2009

IS education – An Empirical Study Of Individually Assigned Homework

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Abstract

There is a general agreement that homework plays an important role in students' learning. We argue that without examining and re-examining the potential benefits of homework assignments and whether they are achieved, we miss the opportunity to support students' learning. In this paper we describe an instructional tactic of individually assigned homework that promotes and strengthens individual learning processes. The method was originally developed to cope with the relatively high IS students' failing rate. We describe the study that accompanied the employment of this tactic in a Computer Architecture course and describe respective quantitative and qualitative results. For the first time ever no student failed the course and an increase in students' motivation and learning accountability was observed. We compare the results to a previous study we conducted using the same tactic and discuss the implication of our results for IS education.

Keywords: *Individual assignments, Information Systems Education, Individual learning, Effective learning.*

1 INTRODUCTION

There is a general agreement that homework plays an important role in students' learning. We argue that without examining and re-examining the potential benefits of homework assignments and whether they are achieved, we miss the opportunity to support students' learning. This issue becomes significantly important due to several trends in higher education. Some of the trends relate to the characteristics of incoming students, and others to economic constraints that affect the teaching load and the availability of teaching assistance. In many countries there is a trend in the recent decade to widen the opportunities for obtaining higher education. The result is that the students' population gets more heterogeneous with regard to prior knowledge, learning habits; and cognitive and meta-cognitive skills that affect learning. The variety makes it necessary for the teachers to have tools for formative assessment and also makes it necessary for the students to exercise self-assessment. In a paper titled "Homework? What Homework?" (Young, 2002) the author summarizes findings from the National Survey of Student Engagement of that year and suggests some explanations. "Students are studying about one-third as much as faculty say they ought to, to do well," said the director of the survey. The most striking statistic: Nineteen percent of full-time freshmen say they spend only 1 to 5 hours per week preparing for classes. Many education experts say that is well below the minimum needed to succeed. Seniors who answered the same survey reported studying even less than freshmen, with 20 percent studying 1 to 5 hours per week. Many professors say their students are doing less homework these days, though there are always a few model students. The problem may start in high school, where students are apparently spending far less time on homework than those who graduated a decade ago; and also have problems managing their time and getting the most out of their studying (Young, 2002).

As many students come to higher education to make good grades rather than explore new topics, academic dishonesty gets prevalent. Academic dishonesty may be defined as students' attempt to present others' academic work as their own (Jensen et al., 2002). Academic dishonesty among high school and college students is highly common—so common, in fact, that some observers describe it as ''epidemic'' (Haines, Diekhoff, LaBeff, & Clark, 1982). In 1979, a Carnegie Council Report warned of ''ethical deterioration'' in academic life, and the U.S. Department of Education issued a report describing cheating among college students as a ''chronic problem'' (Maramark & Maline, 1993). When students submit homework assignments done by others they miss the chance to learn and the teacher misses the chance to get a realistic mapping regarding students' understanding. As stated by Gibbs and Simpson (2004), plagiarism on assignments presents a serious problem for the integrity of the educational process. Various tools were developed for detecting plagiarism (Jones, 2008) and especially for detecting plagiarism in programming courses (Zhang et al., 2007; Gritchell and Tran, 1999; Joy and Luck, 1999). Bowyer and Hall (2001) in their paper about reducing effects of plagiarism in programming classes describe the effectiveness of such a system – MOSS. They further stress that detection of program plagiarism is made relatively simple using MOSS but the real challenge for the faculty member is to design procedures that reduce the students' perceived pressure to cheat and to make the learning process more effective. Our approach is on a similar line, we are not interested in punishing students and even though we try to raise ethical issues, still our main goal is to maintain an effective educational process. The approach we suggest in this paper is not an afterwards approach – detecting plagiarism; but an approach to design assignments that make plagiarism more difficult and thus support students' learning.

In addition to the heterogeneous students' population mentioned before, most academic institutes have also experienced dramatic decline in Information Technology and Information Systems enrollment in the past several years (Granger et al., 2007). Many studies suggested numerous reasons for the decline, starting with the false dot-com boom, job off-shoring, misconception of the profession and even poor computing teaching (Clear et al., 2008). On top of the low enrollment issue, there are also the gender issues and the retention problem. McGettrick et al. (2005) stated that: "People view the curriculum as being too complex and too crowded. Evidence for this is the dropout rate in many institutions, which often is as high as 30-50 percent." Some studies directly link the dropout rate to the first and second year's introductory courses and the way they are being taught. D'Souza et al.(2008) defined: "Programming is central to Computer Science and cognate disciplines, and poses early-learning challenges in problem-solving and coding."

