Student Responses to Homework Wrappers

Carl R. F. Lund
Department of Engineering Education
University at Buffalo
Buffalo, NY, USA
lund@buffalo.edu

***Abstract*—This Innovative Practice Work-In-Practice paper examines use of homework wrappers in an upper-division problem-solving course. Problem-solving homework assignments can afford students the opportunity to practice applying and integrating newly acquired knowledge, thereby increasing their mastery of the subject they are studying. Often, when solving homework problems, students' goals are to obtain a correct answer. Common student strategies for obtaining a correct answer do not help them learn and understand how to obtain that answer. In the undergraduate chemical reaction engineering course used to this study, the same small set of primary equations is used to solve several different types of problems. While the equations are the same, the way in which they are used is quite different from one problem type to the next. After completing each problem-solving homework assignment, students have been required to submit a brief, reflection on their approach to solving the problem. These reflections, called homework wrappers, aim to help students assess their ability to differentiate different types of problems, their understanding of the approach required for solving each problem type and their proficiency in applying that approach. The conceptual mistakes identified by the students were compared with an expert's assessment of the conceptual mistakes they made. The results show that the rate of recurrence of a mistake that a student correctly self-identified was 4.6% while the rate of recurrence of mistakes that went unidentified was 29.3%. On the basis of these early results, continued study and refinement of the use of homework wrappers as learning tools is suggested.**

Keywords—feedback, problem solving

I. Introduction

In an upper-division engineering problem-solving course taught using traditional lectures with graded homework assignments and exams, it was observed [1] that course grades increased only slightly with increased homework effort. The difference in the distribution of exams scores for those who made an above average homework effort was equal to that of those who made a below average effort. Over time, four changes were effected: the class was converted to a flipped instructional format, the basis for homework grading was changed from accuracy to effort, expert reasoning during problem solving was explicitly and implicitly taught and homework wrappers were added to most homework assignments. The intent of these changes was to increase opportunities to practice without penalty for failure, to shift student motivation from grades to learning and to improve feedback to the learners. After the changes, exams grades increases with homework effort were over 2.5 times greater than before the changes.

Generally, wrappers are assignments that ask students to reflect upon their learning strategies [2-4]. They are often used following exams, prompting students to consider how they prepared for the exam and how they might change their preparation for future exams. Here wrappers were used with homework and prompted the students to self-evaluate their problem-solving mastery. The specifics of the homework wrappers have been described previously [1, 5]. Briefly, after the solution to a homework problem was posted, students were asked to compare their solution to the posted solution. They were instructed to focus upon whether, at the time they solved the problem, they knew which equations to use and how to use those equations. They were then asked to identify their mistakes, classify them using a given set of options and write a brief (1-4 sentence) self-assessment.

A previous study [5] examined the accuracy of the students' self-generated feedback when using homework wrappers. Specifically the students' classifications of their errors were compared to an error classification generated by an expert in the field of the problems. That study found a low rate of response (61%) to the wrapper assignments and a low accuracy (43%) of the responses. Changing the details of the implementation should lead to increases in both the response rate and the response accuracy. This paper examines the relationship between wrapper responses and non-responses and the recurrence of specific problem-solving mistakes.

II. Methods

The subjects in this study were the 81 students taking the Fall 2018 offering of a required upper-division chemical engineering course on reaction kinetics and reactor design. The class met for 50 minutes, three times per week over a span of 15 weeks with an additional 3 hour final exam in the 16th week. In total, the course spanned 109 days from the first class meeting through the final exam. Prior to most class meetings, the students were assigned videos and written material to watch and read. At the start of class, those materials were reviewed and students had an opportunity to ask questions. For the majority of the class meeting, students were engaged in solving a problem based upon the pre-class materials. These in-class activities were often scaffolded and were designed to lead the students through the reasoning used by an expert when solving that type of problem. Typically the students worked in ad hoc groups of three during class while the instructor circulated through the class answering individual questions, observing and offering advice.

In this course three basic equation types (mole balances, energy balances and momentum balances) are used to solve most problems. However, these equations are used in very different ways depending upon the specific type of problem being solved. In kinetics data analysis (KDA) problems, the equations are fit to experimental data; in response problems, the equations are solved for specific quantities appearing in the equations; in optimization problems, the equations are used to maximize or minimize a specified quantity and in design problems the equations are used in an exploratory manner. While the primary equations are effectively the same in all of these activities, the way they are used and the ancillary equations needed to obtain a solution are different. Students must learn to recognize the different problem types and they must appreciate how to utilize those equations to solve a problem.

When one of the mentioned problem types was first encountered in class, explicit instruction was provided on how to identify that type of problem and differentiate it from previously encountered problem types. The general procedure for using the primary equations to solve that type of problem was then presented. These points were reemphasized during subsequent in-class problem solving activities. The wrappers for that type of problem offered mistake classifications that corresponded to identification of the problem type and the general process for using the primary equations and necessary ancillary equations to solve problems of that type.

