Paper ID #35945

Impact of student problem creation on self-reported confidence in mechanics

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Introduction

Learning in engineering science courses typically involves solving textbook-style questions. In a typical textbook-style question, students are given a problem statement, often with an associated image, that they must interpret and solve, coming up with a single correct answer.

Textbook style questions present the student with a problem statement, and typically include several key pieces of information, as well as an image to help with interpretation. Contrary to multiple choice problems, where a student chooses from several given answers, solving textbook style questions, with a clear and replicable solution requires a thorough understanding of the content. Multiple choice problems generally do not accurately assess the student's understanding of the content, as the student may have done the majority of the question correctly, but made an error in their final calculation, which would be given a mark of 0. Multiple-choice problems can also be randomly answered, giving a chance of getting the mark, without actually knowing the content. Textbook style questions come closest to typical real-world problems, and are those most often encountered on exams. The questions are more open-ended with the way they are marked, which offers students the potential for partial marks.

As part of a co-op term working on an OER project developing practice problems for engineering students, two of the authors (JGD and MS) anecdotally noted that the creation of problems deepened content understanding for the student problem developers. The process of creating many problems in a certain subject and preparing clear and correct solutions introduced the students working on the project to the different types of problems that can be asked in each subject.

Problem creation could be an effective part of the engineering science teaching and learning toolbox, however some mixed results have been observed. Problem creation has been previously explored in immunology and pathology as a method of improving student's knowledge and learning. After randomly splitting a class of 62 students (32 experimental, 30 control), the experimental group students were asked to write, answer, and explain 60 multiple choice questions covering different topics over the length of the term (Shakurnia 2018). Both groups completed identical multiple choice pre- and post-tests, and experimental students were surveyed on the question creation activity (Shakurnia 2018). The experimental group achieved on average 10% higher grades on the post-test, but the students noted that question writing is unfamiliar and unpopular as a learning strategy (Shakurnia 2018).

Students in their second year studying general pathology were assigned to create 4 multiple choice problems in the subjects of immunopathology or disturbances of electrolyte and acid-base status (n=75), and students in their third year studying pathophysiology were assigned to create 4 multiple choice problems in the subjects of blood or respiratory system pathology (n=109) (Herrero 2019). Students' performance on the specific section they had created questions for was compared against the rest of the class (Herrero 2019). The results of the study showed that students who wrote questions about immunopathology obtained scores on average 12.7% higher in that section than those who wrote problems in the other section, but those who wrote questions for the other section, or in the pathology group, showed no significant difference (Herrero 2019).

Similarly, there is evidence of student created problems benefitting learning in other science courses. The PeerWise system which allows students to write, answer, and comment on questions was used in 5 mainstream science undergraduate modules in three UK universities (Hardy 2014). The PeerWise assignment replaced a regular problem set, and prior to the assignment, the students were given an orientation and scaffolding session focusing on the benefits of the activity (Hardy 2014). 850 students were assigned the task of creating multiple choice questions on the PeerWise platform, with each class setting slightly different minimum requirements for the activity (Hardy 2014). The results suggest that students in the lower/intermediate part of the classes may have benefitted the most from the activity (Hardy 2014). It is important to note that the quality of student problems were not taken into account during the analysis (Hardy 2014).

Within the field of engineering, studies into student problem creation as a learning tool have also returned mixed results. 32 students studying electrical engineering were randomly-assigned to an experimental group (n=16) that was asked to select real-life problems and create solutions applying course knowledge, or to a control group (n=16) that was asked to complete a lab report for regular lab activities (Algarni 2021). Both groups were given pre- and post-tests of both knowledge and self-perception of their problem solving skills (Algarni, 2021). Knowledge results did not differ between groups, and problem-solving confidence differences were very limited, with the control group reporting more confidence on two out of nine items (no overall differences) (Algarni 2021).

In another study, 15 students in a manufacturing engineering technology program were asked to create a mock final exam as well as the corresponding answer key for the material assigned by the professor (Brink 2004). The students' exam was to include different question types, such as essay questions, calculation questions, and graphing hydraulic and pneumatic circuits (Brink 2004). The students were also explicitly instructed not to use multiple choice format questions. The students' questions were graded based on 3 criteria: quality, completeness/accuracy, and comprehensiveness (Brink 2004). After the course's final exam, the students were split into 3 groups: group 1 included those who had a final exam grade above 75, group 2 included those whose final exam grade was between 65 and 75, and group 3 included students whose final exam grade was below 65 (Brink 2004). Group 1 had an average question quality of 75.46, group 2 had an average question quality score of 68.12, and group 3 had an average question quality of 61.67

(Brink 2004). The results suggest that student problem generation is a more effective study method for above average students than for below average students (Brink 2004). This may however be due to above average students being better at predicting what the instructor will ask on an exam.

A lot of the research into problem creation as a learning tool focuses on using multiple choice questions, with a limited number of studies focusing on textbook-style questions. Also, the effectiveness of student problem creation as a learning tool has not yet been explored in engineering mechanics.

