121st ASEE Annual Conference & Exposition
Indianapolis, IN
June 15-18, 2014
Paper ID #9277

# Writing Abstracts of Homework Problem Solutions: Implementation and Assessment in a Material Balances Course

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## Abstract

This paper describes a one-semester experiment intended to assess the effect of requiring students to write abstracts for homework problems. The literature contains examples in which use of reflective writing assignments led to improved achievement of student outcomes. In this case, it was hypothesized that requiring students to write abstracts for homework problem solutions would help students to see connections between concepts and develop a methodical procedure for solving problems. Two sections of the course were taught at Rowan University in the Fall 2013 semester, allowing the authors to conduct a control experiment. Students in both sections of the course were assigned the same weekly homework assignments, consisting of problems assigned from the course textbook. Students in both sections completed these assignments in teams of three, and they submitted one solution per team. In addition, in the "experimental" section, each individual student was required to write an abstract for one problem from each homework assignment. The abstract summarized the purpose of the problem, the physical system under consideration, the known and unknown information and the solution procedure. The experimental and control sections took identical tests under identical conditions, and each problem was graded by the same instructor for both sections. There was no evidence that writing abstracts was beneficial to the students in attaining the instructional objectives; the control group scored at least as high as the experimental group on all exams.

## Introduction

The first core chemical engineering course in the curriculum typically focuses on material and energy balances. Historically this course has had the reputation of being a conceptually demanding course that induces fear in many students[i]. For many students, one of the greatest challenges is the interpretation of text problems: the translation of the text into a clear picture of the physical situation and the development of an appropriate mathematical model. Another aspect of the struggle is developing a systematic solution procedure. Often students can solve simpler problems in an intuitive manner, but when the problems become too complex for this approach, students who lack a systematic problem solving approach may struggle to get started. Also, students often can solve example problems in class when some guidance is given, but may flounder when they are left to solve a problem independently. This paper discusses a strategy that was developed to help teach students to apply problem solving strategies in a systematic way.

The authors observe that when students obtain a numerical result to a problem (regardless of their approach), they are happy to consider it "solved", draw a box around the result, and move on without reflection. In this paper we explore the use of writing abstracts to encourage reflection on how the problem was actually solved, with the intention of improving student learning, specifically with respect to parameterization of the process, application of principles, and development of a methodical solution procedure. The use of abstracts was first integrated into the course in the Fall of 2012, as described previously.[ii] The following sections explain the rationale for the use of abstracts, summarize the outcomes from the Fall of 2012, and then describe a control experiment designed to assess the impact of the abstracts.

## Writing Across the Curriculum

The literature contains numerous examples illustrating that student learning is, or at least can be, enhanced when students reflect upon and write about what they learn. Maharaj and Banta[iii] used four types of writing assignments (summaries, analogies, word problems and explanations) to promote students' understanding of course content and to increase the students' active role in the learning process. Sharp et al.[iv] propose several types of writing assignments such as journals, brainstorming, freewriting, and categorizing, that meet the needs of different learning styles to enhance learning. Felder and Brent[v] designed a variety of writing assignments that enhance students' interest in course material and facilitate learning. Burrows et al.[vi] showed that reflective journal enhances conceptual understanding and additionally improves learning of *content*. Korgel[vii] found that journal writing exercises can improve deep learning and creativity. In the Chemical Engineering curriculum, Miller uses journal writing to foster the development of higher order thinking skills in a fluid mechanics course.[viii]

In sum, writing assignments can be used as a tool to instill in students a reflective approach to learning. The literature contains evidence that this does, or at least can, lead to improved student achievement of learning objectives. The next section discusses the specific writing assignment used in the current study, and the course in which it was introduced.

**Prior Work: Fall 2012**

At Rowan University, the introductory courses in the Chemical Engineering curriculum are Principles of Chemical Processes (PCP) I and II. PCP I focuses on material balances, PCP II on energy balances. The literature contains several articles on strategies for teaching material and energy balances. PCP I is a two-credit course taken in the fall of the sophomore year. The class meets for one 75 minute period and one 140 minute period per week. A variety of active learning strategies are typically employed in the class as recommended by Bullard and Felder[ix,x]. Elementary Principles of Chemical Processes ($3^{rd}$ ed.) by Felder and Russeau was the chosen textbook throughout the time period discussed in this paper.