KDA problems are the first type encountered by the students and were selected for the present study. Fig 1 shows the timeline for KDA problems and wrappers. There were six homework assignments for this problem type; after submission of four of those, a wrapper for the problem was included in the next assignment. The other two assignments were practice exams and did not have wrappers. As the timeline shows there was one exam (on day 39) during the period that KDA problems were being presented in class, and then two additional exams (on days 74 and 109) included KDA problems later in the semester. During the intervening period, other problem types were being presented and practiced in class and assignments; therefore the exams on days 74 and 109 are referred to herein as "delayed".

As described elsewhere [5], each student wrapper was coded to indicate what they identified as their first mistake in the general procedure for solving that problem type. Separately and without seeing the student wrapper, the instructor (an expert) independently coded the first mistake the student made in their solution. The list of possible mistakes included "no error" and "math/coding error" as possibilities. In some instances where a student made a mistake, their wrapper did not identify any mistake, but instead included a statement such as "I didn't understand how to solve the problem, and I will need to study more". This type of response was coded as "no response".

In order to facilitate the presentation and discussion of the results, it is useful to define the following terms:

opportunity - homework assignment or exam that includes a KDA problem; all but the exam problems on days 74 and 109 are considered "short term" while those on days 74 and 109 are considered "delayed".

response - student problem solution submitted in response to an opportunity; expert-classified as either correct or incorrect.

recurrence opportunity - number of responses submitted by a student after their first incorrect response.

identified error - error on an incorrect response that the student correctly identified in the associated wrapper.

unidentified error - error on an incorrect response that did not have an associated wrapper or that the student incorrectly identified in the associated wrapper.

recurrence - incorrect response to a recurrence opportunity where the error had been identified in one of the student's previous responses.

recurrence rate - number of recurrences divided by the number of recurrence opportunities expressed as a percentage; calculated per student or in aggregate; further refined as short term or delayed and as involving identified or unidentified mistakes.

It should be noted that only the first mistake in the general procedure was coded. For this reason, each response after a student's first incorrect response was counted as a single recurrence opportunity. It is conceivable that a student might make two mistakes on one of these problems, but the coding procedure would only identify one of the errors. The complications associated with coding multiple mistakes and analyzing the resultant data are the reasons for using only the first mistake in the procedure.

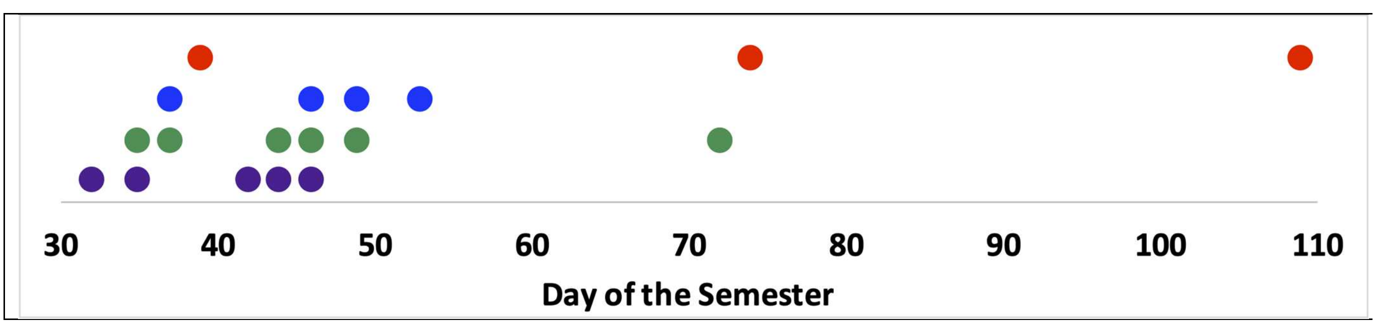

Fig. 1. Project timeline. Purple dots indicate in-class KDA problem solving, green dots indicate KDA practice problem submission, blue dots indicate homework wrapper submission for the previous practice problem and red dots indicate exams that included one KDA problem.

III. RESULTS

There were a total of 729 KDA problem opportunities. Of these, 81 represented the student's first response to a KDA problem, and no response was submitted for 105 opportunities. There were 4 additional responses where the student had not yet submitted an incorrect response. As a result, there were 539 recurrence opportunities in total; 226 of these were delayed recurrence opportunities. Table 1 shows the overall recurrence rate to be 34%, with 4.6% being previously identified mistakes and 29.3% being previously unidentified mistakes. The delayed recurrence rates was slightly greater at 43.8% (6.2% being previously identified and 37.6% previously unidentified).

Looking at recurrence on a per-student basis, Fig 2 shows the distribution of individual overall recurrence rates. This figure includes both short-term and delayed recurrences, and it includes both identified and unidentified recurrences. In contrast, Fig 3 includes only the recurrence of identified mistakes (both short-term and delayed). It should be noted that the total number of students in Figure 1 is 81 while the total number of students in Figure 2 is 34.