Our research questions are:

- Does creating their own textbook-like practice problems improve students' self-reported understanding of dynamics?
- Is creating their own practice problems viewed by students as an effective studying strategy and does their perspective change after creating one or more problems?
- Are there differences in the responses related to understanding and effectiveness between students who completed a one-problem bonus assignment in a course versus students who created many problems as part of a work-term?

Methods

We obtained institutional ethics approval (ethics approval number H21-03521) to complete the surveys in this study. Evaluation of the student-developed problems was part of program evaluation and did not require ethics approval.

In this cohort study, we performed surveys to assess self-reported confidence and understanding of mechanics topics related to problem-creation activities within two populations, “course students” (123 students from a second-year dynamics course) and “OER students” (current and previous members of our open educational resource (OER) mechanics homework problem project).

Student problem-creation assignment

As a part of course activities, the instructor assigned (for bonus marks) students in a second-year dynamics course to create one problem and solution in a course topic of their choice. The assignment was given near the end of the term, and all topics had been at least partly covered.

The students were asked to make a problem involving a children’s television show character, to help ensure the question was their own work and not merely a copy of an existing problem. The instructor offered a +2% bonus on their overall dynamics subject tests/exams mark for submitting a complete textbook-style problem and solution in any topic. The bonus marks were given regardless of problem correctness, and students could complete the course activity and obtain the bonus marks without participating in this study. The instructor also announced in advance that one of the top 10 highest-rated correct student problems would be asked on the final exam. Students submitted their work on ComPAIR for peer evaluation, to help determine the highest-rated problems and sort for correctness.

ComPAIR is an open source online tool used in courses for students to compare others' work after submitting their own. Students see pairs of their peer's work presented side-by-side for criteria based comparison and feedback, judging which one is better (but not how much better) in several categories (ComPAIR 2022). The students learn by comparing and identifying weaknesses and strengths that may not be apparent in an isolated assignment, encouraging critical thinking (ComPAIR 2022). The system uses an adaptive algorithm that pairs assignments with similar rankings as the comparisons go on, allowing an overall ranking of assignments to emerge from a large number of comparisons.

OER Mechanics project and WeBWorK

The OER (Open Education Resource) Mechanics project is an ongoing 2-year long project to develop open mechanics problems which will be published to the WeBWorK platform for use in first- and second-year engineering. The project aims to create hundreds of problems of varying difficulty for use in student homework and practice. The created problems will include clear images and full solutions. As part of the project, 13 co-op and part-time students have been hired to author and verify problems.

WeBWorK is an open-source online homework system for math and science courses (WeBWorK 2022). WeBWork is supported by the MAA and the NSF and comes with an Open Problem Library (OPL) of over 35,000 homework problems, most of them in mathematics topics (WeBWorK OPL 2022). The platform allows problem authors to randomize variables so students work with different sets of values. It provides students with correct/incorrect feedback on their answer submissions, and can supply hints and/or solutions.

The process of authoring a problem for the OER project starts with choosing a subject and unit to make the problem in. Then a type of problem is chosen (height based potential energy problem or a spring based potential energy problem). After the subject and type of problem are chosen, the problem is written down on paper, a rough image is prepared, and a solution is created. The problem is coded in Perl as a WeBWorK problem, then another student completes the WeBWorK problem to verify it is working properly and to check for clarity. The verification process is sometimes iterative, requiring a couple checks and fixes. After the verification is complete, a professional image is created for the problem. Once the entire problem is complete, the Perl file, the solution, and the image are uploaded to the database. Note that two paper authors (MS and JGD) were student problem authors in the OER project.

Surveys

For the first population (which we will designate as "course students"), a group of 123 students from a second-year dynamics course were sent a pre-survey assessing their understanding of topics in dynamics, whether or not they create their own practice problems to aid with studying, and why they do or do not create practice problems. Students were asked to develop their own practice textbook-style problem with a full solution as an optional bonus assignment during a second-year rigid body dynamics course. A second survey, distributed after the assignment was completed, asked students (both those who submitted problems and those who didn't) to self-evaluate their understanding, and ask whether or not they plan to incorporate problem creation into their regular studying habits (and why or why not).

Then, a third separate survey was sent out to 13 current and previous members of our open educational resource (OER) mechanics homework problem project (which we will designate as "OER students"). This project is an ongoing 2-year project where students create ~50-100 problems each per work term. We wanted to evaluate whether creating their own problems improved their understanding of dynamics and/or statics, and whether they have since implemented problem creation into their studying.

To answer our research questions, we prepared three surveys using the survey software Qualtrics (Provo, UT) to be presented to the students participating in the study. Two surveys were presented to the course students: the pre-survey and the post-survey. One survey was presented to the OER students.