However, based on our experience, the problem is not related only to programming, there are additional introductory courses which are high on the failing list. At our college the failing rate among first year students is about 25% and only half of the cases are related to programming. Understanding the critical role of first years' courses, especially the introductory ones, we offer, in addition to the standard lab exercises and teaching assistants' aid, a wide variety of student mentoring services. However, even with the extra resources allocated and after trying various teaching strategies, an inherent problem still exists and is clearly demonstrated by the bimodal distribution of grades in several courses. This bimodal distribution is mainly due to the students' heterogeneous population and learning habits (Chang and Chang, 2000). In particular, this is applicable to first year students, who are less prepared for college level learning. The bimodal distribution reflects students' prior knowledge and their lack of proper learning habits.

Research on learning in the last decades emphasizes the important role that collaborative learning plays in the learning process. Collaboration is expected to promote activities like elaboration, justification and argumentation that trigger learning mechanisms. Despite the expectations, there is no guarantee that these activities will occur without additional educational design constraints (Dillenbourg, 1999). Information Technology graduates are expected to work in teams and the collaboration skills are necessary; but how the capabilities for individual work come in? Is it necessary for making the collaboration effective? We believe that any successful collaboration starts with individual capabilities and individual responsibility and motivation. In this paper we stress the need of instructional design for enhancing these individual capabilities, which later become a cornerstone in any collaboration activity. Some researchers dealing with instructional design for collaborative learning also emphasize the individual facet (Puntambekar, 1999). Hoadley and Enyedy (1999) use the metaphor of monologue and dialogue to describe the social activities in which learning is grounded and suggest the need for learning environments that help students' transition from dialogue to monologue and back again. Pair programming, for example, when employed as an instructional methodology emphasizes the different roles and different responsibilities for each participant. This collaborative environment is effective only if each student carries his/her own task and does not "rely" on the other. This demonstrates the importance of personal assignments and accountability even in a collaborative framework. Within collaborative learning research there are also studies where the conflicts between individual solutions are used to trigger effective collaborative learning (Constantino-Gonzalez et al., 2003; Or-Bach & van Joolingen, 2004).

We claim that there is not enough focus in the current learning research on ways to make students employ spiral learning processes by themselves: analyze, solve, debug, reflect and repeat the process as long as necessary. These individual capabilities (or learning habits) play a crucial role in any future collaborative learning or collaborative work environments.

The instructional tactic suggested in this paper is based on a unique design for individually assigned homework. By individually assigned homework we mean that homework is required to be done individually (versus collaboratively), required to be done by the student himself; and designed in a way that each student uses different data than the other students for performing the task. The idea behind the design is to force students to try to employ individual learning processes as the intermediate and final values are different from one student to another and any comparisons (or "borrowing") of values is fruitless.

This study is a follow-up of a previous study (Yadin and Or-Bach, 2008) and the results of this study provide further evidence for the benefits of individually assigned homework. In the following sections we describe the course Computer Architecture and one of its individual assignments along with the accompanying study and the encouraging results. We conclude with a discussion of the results and their implications regarding the role that individually assigned homework can play in students' learning.

2 THE COURSE AND THE INDIVIDUAL ASSIGNMENTS

The course Computer Architecture is an elective course providing basic understanding of the computer hardware operations, data types representation, system's architecture and optimization techniques. The participant students are in their second year after successfully completing all first year requirements. The main course objective is to enhance software developers' capabilities through a better understanding of hardware functions and operations. Being a second year course, Computer Architecture provides an excellent opportunity to assess the students' understanding as it relates to more abstract issues. At this stage of their studies, the students have acquired the necessary mathematical background, are already familiar with the computer hardware basic operations as well as the programming paradigm.

Various versions of the Computer Architecture course were taught during the past six years. The course was accompanied by an action research study that highlighted the need for some changes during the years such as the inclusion of mid-term exams, additional in-class lab exercises and revised assignments both manual and computerized ones. Albeit the improvement attempts there was a constant increase in the students' failing rate percentage.

