4 format that is between 3 to 5 minutes in length.
- Students must record themselves speaking over an informative slide or series of slides to answer the prompt provided above.
- Slide(s) must be well-organized and informative helping to answer the assignment prompt.
- Slide(s) must include words and/or equations and at least one graphic, if a graphic is included from a source other than yourself you must provide the citation in the caption.
- Clearly presented and neat handwritten content may be used.

Submission File Format: A single .mp4 video file

Assignment Grading

Submissions will be graded using the holistic rubric shown below.

Excellent	Proficient	Developing	Beginning	Not Evident
100 %	*90 %*	*80 %*	*70 %*	*0 %*
The assignment demonstrates the student has a strong and accurate understanding of the material, delivers the oral explanation clearly, and uses well-crafted, organized, and relevant slide(s) to support their verbal content.	The assignment demonstrates the student has a proficient understanding of the core material, delivers the oral explanation clearly, and uses effective slide(s) to support their verbal content.	The assignment demonstrates the student has a partial understanding of the material, and/or the delivery lacks polish and/or the slide(s) are underdeveloped, cluttered, or not fully aligned with the spoken content.	The assignment shows the student has engaged with the content in a meaningful way but struggles with the content and/or the slide(s) may be difficult to follow, slightly off-topic, and/or the verbal explanation is unclear/unfocused.	The assignment was not submitted or in an improper format or was submitted and was significantly off-topic and/or does not demonstrate a meaningful attempt to engage with the content and/or shows little or no evidence of understanding or effort.