In the surveys for the course students, the students were asked to create a unique code so their responses could be matched between pre and post surveys. The students were then asked to self report their confidence in the different course topics. In the post survey, the students were asked whether or not they created a problem for the assignment and which topic it was in. If the students reported that they created a problem, they were asked to self-report (on a Likert scale) their change in confidence and whether or not they would create problems as part of their future study practices. If the students answered that they would not use problem creation as a study method in the future, they were then given several multiple choice options, of which they could pick multiple, why they would not create problems. The students were also given similar multiple choice options if they answered that they would use problem creation as a study method in the future. At the end of the survey, the students were given an open ended text box for any additional comments they had about problem creation and its impact on learning dynamics. The surveys given to the OER students also asked whether or not they would use the study practice and why or why not.

Results
Out of the 123 students in the course, 77 (62.6%) students submitted problems as part of the bonus assignment. 21 of the students who submitted problems (27.2% of submissions) licensed their work with a Creative Commons license. A sample course student-created problem is shown in Appendix B.1.

The problem topics were not evenly distributed, with 44% of students choosing work-energy problems (Figure 1). This includes a large number of problems that did not require rigid body dynamics knowledge (i.e. no rotational kinetic energy), and was therefore content covered in the previous mechanics course. In contrast, only one student created a vibrations problem.

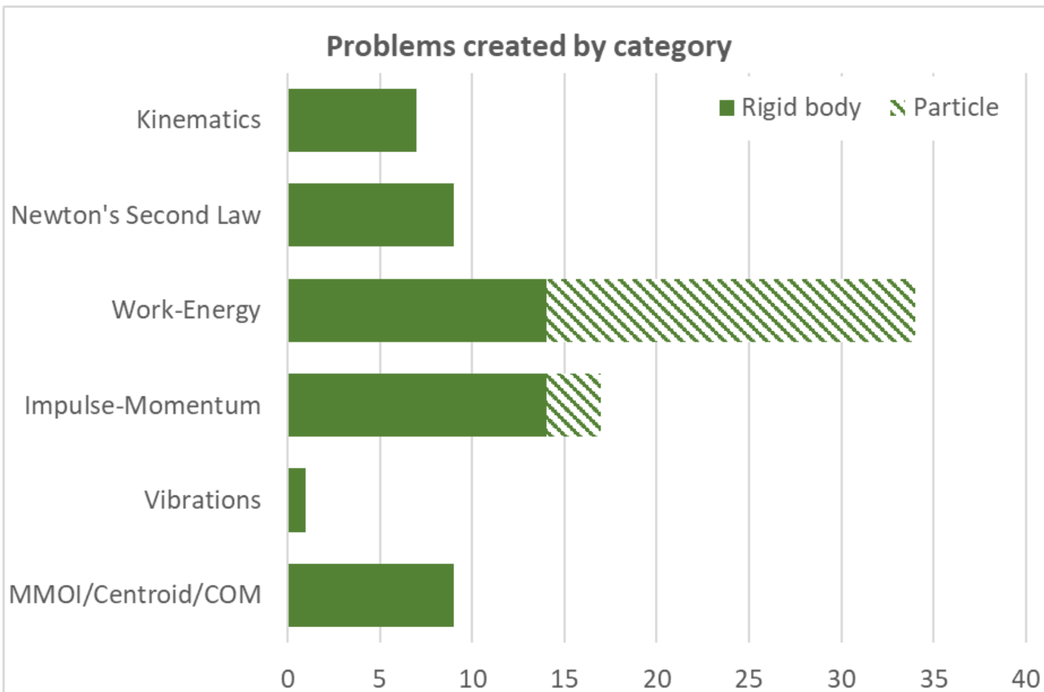

Figure 1: Categories of problems created by course students (n = 77). In cases where a problem included content from more than one topic, the topic presented later in the course was selected. In a couple of cases, one topic was particle-based and one topic was rigid-body based - in those cases, the rigid body topic was selected. MMOI = Mass Moment of Inertia, COM = Centre of Mass.

Twelve course students responded to the pre-survey and 10 course students responded to the post-survey. 5 students completed both surveys. Out of 13 OER students who worked on the project, 6 students responded to the survey. A sample OER student-created problem is shown in Appendix B.2.

The pre-and post surveys evaluated students' self-reported confidence in each of the 5 mechanics topics on a 4-point scale from "not at all confident" to "very confident" (Figure 2). It is important to note that the impulse and momentum topic was only partially covered in the course when the students were asked to fill out the pre-survey. The confidence results are mixed, with some areas showing increased and others showing decreased confidence

Five individual pre- and post- survey results were matched using their personalized codes, allowing for comparing confidence level in topics prior to and following problem creation (Table 1). 16% of student-topic confidence measures decreased, 40% increased, and 44% were not affected following problem creation.