During the academic year 2008 we introduced into the course the idea of individual assignments. The main idea behind the design of the personal assignments was to make students invest more time by themselves on the task before comparing with other students as they are used to do; and as a result have them exercise basic learning skills. The wording for each assignment is identical, however, the assignment for each student is based on some unique identifiers each student posses (identity number, driver license number, phone number, address, etc.). Using a simple algorithm, these unique identifiers are migrated into the assignment data, creating a different solution for each student.

The following is an example of such a task given in the Computer Architecture course. The purpose of the assignment is to rehearse and assess the students' understanding of the disk arm movement algorithms. By utilizing a unique example for each student, these abstract algorithms "come to life" and are better understood. The algorithms to be rehearsed by the students are: (1) FCFS (First Come First Serve) - the requests in the queue are processed in the order issued causing a longer seek time; (2) SSTF (Shortest Seek Tine First) - the driver serves the request in the queue based on the relative distance for current position; (3) SCAN - the arm moves from this position onwards in one direction serving all available requests in the queue. When it gets to the last position, the arm reverses direction serving the available requests; (4) C-SCAN (or Circular Scan) - the arm moves in one direction only. When it gets to the last position, it starts all over again from the first position; (5) C-LOOK - similar to the C-SCAN only C-LOOK will move the head only to the last required position and not top the end of the disk like with C-SCAN.

Disk arm movement

1. On top of the assignment write your 9 digits student ID number ($N_9N_8N_7N_6N_5N_4N_3N_2N_1$)
2. Starting from the right-hand side, divide the ID number into single digits (N_9 N_8 N_7 N_6 N_5 N_4 N_3 N_2 N_1)
3. On each digit apply a simple algorithm of multiplying by ten and adding an increasing number

   $N_1 = N_1 * 10 + 1$

   $N_2 = N_2 * 10 + 2$

   $N_3 = N_3 * 10 + 3$

   .

   .

   $N_9 = N_9 * 10 + 9$
4. Assume that the numbers (N_1, N_2, … N_9) represent the disk arm movement request queue.
5. Build the table to represent the disk arm movements and the total track moves when applying each of the algorithms:
   a. FCFS (First Come First Serve)
   b. SSTF (Shortest Seek Time First)
   c. SCAN
   d. C-SCAN (Circular Scan)

e. C-LOOK (Limited Scan)

6. Build a new table and calculate the total track moves assuming the queue contains the reverse order of the numbers (N_9, N_8, … N_1). Repeat it for all algorithms.

This type of assignments makes it impossible to "import" the full or partial solution from a colleague or compare results before employing self-monitoring/debugging procedures. Any help provided by a fellow student or a teaching assistant will have to concentrate on the solving process without mentioning exact outcomes. The fact that each student gets his/her "own" assignment encourages good individual learning habits. This type of "individualization" might also have an affective effect, making students more attached and motivated to solve their own tasks. In this case students might relate better to any feedback given to them. Since the students thought about their assignment by themselves, the feedback they receive makes sense to them. There is also the affective facet, students feel the feedback is personal - relevant to their "own" problem and was produced especially for them.

3 THE STUDY

In the academic year 2008 (where the final exam was on June 2008) there were in the Computer Architecture course six assignments during the semester, contributing 10% of the total grade. All the assignments were of the "individualized" type described in the previous section. Each submitted assignment was graded and in addition, since feedback is essential for the students' improvement, detailed informative feedback was provided. When necessary, the feedback included extra explanations, links to the learning materials and to additional exercises. The feedback served also for adding and enhancing the course materials for next year. Our LMS (Electronic Learning Management System) was used to publish the assignments, set the last date for online submission, collect the students' work and present the relevant feedback for each submitted assignment.

Figure1 clearly depicts the change of trend during the semester in which the "individualized" assignments were introduced after several years with a constant increase in the failing rate percentage (due partially to enrollment problems). 2008 was the first year ever, no one failed the course. In our college, the students are entitled to take the final exam twice (if they failed the first one, or in order to improve the final score) and that is the reason for having the two lines for the first and second exams. The final score is the one the student got in the last exam he/she took. The numbers in parentheses (underneath the year) indicate the total number of participating students. During the 2006 academic year, the course was not offered, so in the graph we used the average of 2005 and 2007. The number of students during the study year is relatively small so any general conclusions should be considered carefully, however, this is a follow-up study and it strengthens the results of our previous study.

