Back to the Basics: Implementation of Structured Homework Assignments in Dynamics

Introduction

The authors experimented with a structured homework system in a required dynamics course for mechanical engineering students. This course typically has 40-90 sophomore and junior level students enrolled and has been taught in a flipped format, using the SCALE-UP model (Beichner 2008) and team-based learning (Michaelsen, Knight et al. 2002) for several semesters. For many semesters, the instructor has utilized an online homework system. Recently, the instructor wondered about the impact of the online homework system on the ability of students to solve problems and on their engagement with the material.

The online homework system, while very convenient for the instructor (automatically assigned, graded, incorporated into the learning management system), seemed to have unintended side effects on how students were approaching the homework. For instance, students rarely had collections of their work related to the homework assignments, which in previous offerings of the course were a major component of their study material for exams. Additionally, the homework system encouraged a focus on obtaining the correct numerical answer, with no value attached to the process of solving the problem. Finally, the homework was disconnected from the way the rest of the course was taught. In-class work focused on understanding the process, setting the problem up correctly, etc. but the online homework system focused on obtaining the correct numerical answer, regardless of how the problem was set up or what process a student used. Therefore, the instructor developed a structured problem-solving template that was used for in-class examples, in-class work, and homework. This paper explains the implementation of the structured homework system and survey results from students who took the course with either the online homework system or the new system.

Methods

Course Format: In Spring 2017 (online homework system) and Fall 2017 (new homework system), the course was taught in a flipped format (Beichner 2008) in an active-learning classroom and utilized team based learning (Michaelsen, Knight et al. 2002). Each class meeting consisted of: 1) reading quiz, 2) team development, 3) lecture highlights, 4) example problem(s), and 5) group work. The instructional team consisted of the professor, two graduate teaching assistants, and two undergraduate teaching fellows (UGTFs). Undergraduate teaching fellows were undergraduates who had recently done well in the course and were embedded into the course to help with active-learning activities. The instructor, GTAs, and UGTFs walked around during the group work time to assist groups and/or individuals with questions.

Description of Homework Systems: In Fall 2017, the homework system changed compared to Spring 2017. The instructional team developed new homework problems, and a common homework template (example shown in Figure 4 at end of paper). The template included an instructor-provided problem statement and problem illustration. The student had specific places on the page to: a) gather information, b) organize their approach, c) sketch the system, d) analyze the problem symbolically, e) solve the problem with numbers, f) report final numerical answers, and g) reflect on the answer. Parts a, b, and c together were worth 2/10 points. Part d was worth 4/10 points, part e was worth 3.5/10 points, and part g was worth 0.5/10 points. To create the problems, graduate research assistants browsed several dynamics books to understand the typical types of problems used, and then created problems similar in scope and content. The homework solution template was designed to force students to utilize the problem-solving approach the instructor was working to develop. For instance, students had to draw a diagram of the system, which sometimes seems unnecessary to students early on because the problems are straightforward. However, forcing them to get into this practice helps to make sure they understand the system before they get started crunching numbers and builds the correct habits that will allow students to solve more complicated problems with ease.

The students were required to first solve the homework problems algebraically and determine the symbolic solution, before plugging in the given values and finding the numeric solution. This served several purposes: first, it helped the students think about the problem and the approach that they should take before they jump straight into plugging numbers into equations and seeing if they can come up with an answer. Secondly, in the future, this will allow for video solutions to be created that walk students through the solution to the problem, but will only address the symbolic solution. By doing so, the same problems can be reused in future semesters, with new given parameters resulting in different answers for the problems, but the video solutions can remain the same because the problem-solving process remains the same.

One of the main advantages of the online homework system is that the students receive immediate feedback on their solution to the problem, which students appreciate and helps with learning the content. To deliver similar feedback with the new system, the students were given the numerical solutions to each of the homework problems through the course website. By providing the numerical answer, the students could ensure that they were solving the problem correctly, and if they were not then they could either try and fix their mistake or come to office hours to receive help on the problem.

To help alleviate the amount of time required to develop additional homework problems that can be used in future semesters, students were given the opportunity to develop their own problems for extra credit. They worked with their team to develop a relevant problem that addressed a specific learning objective and a complete and correct solution. In previous semesters, the students had been given an opportunity to solve extra problems through the online homework system and receive extra credit towards their semester grade. This gave the students a similar opportunity to boost their semester grade.