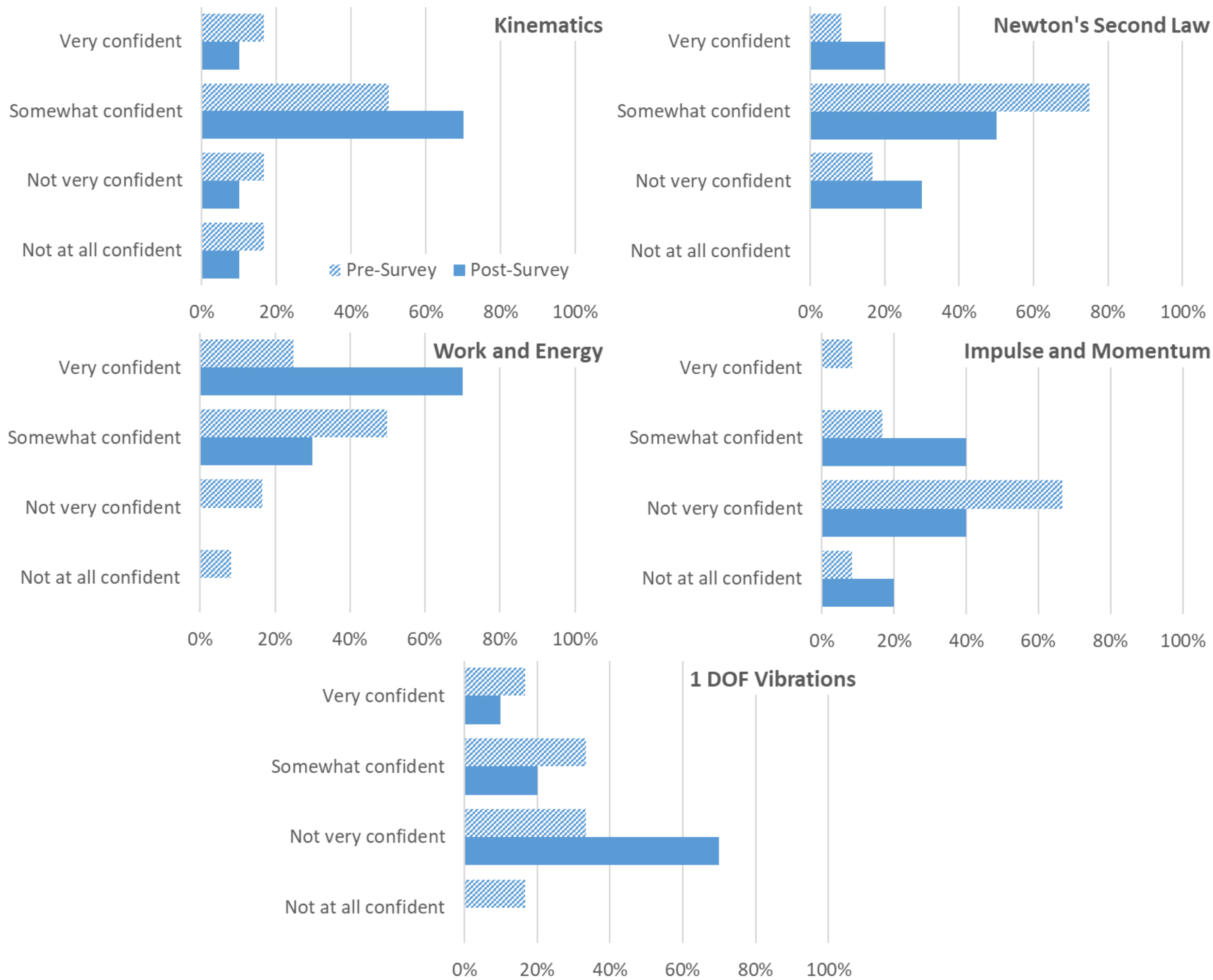

Figure 2: Course students' self-assessments of confidence in five rigid body mechanics topics on a 4-point scale. Students were asked, "How confident are you completing test questions in the following course topics?" The pre-survey (n=12) was taken near the end of the course when students had covered most topics, but before students had the opportunity to create their own rigid-body problem, and the post-survey (n=10) was offered afterwards.

Seven course students in the post-survey had participated in the problem creation activity. We asked if their confidence in their understanding of the particular topic of their created problem changed. Six students indicated their confidence in their problem topic stayed the same, and 1 indicated their confidence in their problem topic increased. OER students were also asked if their understanding of the mechanics content changed after their work term. Ten OER students said their understanding increased, and one said it stayed the same.

Table 1: Change in course students' self-reported confidence of five rigid body topics (post-survey minus pre-survey). (n=5)

Student	Kinematics	Newton's Second Law	Work and Energy	Impulse and Momentum	1 DOF Vibrations
1	1	1	1	1	1
2	0	0	0	-3	-1
3	0	0	1	-1	1
4	0	-1	1	1	0
5	0	1	0	0	0

Participants were asked if they created their own practice problems during study. If they said "no", they were prompted during all three surveys to select "What are the reasons you do not create questions as part of your regular dynamics study practice?". Results showed students have a variety of reasons, some of which changed after the problem activity in the course, or differed between cohorts (Figure 3).