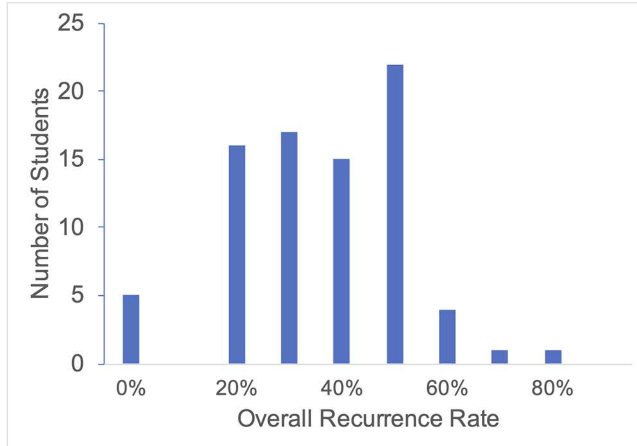

Fig. 2. Distribution of individual overall recurrence rates.

IV. DISCUSSION

Two well-established learning principles [3] state that "to develop mastery, students must acquire component skills, practice integrating them and know when to apply what they have learned" and "goal-directed practice coupled with targeted feedback enhances the quality of students' learning". In the present context, most students understand the primary equations and they know that they need to apply them to solve problems in the course. What they most often lack is the ability to integrate that knowledge and formulate a problem solution. That is, they know the equations to use, but because they are used differently in different problems, they may not fully understand how to use the equations. In addition, students' motivation for solving problems is often dominated by grades and not by learning [6-8]. The intent of the homework wrappers used in this study was to cause students to reflect upon their understanding of how to use the primary equations for a particular problem type and to enable them to self-generate feedback related to their learning and not grades. That is, feedback on whether they knew how to get the answer and not one whether or not the answer was correct. The other changes made to the course and mentioned in the introduction also support these intentions.

The results to date in this work-in-progress are very promising. Overall, the recurrence rate for mistakes that students had self-identified using a wrapper was only 4.6% compared to the rate of 29.3% for mistakes that had not been self-identified. In the present analysis, no distinction was made between students who mis-identified their mistake and students who did not attempt to identify their mistake. Further, it may be possible, by changing the procedures used to administer the homework wrappers, to improve in both of these areas; that is to improve the accuracy of student error identification and to increase the sincere wrapper submission rate.

In this study, the response was submitted as part of one assignment, and the wrapper was part of the next assignment. Because the responses are only graded on effort and carry a relatively low weight with respect to overall course grade, students do not respond to all opportunities. If a student does not respond to an opportunity, any mistakes on that response and on the previous response will be unidentified. If instead, the response and the wrapper are both included in the same assignment, only one mistake self-identification will be affected by skipping a response.

Additionally, in the present study, the students did not receive any feedback on their wrappers. That is, they were not told that the expert disagreed with their mistake identification. Providing them with that kind of feedback might improve their self-assessment accuracy. In addition, knowing that their wrappers are being examined may cause students to take them more seriously and reduce the number of superficial responses.

TABLE I. TOTAL AND DELAYED RECURRENCES

539	Total Recurrence Opportunities
183	Total Recurrences
25	Recurrences of Identified Mistakes
158	Recurrences of Unidentified Mistakes
226	Delayed Recurrence Opportunities
99	Delayed Recurrences
14	Delayed Recurrences of Identified Mistakes
85	Delayed Recurrences of Unidentified Mistakes

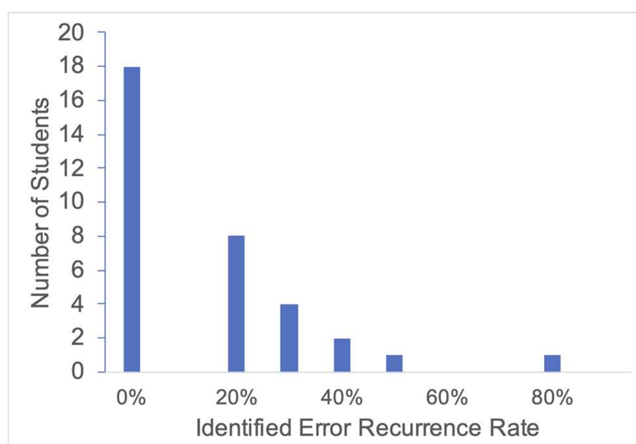

Fig. 3. Distribution of individual identified mistake recurrence rates.

As opposed to sincere responses, superficial responses are ones where the student clearly made one or more mistakes, but indicated on their wrapper that their mistake was a math/coding error, as well as the nonspecific responses mentioned previously.

V. Summary

Homework wrappers were used in an attempt to cause students to examine and reflect upon their understanding of how to use a limited set of equations when solving different kinds of problems. The students had four opportunities to assess their understanding of the procedures for solving one type of problem in this way and to identify procedural mistakes in their solutions using homework wrappers. The results are promising in that the recurrence rate for mistakes that were identified using wrappers was 4.6% compared to a recurrence rate of 29.3% for mistakes that were not identified using wrappers. On the basis of these early results, continued study and refinement of the use of homework wrappers as learning tools is warranted.

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