Survey Description: A survey was sent via email to students who had taken the course in the previous semester (Spring 2017), and those that were currently in the course (Fall 2017) and using the new homework system. The survey asked Likert-scale questions about the following: "*How often did you complete the homework assignments?*" "*How likely were you to have the solutions you generated available to you after turning in the homework?"* and *"How satisfied were you with the homework system?"* Students were also asked, if given a new dynamics problem similar to what they have seen in the course, to rate their level of confidence in their ability to: 1) understand the problem and set it up correctly, 2) Knowing the steps needed to solve the problem, and 3) Getting the correct answer. Finally, students were asked for their open-ended responses to the following questions: "*If you were given a dynamics problem similar to what you may have seen in the course, how would you go about solving it? Describe the process you would follow," "What aspects of the homework system did you find effective in helping you to master the course content," and "What aspects of the homework system did you find ineffective in helping you to master the course content?"*

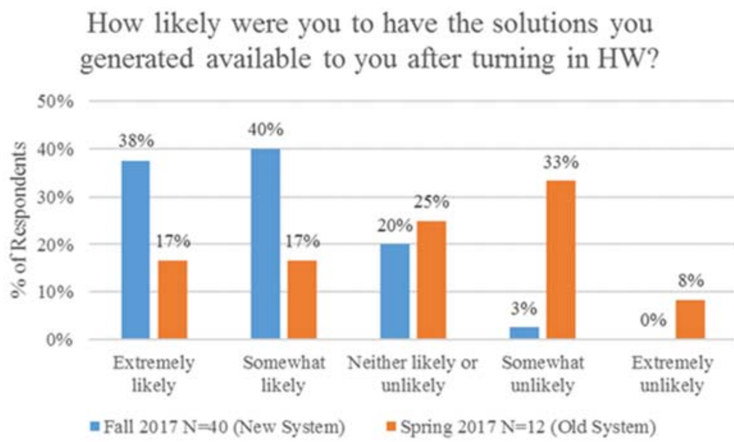
Responses to the open-ended question about the process of solving the problem were reviewed and categorized as: "outlined the process in detail," "outlined the basic process," "vague or no outline of process," and then those that indicated "googling it" or following a process "similar to the homework" were also noted.

Results

Instructor Feedback: The instructional team for the course reported being more highly satisfied with the engagement level of the class. In the Spring 2017 offering of the course (online homework system), the graduate teaching assistants reported seeing approximately 1 student per week in the 4 hours of office hours offered, and a total of 2-3 different students over the course of the semester. In the Fall 2017 offering of the course (new homework system), the graduate teaching assistants reported seeing approximately 8-10 students in office hours each week, and a total of 15-20 different students over the course of the semester. Students seemed to understand the concepts associated with the course much better and came to office hours with the goal of understanding how to do the homework in the Fall 2017 class, instead of coming to office hours with the goal of getting the right answer on the homework, which was typically the case in the Spring 2017 course.

Survey Results: The survey was sent to 42 students who had taken the course in the Spring 2017 semester, and 12 responses were collected. The survey was sent to 58 students who were enrolled in the Fall 2017 (current) offering of the course, and 40 responses were collected. The comparisons made in this section are presented with the caveat that only 28% of the students who used the previous system responded to the survey.

Students in both offerings of the course completed the homework the majority of the time, but students using the new homework system were more likely “always” complete the assignment (80% compared to 58%). 78% of students using the new homework system were either “extremely likely” or “somewhat likely” to have the solutions they generated available after turning in the homework, compared to 34% of students using the old system (Figure 1). This is consistent with what the instructor noticed, which is after getting the correct answer to the homework on the online system, students often discarded their work. 80% of students using the new homework system indicated they were either “extremely” or “somewhat” satisfied with the homework system, compared to 50% of respondents who used the online system (Figure 1).