The "other" responses about why students do not create their own problems were primarily related to the need for proper feedback on their work. They feel creating their own problems does not allow them to verify their understanding. Students also mentioned that they do not have enough time to create problems, and there are already many existing problems.

If students in any of the surveys replied that they did create their own study problems, they were asked to select reasons why they did so. The following options were possible:

1. It helps cement what I've already learned*
2. I can apply what I've already learned
3. I can better recognize where I make mistakes
4. It helps me figure out what information in the question is important
5. It helps me figure out what kinds of problems will be asked on the test
6. It helps me see why the instructor asks particular problems
7. It helps me see how the theory could apply to a new situation
8. I learn more than I do from other study practices

9. I get better marks when I make questions
10. I learn more from peers when I make questions
11. I become more confident in the material after creating questions
12. I understand the material better after creating questions

*Not offered as an option in the OER student survey

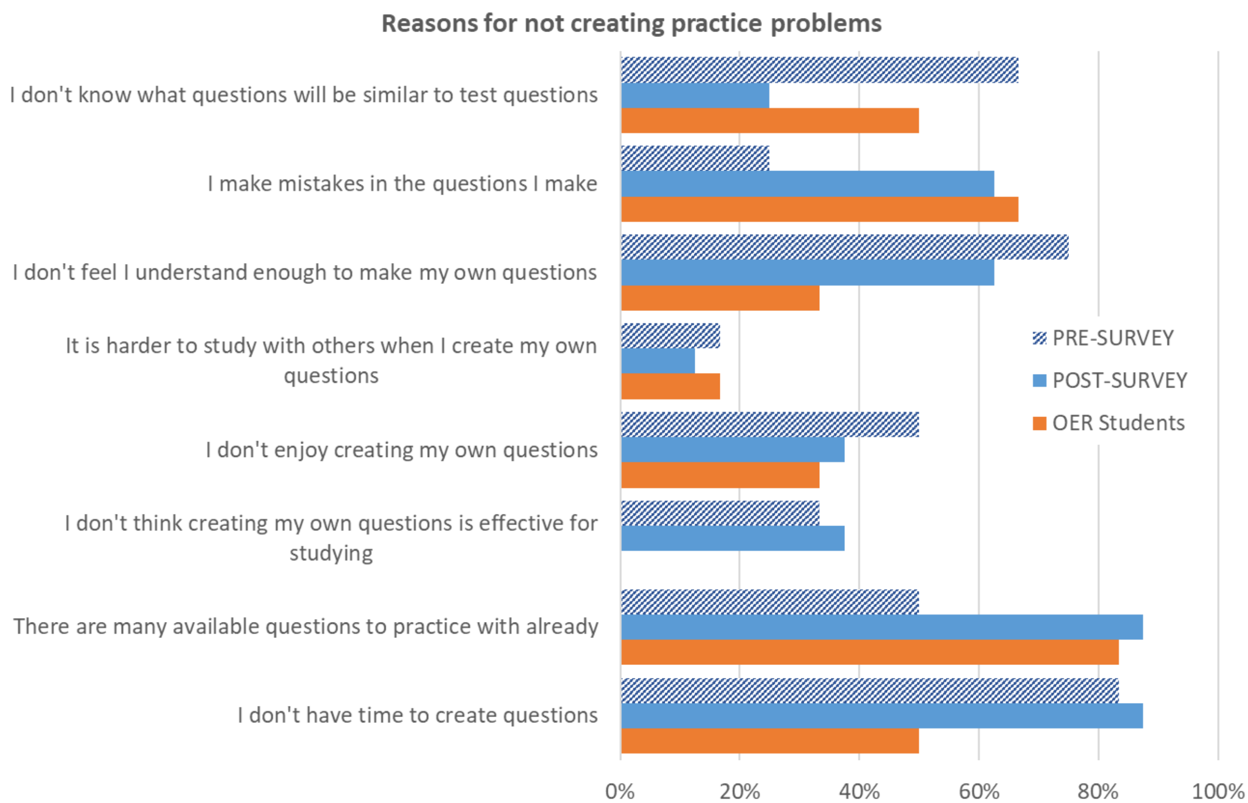

Figure 3: Summary of reasons for not creating problems, collected across all three surveys. Participants were given a checklist of 8 reasons to choose from. The pre-survey, post-survey, and OER Students survey had 12, 8 and 6 responses respectively.

Only one course student responded to the post-survey with reasons for creating their own problems. This student selected prompts 4, 5, 6,10, and 11. The remaining prompts (1, 2, 3, 7, 8, 9, and 12) were not selected.

Three OER students gave reasons for creating their own problems. Among these, all students selected prompts 3 and 4, two students selected prompts 2, 7, 10, and 12. Prompts 5 and 11 were selected by 1 student each, and the remaining prompts (6, 8, and 9) were not selected.

