

Implementation Of Phased-Array Homework: Assessment And Focused Understanding

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Abstract. Students demonstrate different levels of understanding of material which often coincide with how diligent the students are with their daily preparation for class. Having students attempt homework problems prior to class enables them to be better prepared to ask specific questions about concepts and to perform on exams, as well as to develop as self learners. This paper will introduce “phased-array homework” that is a flexible system of assigning homework. In addition, this paper discusses resources for students that provide a scaffold for completing this type of homework. As the name of the homework system implies, phased-array homework (PAH) allows an instructor to shape and steer student understanding in much the same way that a phased-array antenna allows for the shaping and steering of a transmitted electromagnetic signal to yield its subsequent effective radiation pattern. Implementation method and results will be presented as well as student perspective on the system.

Keywords: Phased-array homework, assessment, homework system.

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INTRODUCTION

In this paper, an alternate method for assigning and grading homework that is designed to give homework more of an impact on student motivation and performance will be presented. In addition, this method is one which allows for greater flexibility of assessing and reinforcing of key concepts by the instructor. The phased-array homework (PAH) method is intended to be a vehicle for more in-depth student understanding of material by way of learning from mistakes and correcting those mistakes in a timely manner. Guiding students through the timely correction of mistakes is a way in which to measure the process of learning instead of the typical way of assigning and grading homework which measures the end result of the learning or the lack thereof [1,2].

There are many ways to inspire students to prepare daily; however, when they attempt homework problems prior to a particular class, students are prepared to ask specific questions about specific concepts. A challenge, particularly for a physics class comprised of mostly students who are not math, science, or engineering (MSE) majors and who question their abilities in these subject areas, is guiding students in obtaining needed problem solving skills and confidence to attempt problems for which they are learning the concepts for the first time. In essence, physics provides them with the skills and attributes needed to become successful independent learners. There is, and may always be, some question of whether graded homework has a positive effect on the

test performance of students [3]. However, there have been several studies that have attempted to determine this by way of alternate homework methods. It is these alternate methods that provided inspiration for the PAH method employed in this study.

LITERATURE SURVEY

The way in which we assign and grade homework could greatly enhance the likelihood of students becoming successful, independent, active learners. There are many advantages to “flexible homework” which allow for tailored approaches to assigning/submitting specific homework problems in a homework set [4,5]. Bao and Sadaghiani’s flexible homework system shows positive results in motivation and performance. Homework systems like the flexible homework system are becoming more prevalent in order to achieve a number of goals which align with five principles for education suggested by Chickering and Gamson [6]. Those principles are 1) providing prompt feedback, 2) encouraging contact between faculty and students, 3) developing cooperation among students, 4) encouraging active learning, and 5) communicating high expectations [6,7]. There are also benefits to allowing students to correct their own mistakes, which is a principle encouraged by Davis [7,8]. In fact, an alternate grading method which allows students to leverage self-correction of their work after some initial feedback from the instructor was employed with some success in the area of student motivation and in peer collaboration in three

mechanical engineering classes at the US Military Academy [7].

Other systems employ a method of providing imperfect solutions to students in order to have students analyze their work and determine where the flaw is in the imperfect solution and/or their own solution [8]. The imperfect solution method enables students to critically assess his/her own work and the possibility of reinforcing incorrect understanding is mitigated during classroom discussion about the problems [9].

Yet another approach to improve several of the aforementioned education principles, specifically student cooperation and interdependence, is to have a designated subset of students in the class be responsible for publishing a set of solutions to a homework set [11]. Eschenbach calls these solutions the “Beautiful Homework Solutions” and has a different group of students develop and publish them each week [11]. The method of peer-assessment reduces some of the instructor resources on grading. In addition, peer-assessment allows for the evaluation by one student of scientific information presented by another student and thus fosters professional development for future work by the student [12]. This method also addresses the needs of a program which has an outcome of a student who can critically assess scientific and technical claims and comment on their validity as is the case for the core physics program at the U.S. Military Academy. Murthy employed peer-assessment by way of having students follow a grading rubric at MIT with some success [13].

