The Impact of Delayed Instructional Support on Adult Learners in the ODL Context

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Abstract

This paper investigated whether productive failure (PF) as an instructional strategy boosts students' understanding on the subject matter in a face-to-face tutorial. PF instructional design advocates the delaying of support for the learners during the learning. This paper reports an initial study of a quasi-experimental that compares a ''productive failure'' instructional design with a traditional ''lecture and practice'' instructional design for a 2-hour tutorial session attended by adult learners. A total of 17 adult learners participated in the study. Learners experienced either a traditional lecture and practice teaching cycle or a PF cycle, where they solved complex problems in small groups without the provision of any support or scaffolds up until a consolidation lecture by their teacher during the last hour of the tutorial. Findings suggest that learners from the PF condition produced a variety of problem models and methods for solving the problems but were unsuccessful in their efforts, be it in groups or individually. Despite failing in their group and individual problem-solving efforts, learners from the PF condition performed better than their counterparts from the lecture and practice condition on both knowledge and higher order application problems based on the post-test.

Keywords: *Productive Failure, Adult Learners*

Introduction

Open and distance education (ODE) is fast becoming the way of providing education to the masses. ODE provides the opportunity for the working adults to enroll in programs that match their interest without leaving their job. Adult students are the main subscribers of ODE. Adult students are loosely identified to a larger group characterized as "non-traditional." While definitions vary, the National Center for Education Statistics (NCES) in United States (US) has come up with seven characteristics that typically define non-traditional students. According to the NCES, adult students often: (a) have delayed enrollment into postsecondary education; (b) attend part-time; (c) are financially independent of parents; (d) work full-time while enrolled; (e) have dependents other than a spouse; (f) are a single parent (in some cases); (g) do not possess the standard high school diploma. Serving adult learners and conventional learners are two different extremes. According to the Council for Adult and Experiential Learning (CAEL) based in the United States, there are EIGHT principles of effectiveness for serving adult learners as given in the following figure.

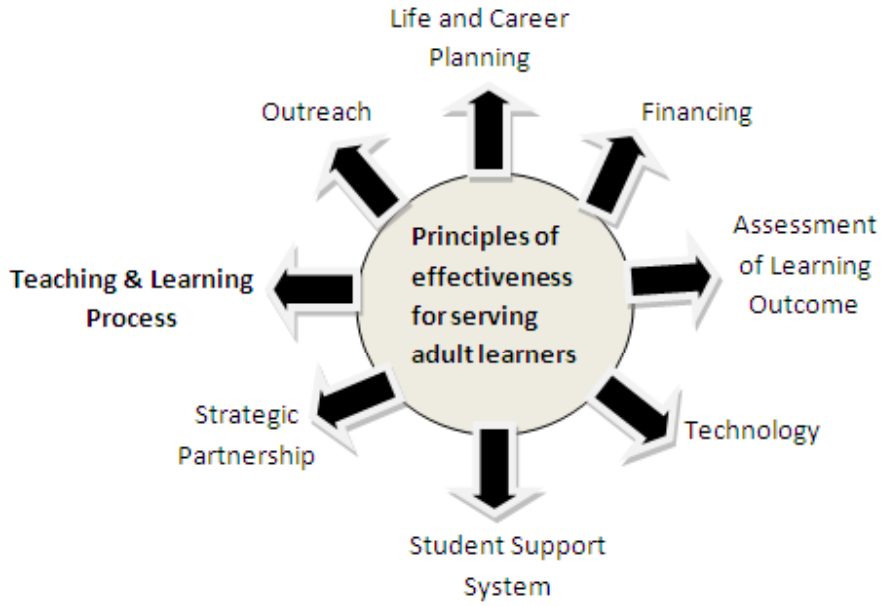

Figure 1: Principles of Effectiveness for Serving Adult Learners

Among all the dimensions in Figure 1, the teaching and learning process is the important component as it directly involves imparting knowledge to the learners. This is also the place where the academics interact with the learners. Besides empowering students to adapt to current and future environments and to find solutions to challenges, learning is also the measure of the need that adults feel for connecting education with its application. As a consequence of this, colleges and universities continuously seek to impart critical thinking and problem-solving skills to their students through the curriculum. But acquiring these skills demand both experiential and problem-based methods. Teaching and learning in ODE is typically conducted via the blended pedagogy. In a typical scenario, the three components that make up the blended learning are: face-to-face tutorials, online learning and self-managed learning (see Figure 2). The blend of these three components appears to have been the solution that has worked rather well for the majority of the adult learners.