Student comments created during the comparison process (n=512) were coded for type of comment. Students were provided with guidance questions and examples for evaluation, but most comments were short (mean 56.1 (SD 59.2) characters per comment). The distribution of types of comments showed that around half of comments did not include any constructive feedback (Table 2). These comments were typically supportive (e.g. “Good question!”). Most of the comments that provided constructive feedback were around clarity of problem, solution or image. Only 3.1% of comments provided feedback on correctness of the problem or solution. There were also few comments on the usefulness of the problems either for studying or as an exam problem (5.7%).

The instructor also provided feedback for a subset of problems, based on a short review (not a full check including math). The instructor comments typically addressed correctness but were not included in the totals above. This included completing 13 comparisons (26 problems) to contribute to the ranking. Of these, the instructor identified errors in 12 problems (46%). The instructor also made public comments on the 18 top ranked problems, starting at the top, in order to find 10 correct ones. Of these, the instructor identified errors in 9 problems (50%). These rates of error detection were much higher than the student rates. Students had access to the instructor comments prior to the post-survey.

Table 2: Content analysis of ComPAIR comments from students. A total of 512 comments were left for other students as part of the comparison process. Some comments had more than one type of content, so totals are >100%.

Comment content	**No. of comments**	**% of comments**
No constructive comments and/or remarks about creativity/humour/etc.	252	49.2
Supportive remark about dynamics content/realism	32	6.3
Supportive remark about correctness	3	0.6
Supportive remark about level of difficulty	29	5.7
Supportive remark about clarity of problem/image/solution	165	32.2
Supportive remark about usefulness	23	4.5
Critical remark about dynamics content/realism	12	2.3
Critical remark about correctness	13	2.5
Critical remark about level of difficulty	27	5.3
Critical remark about clarity of problem/image/solution	77	15.0
Critical remark about usefulness	6	1.2

Discussion

In this paper we explored the learning potential of student problem creation in two separate cohorts - a course cohort that completed one problem and received limited feedback on correctness, and an OER student worker cohort that completed many problems and received detailed feedback on correctness.

In the course students, question quality was low - this included correctness and covering current course topics (rather than previous topics). In contrast, Bates et al. (2014) found high levels of student quality (75% met quality criteria). Differences between these results could include the scaffolding process implemented in that study which was not present in our activity, and the characteristics of multiple choice problems in a more introductory course, which may have simpler solutions (therefore fewer opportunities for error).

Students had very consistent reasoning for why they did not create their own problems in studying. Few of the problems were given critical feedback, and few students identified issues with correctness of the problems, while the instructor provided corrections to a large proportion of problems. It is possible that the increase in course students reporting “I make mistakes in the questions I make” in the post-survey is somewhat a response to instructor feedback. OER students also received detailed feedback from both student co-workers and at least one faculty member. If this is the mechanism for recognition of errors, it makes sense that the response rates for this item are similar between the post-survey and OER students. Most students also reported a lack of time and lack of available solutions (confirmation that the answer to their developed problem is correct) as reasons for not creating their own problems.

OER students likely built more confidence in creating problems through both volume of problems created, critically reviewing the work of other students, receiving instructor feedback, and revising problems. OER students also tended to cover a range of topics, and could not stick only to those they felt comfortable with. There was also no OER student who felt that problem creation wasn’t an effective learning strategy - it would appear that they did learn from this work. OER students also felt they know enough to make problems, which may reflect their having completed the course(s) in the topics they were working on. Shakurnia et al. found learning benefits for students who created 60 multiple choice questions covering different topics over the length of the term, which is closer to the experience of the OER students than the course students. OER students overall reported that their understanding of mechanics increased following their work term.

Course students seemed to stick with topics they were comfortable with (e.g. Work-Energy), and were not required to revise and correct their problems. The students who completed the problem creation activity and the post-survey did not indicate substantial gains in confidence in the topic of their problem.

Identification of errors in problems appears to be a critical part of learning in the problem creation activity. In the case of this course, no marks were allocated for good critical evaluation of other students' work. Based on comments indicating their enjoyment of the character or situation involved in the problem, student motivation in giving feedback appeared to be to promote the problems they thought were amusing or evoked nostalgia. In future, both providing training in evaluation and having marks allocated for critical feedback may improve this aspect. The opportunity or requirement to revise and correct problems with issues could also be added.

Because multiple choice questions require different creation strategies than typical mechanics homework problems (e.g. focus on a single concept, creation of distractors), it's not clear if learning gains are the same as many of the previous studies that have looked at the impact of student problem creation.

The strengths of this work include evaluating the impact of student problem creation in two different groups of students. We were also able to evaluate course student feedback and aspects of problem quality. We explored a range of reasons why students do or do not make their own problems as part of their study practice.

Limitations of this work in terms of the course-bases intervention include lack of scaffolding, only one problem required, no incentive to produce correct problems, no incentive to give constructive feedback, and no requirement to revise. There were also low survey response rates among the course students.

Future work may include revising the single problem creation activity into a longer, more structured series of problems, and investigating some of the identified barriers to creating problems as a study method.