A long-standing practice in this course at Rowan University is that homework assignments have been completed and submitted by student teams, typically composed of three students. In the Fall of 2012[ii], the use of abstracts was introduced. Each team submitted one solution to each problem. In addition, however, each student wrote his/her own abstract of the problem solution and submitted it individually. The abstract was required to summarize essential aspects of the problem: a description of the system, information given, unknowns, solution procedure and result. This type of writing assignment differs from the writing exercises above in that it was structured to require students to reflect on a problem solution and to organize and explain a systematic solution procedure even if the original result had been reached intuitively. It was anticipated that writing abstracts could help students achieve course objectives in several ways, including: helping them to make connections between concepts, helping them to develop a systematic approach to solving problems, and helping them to recognize gaps in their own understanding of course concepts.

**Table 1: Response to survey on homework abstracts, administered in Fall 2012. For all questions, responses were defined as 1=never, 2=almost never, 3=sometimes, 4=frequently, 5=always**

| | 1 | 2 | 3 | 4 | 5 | Average |
|---|---|---|---|---|---|---|
| 1. Does the process of explaining to someone else how to solve a problem change or enhance your own understanding of the problem solution? | 1 | 3 | 9 | 21 | 13 | 3.89 |
| 2. Did writing abstracts for homework solutions change or enhance your understanding of why you approached the problem a certain way? | 11 | 12 | 14 | 10 | 0 | 2.49 |
| 3. Did the act of writing abstracts for homework solutions ever cause you to realize you had made an error in the problem solution? | 14 | 16 | 14 | 3 | 0 | 2.13 |
| 4. Was the content of your homework solution abstracts similar to the content of discussions among your teammates about how to solve the problem? | 5 | 3 | 18 | 17 | 4 | 3.26 |
| 5. Did writing abstracts help you to translate a problem statement into a diagram and/or equations? | 19 | 12 | 9 | 6 | 1 | 2.11 |
| 6. Did writing abstracts help you to see patterns and understand methods in solving problems? | 9 | 11 | 11 | 14 | 2 | 2.77 |
| 7. Did writing abstracts help you to make connections between different concepts? | 11 | 6 | 20 | 8 | 2 | 2.66 |
| 8. Did writing abstracts help you to transfer and organize information? | 11 | 6 | 16 | 12 | 2 | 2.74 |
| 9. Did writing abstracts help you remember how to apply information/concepts so that you could use this information to solve future problems? | 10 | 7 | 17 | 12 | 1 | 2.72 |

Results of a survey administered at the end of the Fall 2012 semester are summarized in Table 1. The survey questions paralleled the intended benefits of writing abstracts, and students answered each question on a continuum from "never" to "always." While the response was mixed, negative responses were noticeably more common than positive responses. Students were also asked whether the abstracts should be kept as a feature of the course. In response, 24 students (51%) gave an unambiguous recommendation that the abstracts not be kept, 16 students (34%) gave a clear recommendation that they be kept, and the other 7 provided no clear recommendation. This comment was typical of the people who were opposed to continuing use of the abstracts:

"I personally found the abstracts to be a complete waste of time. I'd write up the problems, work hard on them, get an answer, understand the material, and then have to write an abstract on something I already did and understood."

Even students who had broadly positive opinions of the abstracts often felt that they took too much time, and/or that they should have been a more important portion of the course grade. Representative comments include:

"I think writing abstracts definitely helps reinforce some concepts, but it takes up too much time to write a good one for each problem. For me, writing abstracts was just doing each problem twice."

"They should be kept only if they are worth a greater portion of the homework grade."

In addition to administering the survey, the authors conducted a direct assessment of the final exam performances of students in the Fall of 2012 (in which the abstracts were used) and the Fall of 2011 (in which abstracts were not used). The assessment showed that the Fall 2012 cohort performed significantly better than the Fall 2011 cohort in several important respects:

- "Parameterization" of the process- defined as accurate translation of a word problem into a flowsheet, with complete and correct identification of the relevant givens and unknowns
- Application of material balances- the writing of complete and correct material balance equations
- Principles of phase equilibrium- the use of principles of VLE, LLE or SLE to construct a valid mathematical model of a multi-phase system
- Solution- progressing from the aforementioned equations to a correct determination of the unknowns

While this was an encouraging result, other changes were also made to the course between the Fall 2011 and Fall 2012 offerings. Consequently, the improvement observed in the Fall 2012 cohort could not be conclusively attributed to the abstracts. The authors designed a control experiment for the Fall 2013 semester, intended to assess the impact of writing abstracts in a more definitive way.