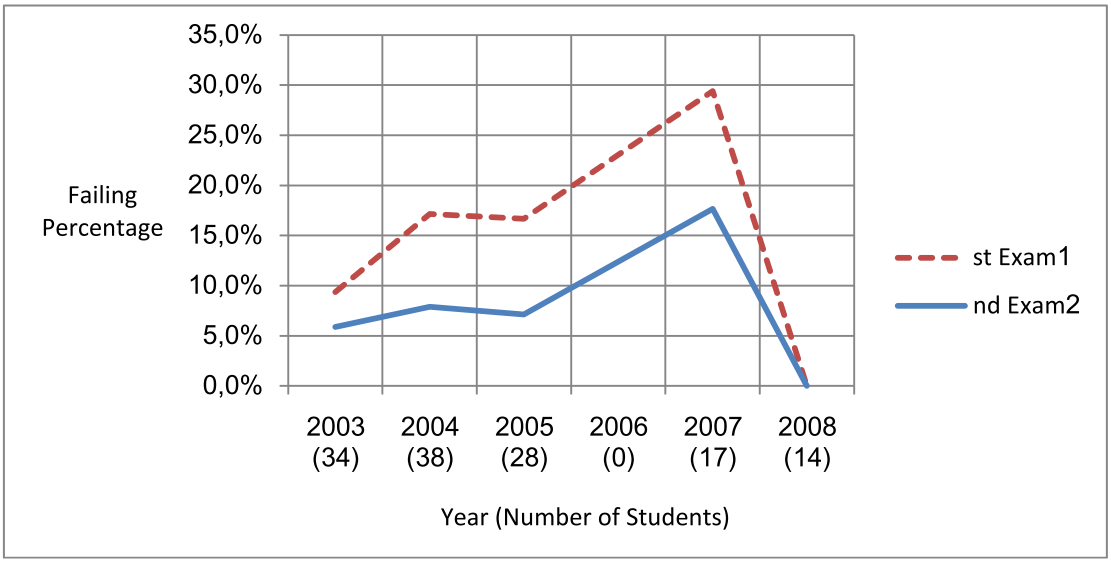

Figure 1. Course failing percentage

In this study we employed three research tools: comparison of the failing rates of students in this course during the last years, comparison of students' use of our LMS during the study year and the year before, and interviews with some of the students to assess subjective impressions. The main factor we used for indicating the learning effectiveness of the individual assignments was the overall course failing rate.

Employing these individualized assignments reduced the course failing rate (compared to previous years). The overall course failing rate was reduced from 18% last year to zero this year.

The fact that no one failed the course correlates to an increased usage of our LMS during the semester for activities such as revisiting learning materials, checking for news, addressing questions to the instructor etc. The average number of times a student entered the LMS for the Computer Architecture course during the semester of this study was 72 (or on average 5.5 times per week), while for the previous year the respective number is 22. An increase of 224% might be an indication of increased motivation and increased active engagement in learning during the semester.

The interviews that we conducted with students revealed additional encouraging findings: (1) Students expressed higher motivation, independence, and confidence in their ability to cope with new and difficult topics related to the course; (2) Students became more involved in self-assessment before submitting their work; (3) Students got to appreciate the value of the feedback they got from the instructor; (4) Most students reported an increase in the level of understanding and the level of perceived clarity due to the individualized assignments. These findings are the same as the findings in a previous study (Yadin and Or-Bach, 2008) that involved the same instructional method of personal assignments but in another course - Computer Organization and Programming. As in the previous study, we noticed a higher degree of student participation and involvement in class (compared to previous years), as well as an increase in students' willingness to assist fellow students both in person and by using the course web-site forum.

4 DISCUSSION AND FUTURE RESEARCH DIRECTIONS

The results we found regarding the increased success and motivation during the semester in which we started to use the individualized assignments on both courses, are encouraging, but not totally surprising. For a long time we had the impression that many students do not invest the time and effort required for thoroughly thinking about the courses' assignments, about possible ways to solve them, and about how to evaluate the solution they submit. Instead they tend to share partial solutions and add some "patches". Only very few students really follow the whole process. As a result of this evolving learning culture students do not exercise good learning habits, do not feel responsible for their submitted work and cannot benefit from the instructor feedback as it is not addressed to their own line of thought. This situation interferes with the effectiveness of feedback for learning that its importance was recognized in many studies (Hattie, 1987; Black & William, 1998). The individual assignments increased students' accountability for their own work as well as their appreciation for the role of homework assignments in the learning process. Furthermore, studies show that (reliable) coursework marks are a better predictor of long term learning of course content than are exams (Conway et al., 1992).