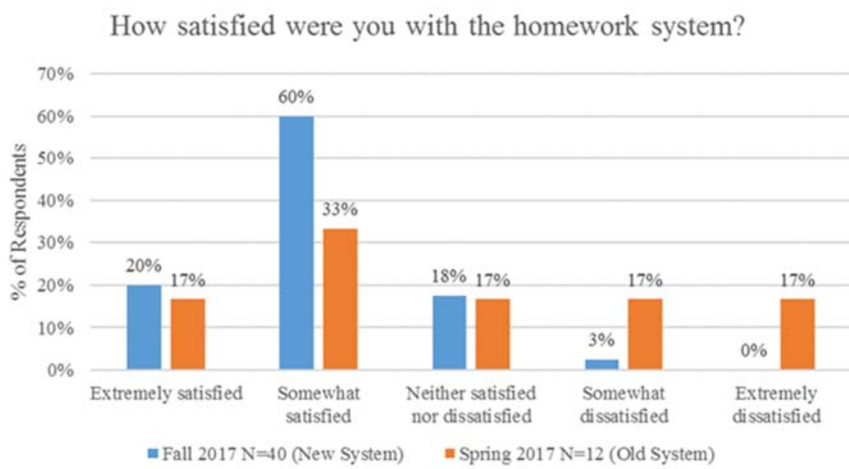


Figure 1. Student survey feedback

When asked about their confidence level in setting up a problem, knowing the steps to solve, and getting the correct answer, respondents using the new system were more confident than students who used the old system at “understanding the problem and setting it up correctly” and “knowing the steps need to solve the problem.” Students using the new system were less confident than those who had used the old system at “getting the correct answer,” (Figure 2).

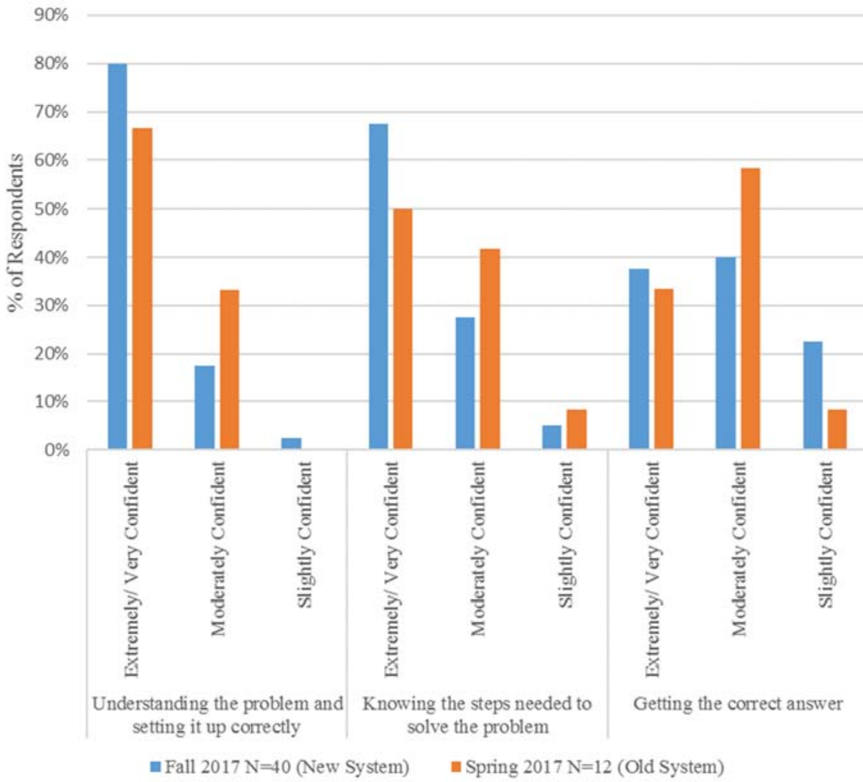


Figure 2. Student survey results on confidence in solving problems

Responses to the open-ended question asking "*If you were given a dynamics problem similar to what you may have seen in the course, how would you go about solving it? Describe the process you would follow,"* were interesting. Two out of the 10 from the online homework semester who answered the question responded that they would "google it." None of the 32 responses from the new homework system students referenced "googling it" or anything else related to looking for the answer online. Figure 3 shows the percentage of answers in each category for both semesters.