Conclusion

We found that students that had experience creating problems recognized that errors were common in their problems, and that students who had created a large number of problems believed that problem creation was effective for learning. Learning may depend on the volume of problems created and/or the critical feedback and revision process. The main reasons students listed for why they would not use problem creation as a tool in their regular studies are a lack of time and a lack of correct solutions.

Acknowledgements

This work was completed on the traditional, ancestral, and unceded territory of the Musqueam people. We would like to acknowledge the leadership of Jennifer Kirkey (Douglas College) on the OER Mechanics project, and our project funding support from BCcampus. We would also like to acknowledge the creative problem development work and study participation of both past project team members and members of the 2021-2022 UBC Mech 2 cohort.

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Appendix A

A.1. Assignment text

DYN Make-Your-Own Exam Question (Bonus marks)

Research has shown that creating your own test questions as part of studying can lead to improved outcomes on tests and exams, and better understanding of the material.
In this bonus activity, create one test-like problem and solution for dynamics. Your problem should:

- Be yours. Not a copy of a textbook problem (although something similar is okay). To facilitate this, I'm going to ask that you make your problem based on one of your favourite children's TV shows. (Think about how characters and objects move in the show). Feel free to link to a sample video of the show if others might not know it.
- Use concepts from rigid body dynamics.
- Have a clear sketch (no need to make professional images).
- Have a complete solution that your peers can follow.

Submit via ComPAIR. Then review other students' problems. You can complete reviews of up to 10 questions (or as few as you'd like). Reviews will dictate the ranking of problems, which will impact which problem gets used on the final exam (see below). (All students will be able to see all submissions, and provide additional feedback.)

Students who submit complete, original problems and solutions will receive +2% bonus on their overall DYN subject tests and exams grade.

If there are at least 10 complete submissions with correct solutions, I will use one (or part of one) of the 10 top-rated correct problems on the DYN final exam.

If you wish to, you can indicate that you would allow your problem to be coded into WeBWorK or made into a homework problem for Mechanics Map. To do this, please add "CC BY-SA" to your submission (top of your PDF submission, or in the text submission field). We will then add your name to your submission during later use (so your name will not be visible to peers in ComPAIR). (If you'd prefer to not be recognized by name, you can list another designation (e.g. "CC BY-SA Rockin' Rotation"), or add "CC 0" (CC Zero, public domain) to your submission). Find out more about licensing your work openly at Creative Commons. There is no requirement to do this for the bonus marks.

A.2. ComPAIR criteria

In the ComPAIR system, instead of absolute evaluations (e.g. give a mark out of 10), students are shown two peer answers, and asked which one is better on several criteria. The criteria used in the assignment from A.1 are the following:

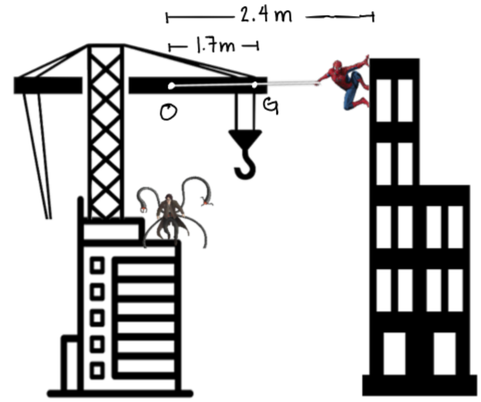
1. Which problem has the clearer problem statement?
   Consider aspects such as:
   - Is the writing clear? [Grammar/spelling errors are fine] Do you understand what is happening?
   - Is all the information you need included? Are any assumptions you need to make reasonable?
   - Is the diagram (if any) clear? Are the necessary variables or points labelled?

2. Which problem would help your studying more?
   Consider aspects such as:
   - Does the problem include dynamics core concepts?
   - Does it highlight a common mistake (e.g. not taking parallel axes from G, forgetting centripetal acceleration)?
   - Does it help you determine if you understand a topic?
   - Is it too hard or too easy?
   - Would you choose to try this problem when studying?

3. Which problem has the clearer solution?
   Consider aspects such as:
   - Is the solution complete? Are all the solution steps included?
   - Is the solution correct? Are there any mistakes?
   - Are there FBDs (if needed), and are they free bodies with all forces and moments?
   - Is the notation consistent and understandable?