**Control Experiment: Fall 2013**

Two sections of PCP I were offered at Rowan University in the Fall of 2013; one taught by each of the authors. The students in the "experimental" section completed homework abstracts. Mindful of the feedback from Fall 2012, in which students indicated that the abstracts took too much time and/or weren't weighted heavily enough in the grade, the implementation was adjusted in the Fall of 2013. A typical weekly homework assignment consisted of ~5 problems, but students in the experimental section were only required to write an abstract for one of these. Each week, the instructor chose the problem that was most challenging and/or had the most new content compared to prior assignments, and each individual student was required to write an abstract for that one. The content of the abstracts was substantially identical to that described in the previous section. As in 2012, each team submitted a single solution to each problem, but the assigned abstracts were written and submitted individually.

The authors made the course as nearly identical as possible in the two sections, aside from the use of homework abstracts. Both instructors:

- Distributed the same syllabus and enforced the same course policies.
- Used homework teams of 3-4 students.
- Assigned the same homework problems each week.
- Weighted homework as 10% of the course grade. In the experimental section, the abstracts accounted for 1/3 of this 10%.
- Gave the same 5 exams, at the same times and under the same conditions, with the same weightings in the course grade.

In grading the exams, each problem was graded by one instructor for both sections. This ensured that both sections were held to identical standards in grading. Thus, if one section earned a higher average score on an exam, that can be regarded as valid evidence of better attainment of the instructional objectives of the course. Unfortunately, the instructors had no practical way of overseeing how specific students were distributed between the two sections. Table 2 demonstrates that the control group, on average, had significantly higher grade point averages in courses completed through the summer of 2013.

**Table 2: Grade point averages in courses completed prior to the start of the Fall 2013 semester (4.0=A, 3.0=B, 2.0=C, 1.0=D).**

| Section | Mean GPA | Standard Deviation |
|---|---|---|
| Experimental Group (n=26) | 3.21 | 0.55 |
| Control Group (n=26) | 3.42 | 0.38 |

In total, 53 students enrolled in PCP I for the Fall 2013 semester: 27 in the experimental group and 26 in the control group. One of the "experimental" students withdrew from the course between the first and second exams. This student's performance on the first exam was excluded from the data and his GPA is excluded from Table 2. The other 52 students (26 in each section) all completed the course and all earned at least a D.

**Assessment**

Table 3 shows a comparison of the performances of the two sections on each of the five exams. The control group scored higher on all of the exams except the first. While the differences between the performances of the two sections were not statistically significant to 95% confidence, there is certainly no evidence that the use of homework abstracts led to improved performance on exams. Note that mean exam scores in both sections decreased throughout the semester as the problems became more complex, which does underscore the authors' motivation for encouraging students to develop a methodical approach to problem-solving.

**Table 3: Comparison of exam performance in Fall 2013 experimental and control cohorts.**

| | Experimental Group | | Control Group | |
|---|---|---|---|---|
| | Mean | Std. Dev. | Mean | Std. Dev |
| Exam 1 | 94.9 | 8.8 | 93.4 | 8.6 |
| Exam 2 | 85.2 | 13.3 | 92.2 | 5.6 |
| Exam 3 | 83.9 | 13.4 | 89.3 | 10.7 |
| Exam 4 | 79.1 | 21.0 | 86.5 | 13.7 |
| Exam 5 | 75.7 | 11.6 | 81.1 | 14.1 |

As shown in Table 2, the control group, on average, had higher cumulative GPAs at the start of the semester than the experimental group. This difference in academic achievement in prior courses (many of which are prerequisite for PCP I) represents a confounding factor in the control experiment. In an attempt to account for this factor, a "class GPA" was computed for each section by averaging the final PCP I course grades (A = 4.0, A- = 3.7, etc.) earned by the 26 students in the section. These were compared to the cohorts' cumulative GPAs at the beginning of the course. In the control group, the "class GPA" was 3.42, which is almost identical to the mean cumulative GPA of the cohort entering the semester. In the experimental group, the "class GPA" was 2.996, which is noticeably lower than the mean cumulative GPA of the cohort entering the semester. Thus, if one assumes that cumulative entering GPA is a reasonable predictor for a student's performance in an individual course, then the control group performed better relative to this predictor than did the experimental group.

## Conclusion

This paper discusses a reflective writing assignment- writing abstracts of homework problem solutions- that was introduced into a course on material balances. The abstracts were first used in the Fall of 2012. Based upon both published results on "writing to learn" from the literature and the authors' observations from Fall 2012, it was reasonable to hypothesize that the activity of writing homework abstracts would lead to improved attainment of the course instructional objectives. However, the control experiment that was conducted in the Fall of 2013 did not produce any evidence to support of this hypothesis.

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