RESEARCH METHOD

The method, used throughout the last three terms, starts by assigning homework sets, each comprised of four to ten problems each. The problems are chosen from an array of suggested problems for each lesson. The problem selection process is one in which several problems are chosen from a large array of possible problems which all meet the learning objectives for those respective lessons. This array is developed by the course director using the course text as a single source for choosing the problems. For each lesson, the course director chooses between six and twelve problems which meet the learning objectives for that respective lesson. From those problems chosen by the course director, the instructor can choose to assign for homework problems from that set and/or to include problems from previous lessons. In choosing problems, the instructor takes into account the way in which they want to reinforce previous learning objectives and/or where they want the students to focus for the upcoming learning objectives. Both of

these areas of consideration are based on their assessments of their respective section up to that point in the course.

This is analogous to a phased-array antenna because this allows an instructor to target specific learning objectives which need reinforcement and/or emphasis; thus, steering the students understanding to an intellectual “location/position” where the student needs to be focused. In addition, it allows an instructor to proverbially shape the next lesson by including specific learning objectives for which the instructor knows may be specifically challenging for them. This process also allows the instructor to obtain a thorough assessment of cadet understanding of the material at the very start of the class so as to immediately address any conceptual gaps.

Once assigned, the cadets are told that there are two phases of turning in the assignment. During phase one, the cadets are to attempt the problem prior to discussing the associated material in class. It is required that the cadet attempt at least the first six steps of the “Physics Problem Solving Process” that we teach cadets to use.

If the cadet shows all steps of the problem solving process and obtains all the correct answers, they turn in the assignment and receive 100% of the points associated with that assignment. If, however, they do not obtain all the correct answers, they can turn-in homework during phase two explained below. The homework set is self-graded in class so that each cadet obtains immediate feedback and is able to ask questions on portions they do not understand. This requires the cadets to mark their own Phased Homework (PHW) with a score of 30% of the maximum points. This 30% represents a grade of the attempt only, not a grade of the correctness of the assignment. This constitutes and completes phase one of the phased process. If a cadet only earns a 30% then they are afforded the opportunity to conduct phase two and re-work the PHW, turning it in the very next lesson for a maximum possible 90% of the maximum points. If they choose not to re-work their PHW and learn from their mistakes, they earn 30% of the total possible marks. The earning of either a 90% or 30% completes phase two of the multi-phased process.

Thus, this process becomes a highly-encouraged, two-phased homework process which allows cadets to learn from their mistakes and immediately correct them. This allows the cadet to quickly adjust their mental model of a physical situation and how to properly solve the problem. In each of the two phases, the first attempt and the re-worked attempt, the cadets are allowed to use any and all available resources including current partial solutions posted on the course website site. Phase two can be turned in at a later date for point reduction if cadets need additional attempts

to correct their mistakes. Thus, cadets are highly encouraged to continually correct their work until they completely and correctly solved the problems.

This method was implemented in three consecutive terms including the spring 2011 term in PH201 (first semester undergraduate physics course). In the spring 2011 iteration, the PAH group size was 27 and the control group size was 29. During this iteration, there were results that suggest possible positive impact. The PAH group was comprised of sections A1 and C1. The control group used homework as an assessment as well but did not use the PAH method. The two groups had comparable GPA's at the beginning of the course. The control group had a GPA of (2.41 ± 0.08) and the PAH group had a GPA of (2.44 ± 0.09) . The control group was compared to the PAH group on four course-wide graded events; the Written Partial Review 1 (WPR1), the Written Graded Review (WGR), the Written Partial Review 2 (WPR2), and the Phase Line Writ (PLW). WPR 1 and WPR 2 were exams of 150 points each and the WGR was a midterm exam of 450 points. WPR1 measured the students understanding of kinematics and Newton's Laws. The WGR was a comprehensive, cumulative midterm type event that measured the students understanding of the first half of the course. WPR2 measured their understanding of rigid body dynamics. And the PLW was a measure of their understanding of applications of fluid dynamics, gravitation, oscillators, and waves. The use of these events as measurements was to see if the PAH method had an impact on their performance on the said event. The expectation was to see different results on the evaluations so as to determine if the PAH method was effective in yielding better understanding, performance, and retention of material.