Appendix B

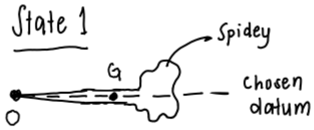
B.2. Sample Course Student problem - Dainelle Morales



Spiderman and Dr. Octopus are fighting!! Their previous commotion left Doc Ock disoriented and Spiderman clinging onto a rooftop. Spidey shoots a web onto the crane just above Doc Ock and lets go of the building. Find Spidey's angular velocity just before hitting Doc Ock. For simplicity, assume:

- Spiderman with the web is a rigid body of m=75kg, K_G= 600mm, and has its centre of mass at point G
- There is no air resistance

State 1



$V_1 = mgh$

$= (75)(9.81)(0)$

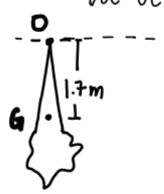
$\rightarrow V_1 = 0 \text{ J}$

$T_1 = \frac{1}{2} m v_G^2$

$= \frac{1}{2}(75)(0)$

$\rightarrow T_1 = 0 \text{ J}$ (at rest)

State 2 : Just before hitting Doc Ock



$V_2 = mgh$

$= (75)(9.81)(-1.7)$

$\rightarrow V_2 = -1250.775 \text{ J}$

★ know:

$I_G = mk_G^2$

$= (75)(0.6)^2$

$\rightarrow I_G = 27 \text{ kg} \cdot \text{m}^2$

★ Also, since point O acts like a pin, we can use:

$v_G = \omega r$

$\therefore v_G^2 = \omega^2 r^2$

$T_2 = \frac{1}{2} m v_G^2 + \frac{1}{2} I_G \omega^2$

$T_2 = \frac{1}{2} m \omega^2 r^2 + \frac{1}{2}(27 \text{kg} \cdot \text{m}^2)\omega^2$

$\rightarrow T_2 = \frac{1}{2}(75\text{kg})\omega^2(1.7 \text{ m}^2) + \frac{1}{2}(27 \text{kg} \cdot \text{m}^2)\omega^2$

↳ Since there's no non-conservative forces, we can use conservation of energy

$$T_1 + V_1 = T_2 + V_2$$

$$0 = -1250.775 + \frac{1}{2}(75)\omega^2(1.7)^2 + \frac{1}{2}(27)\omega^2$$

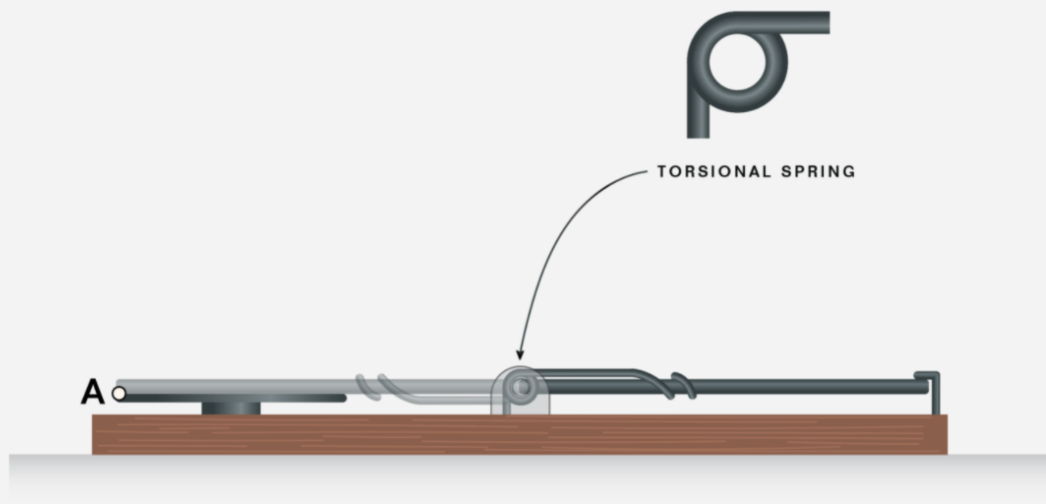
$$1250.775 = 108.375\omega^2 + 13.5\omega^2$$

$$\sqrt{\omega^2} = \sqrt{\frac{1250.775}{121.875}}$$

$$\therefore \omega = 3.2036 \text{ rad/s}$$

B.1. Sample OER Student problem - CC BY UBC Engineering

A mouse trap uses a torsional spring ($k = 150\ N/rad$) to store energy. The spring is wound such that it is undeformed when the jaw of the trap sits on the wooden base. The jaw has a mass of $100\ kg$, a length of $9\ cm$ and a moment of inertia of $3\ g \cdot m^2$ about the hinge. What is the velocity with which the tip of the jaw strike the wood when it is triggered if $8\ J$ of energy is used against friction in the hinge?



$v =$ [ ] m/s

[Note: numeric values differ in solution due to randomized variables]

Solution

This is just a simple conservation of energy problem.

$$E_{\text{spring }1} + E_{\text{kinetic }1} = E_{\text{spring }2} + E_{\text{kinetic }2} + W_{\text{friction}}$$

$$\frac{1}{2}k\left(\Delta\theta\right)^2 + 0 = 0 + \frac{1}{2}I\omega^2 + 100$$

$$\frac{1}{2} \cdot 100 \cdot \pi^2 = \frac{1}{2} \cdot \frac{2}{1000}\omega^2 + 100$$

$$\Rightarrow \omega = 627.3 \quad [\ \text{rad/s}\ ]$$

$$v_A = \omega \times r$$

$$= 62 \quad [\ \text{m/s}\ ]$$