The decrease we found in the courses' failing rate can be considered evidence that most students responded positively to the new instructional tactic. Even though the decrease relates to one year (by now) and to a relatively small group of students, it can still be considered meaningful because of several points that should be noted. One is that until 2008 decrease of number of students in class did not improve the success rate. A small class is not a guarantee for better learning unless other special measures are taken to take advantage of the small number. Another important point is that we got a very similar graph for another course where this type of individual assignments was employed (Yadin and Or-Bach, 2008). The fact that the clear change of trend was observed in both courses which are the only ones where this tactic was employed convinced us of the potential benefits of this tactic.

Findings also showed that all interviewed students appreciated the employment of the individually assigned assignments. It should be emphasized that we do not intend to use the personal and individual assignments to replace the collaborative work. On the contrary, we believe that by fostering good personal learning habits, students become more knowledgeable and responsible; thus their future collaborative work will be more effective.

It should be noted that personal and individual assignments also promote some level of competition mainly among top performance students, which by itself might help to raise motivation. However, in addition, the individual assignments call for a different way to help a fellow student, a way we want to encourage – not showing one's own work but explaining how to get there. Another advantage of the suggested tactic is that when instructors are more convinced that the work they got was done by the specific student they are more motivated to understand the conceptual origin of faulty solutions and are more motivated to direct the student accordingly. In the two courses in which we employed this tactic the specific detailed feedback was related to the student's mistakes and in addition it directed the student to the learning materials, to in-class tutorials, and to additional specific exercises in the topic in which the student needed reinforcement.

The feedback served also for adding and enhancing the course materials for next year. The improved feedback might also explain the change of trend in the failing rate.

From an instructor's point of view, the individual assignments provide a clear and frequent insight into the situation of each student and of the class in general. This helps identify topics that students find difficult, and since it happens early in the process, additional explanations, exercises and personal tutoring can be provided to avoid failing the course. An additional important result obtained by this tactic was the ability to identify error patterns. Discovering these error patterns helped revealing some of the students' hidden conceptual misunderstandings. Some are individual error patterns, while others are shared among several students. Analysis of these students' error patterns is an effective mechanism for determining the problems students have. Our future research and development plans include the accumulation of common errors and misconceptions that were found in students' work. We plan to use them as distractors in multiple-choice questions along with pre-canned feedback. The resulted system will be used by students for self-learning and self-assessment.

The tactic for individually assigned homework that was described in this paper can be further employed, explored and generalized in two directions. One direction is the adoption of the same tactic in courses where it is possible. The tactic can be based on any personal data such as ID numbers, telephone numbers, name etc. Another direction for generalizing our results is for any design of frequent homework assignments that require students to exercise learning processes by themselves. There are various methods that are used by teachers in order to force student to submit individual work. Such examples are found in seminars and other courses, but in these cases the assignments are designed usually for summative assessment and do not support the idea of assessment for learning during the course.

Using any such personalized approach effectively requires innovation in preparing assignments and significant amount of the instructor's time and effort. Resource constraints nowadays in higher education have led to a reduction in the frequency of assignments, in the quantity and quality of feedback and in the timeliness of this feedback. One advantage of the method described in this paper for designing personal assignments is that it enables partial automatic checking. It makes it easy for the teacher to check automatically whether the solution is correct or not, but still further manual checking is needed in order to provide the student with helpful feedback.

Various possible tactics for designing individually assigned homework can be described in a space of two (or more) axes. One axis is that of the level or way for personalization and the other is the level of automatic checking. The study described in this paper relates to one case or point in this space, where we found promising results. As we strongly believe in the role of homework for learning we plan to explore various tactics within this space that can accommodate the different courses with their idiosyncratic characteristics.

The instructional tactic described in this paper was originally developed to cope with the relatively high Information Systems students' drop-out and failing rates' but it seems that the way to do it is to support the development of learning habits that are motivated by individual responsibility for the learning process.

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