RESULTS AND DISCUSSION

Overall the averages for the group using PAH on all major graded events with the exception of WPR2 were higher than that of the control group. There may be evidence of the potential benefit of this method as manifested by a majority of the scores being better than the control group and/or the entire course averages. Figure 1 shows that the PAH group performed better on all of the major course-wide administered graded evaluations except for WPR2. The error bars for each of the groups in each of the five bins in Figure 1 were computed using a standard deviation of the mean within a confidence interval. The major limiting factor to the positive impact on the student scores on the exams was their motivation to complete the homework assignments.

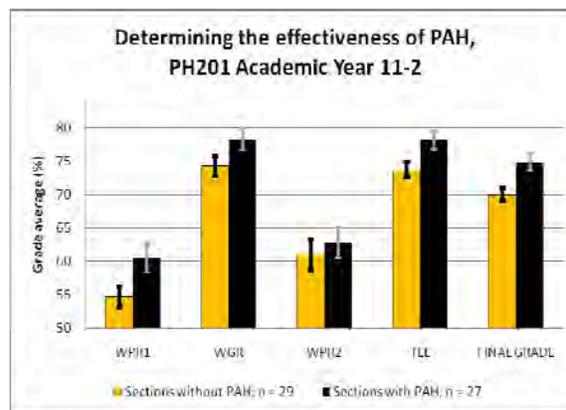


FIGURE 1. The comparison of the performance of section 1 (PAH Group) to that of the control group on all the major graded events and the overall average for the spring term of 2011. Note: $N = 27$ for the group with PAH, and $N = 29$ for the control group

In addition to the impact on student learning and retention, it is necessary to consider if the PAH method affected such things as student motivation, confidence level, and overall satisfaction. There were several survey questions that were posed to the cadets about this homework process. The results of these surveys indicate that the PAH process indeed does allow cadets to gain confidence, better understand the material, and become more motivated to solve physics problems. From the survey results, 88% of the cadets were more confident in solving physics problems as a result of the PAH process; 85% felt that the process assisted them in understanding the material; 83% were more relaxed about the homework grade and more motivated to solve physics problems; and 86% were satisfied with the process. Many students acknowledged in an additional survey taken during the spring 2011 term that they had not taken advantage of the PAH process for WPR2 as they should have.

CONCLUSION

The PAH method inspires cadets (in the test groups) at the U.S. Military Academy enrolled in introductory physics to be more diligent with their problem preparation and be more confident with their problem solving abilities. Overall, this phased-array homework process appeared to be very beneficial. The education system at the United States Military Academy allowed for section by section analysis of how the cadets were preparing daily and how that level of diligence translated to their respective major graded event performance.

Expected future work with this method in the fall term 2011 for an approximate student population of 1200 cadets will include some needed refinement. The

number of solutions which have partial solutions posted after phase one need to be increased. Lastly, the partial solutions need to have more of a scaffold. Specifically, the amount of the solution that is provided needs to be more limited as the term goes on toward lessons 25 and beyond. This will wean the cadets off of this resource and enable them to transition more effectively to truly independent learners.

One question that can be posed from the research is whether this method of revising work until the correct answer is achieved also fosters a good work ethic that will persist throughout the cadets' academic careers and beyond into their profession as officers. Does continuing to stress the importance and acceptance that a professional can gain significant insights from correcting their mistakes and thereby making themselves or the system within which they are working better and show students that the learning process is incredibly important? In addition, will this demonstrate to students that being a member of a profession means continually striving to improve and educate oneself?

The presented Phased-Array Homework process is one which is a good alternative to instructors who desire to assess and evaluate the learning process as opposed to the end result of learning. PAH also seems to enable students to value homework and produce higher problem-solving skills. Lastly, the PAH process is a good alternate method to provide prompt feedback, encourage contact between faculty and students, develop cooperation among students, encourage active learning, and communicate high expectations of life-long independent learners.

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