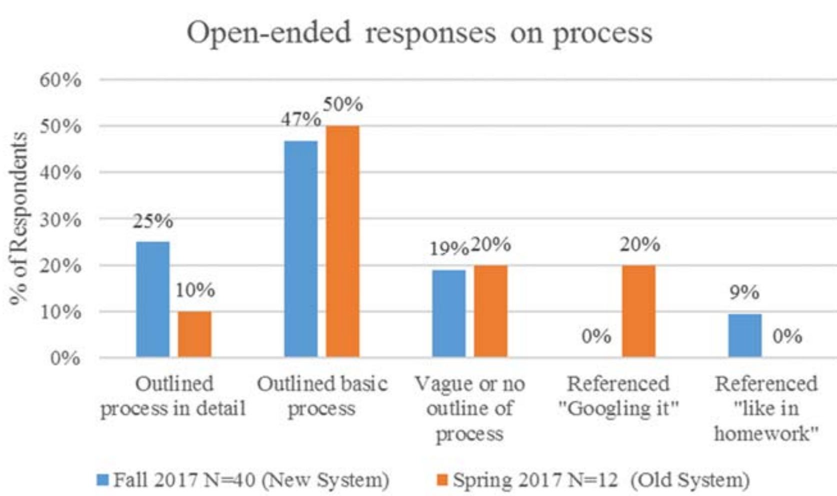


Figure 3. Student survey results on confidence in their problem-solving process

Discussion

Survey feedback and feedback from the instructional team indicate that the new homework system encourages more student engagement with the homework. The online homework system has many benefits. The students like the immediate feedback, the hints that were available, and the large number of problems available to work through. The instructors appreciated the convenience of the automatic grading and integration with the school's learning management system. However, the new system has shown to be effective at getting students engaged with the homework earlier than normal, and at a deeper level than before- indicated by the much higher numbers of students spending time at office hours and the types of questions asked.

Students were more likely to keep their solutions and have them available to them for studying. Students were also more than twice as likely to be able to describe, in detail, the process they would go through to solve a dynamics problem, compared to students utilizing the old system. Both of these outcomes address the motivation for creating the new homework system, and the new system will be used in future offerings of the course.

Future work includes collecting more data on the impact and feasibility of the new homework system, creating the video solutions to go along with the homework problems, and investigating the sustainability of this system as more and more offerings of the course utilize these problems. More robust data on how the homework system impacts student learning may be conducted as more semesters of data are collected. Individual performance on learning objective achievement, and performance in downstream courses may be investigated to understand the impact of this change on student learning.

Acknowledgements

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References

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HW Problem **Name:**___________________ **Team #:**____ **Student #:**____

LO: Find kinematic quantities (s, v, a) of a particle traveling along a straight path.

Problem Statement

An object has an initial position $s_0 = 0\ m$, and initial velocity $v_0\ [m/s]$, and is under an acceleration of $a(t) = kt\ [m/s^2]$, t being in seconds, and k being a constant

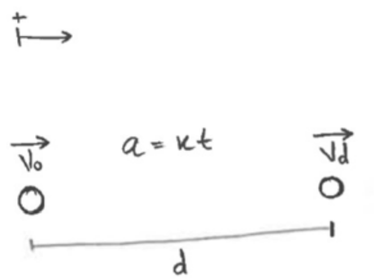
Determine:

1. The units of k.
2. The equations describing the object's velocity $v(t)$ and position $s(t)$ as a function of time.
3. The velocity in $[m/s]$ of the object when it has reached the position $s = d\ [m]$
4. The time in seconds that the object takes to reach $s = d\ [m]$

Remark:

- When solving questions 3 and 4, solve for the smallest positive time.

Problem Illustration.



A. Gather Information.

Given:

Find:

Parameter Values Provided:

$v_0 =$

$k =$

$d =$

B. Organize Your Approach.

Provide your strategy, principals and equations.

C. Sketch your system.

For example, provide the free body diagram (FBD) and kinetic diagram (KD), etc.

Figure 4. Structured homework template, page 1

HW Problem **Name:___________________ Team #:____ Student #:____**

LO: Find kinematic quantities (s, v, a) of a particle traveling along a straight path.

D. Analyze the problem using symbols.

Note: do not substitute in any numbers into your equations (e.g. initial conditions, parameter values, etc.). Must show all steps. Circle your final answers expressed in symbols.

Figure 4. Structured homework template page 2

HW Problem **Name:____________________ Team #:____ Student #:____**

LO: Find kinematic quantities (s, v, a) of a particle traveling along a straight path.

E. Crunch the numbers.
Using results from step D, if provided, substitute in all numerical values for initial conditions, parameters, etc.

F. Report final numerical answers.

1.

2.

3.

4.

G. Reflection.
Demonstrate that your numerical answers are reasonable.

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Figure 4. Structured homework template page 3