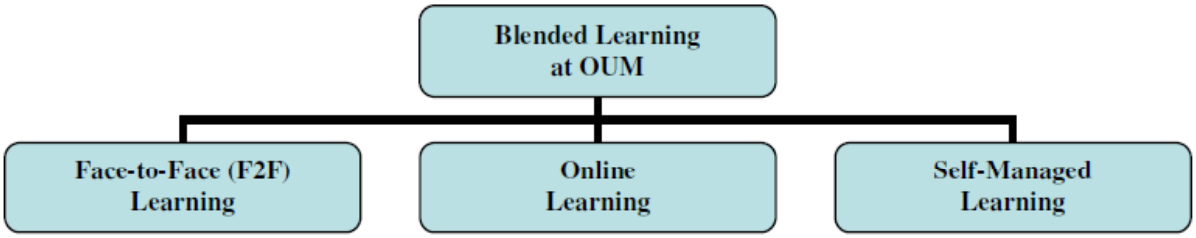

Figure 2: Means to Manifest Teaching & Learning Process at Open University Malaysia (OUM): Blended Pedagogy

F2F meeting remains as an important component as it enables the learners to meet their instruction in a direct communication. In a survey by Zoraini (2004), learners prefer the F2F learning compared to other components. Various instructional techniques have been employed to deliver F2F interactions. These include tutorials, brainstorming, hands-on session, problem-solving and presentation sessions. How can face-to-face interactions be improved further in blended pedagogy so that adult learners gain valuable knowledge? In this paper, we are looking to assess if productive failure (PF) instructional technique can boost students' learning.

PF instructional design has been used successfully especially in secondary schools which have regular contacts with the instructor. It is unknown whether the use of PF instruction among the adult learners in the face-to-face interaction will yield such a positive effect. Can PF instructional design be used in tutorials such as in the blended pedagogy that caters for adult learners with fruitful learning outcome? This will be the main focus of this paper.

Productive Failure

Socio-constructivist theories of learning have given importance to learners to engage in successful learning. It stresses the complex problem-solving activities for a meaningful learning. The complex nature of the problem demands the support such as scaffolding and guidance or structures be provided to enable learners to engage in solving such problems. Without such support structures, learners may fail in their learning. This has led to substantive amount of research examining students solving complex problems with the provision of various support structures and scaffolds (e.g., Cho and Jonassen, 2002; Ge and Land, 2003; Hmelo-Silver, 2004).

However, letting learners to persist, struggle, and even fail at tasks that are complex and beyond their skills and abilities may in fact be a productive exercise that will enhance their learning process later on as explained in the productive failure (PF) instructional design (Kapur, 2010). PF instructional design advocates the delaying of support for the learners during the learning process (Kapur, 2010). The more they struggle and even fail while trying to master new information, the better they are likely to recall and apply that information later (Kapur, 2010). This is also supported by VanLehn et al.'s (2003) findings which suggest that it may well be more productive to delay that structure up until the student reaches an impasse or a form of failure. His research shows that there is a relationship between structure and failure which should be capitalized in the teaching and learning process by using the PF instructional strategy.

Purpose

The purpose of this study was to design a productive failure instructional cycle for adult-based interactions in a face-to-face tutorial and compare it with a conventional lecture class (i.e. strictly direct instruction). We wanted to determine if there is a hidden capacity to produce the desired outcome in the delaying structure in the learning and performance space of adult students. This is done by having them engage in unscaffolded problem-solving of complex problems first before the direct instruction. To achieve this, one classroom-based, quasi-experimental study with first-degree level adult students was carried out; each study targeting a 2-hour tutorial class.

Method

The research approach adopted for this study is discussed in the subsequent sections.

Participants

Participants were n=17, second year students enrolled in the Bachelor of Information Technology programme (13 male, 4 female; 25–47 year-old) at Open University Malaysia (OUM). Students were from two programming classes (8 and 9 respectively) taught by the same instructor. The average-ability students were based on their prior knowledge on programming determined through a pre-test. Students had limited or no experiences with the targeted concept—*object* and *classes*- prior to the study.

Research Design

The proposed research design for this paper is adopted from Kapur (2010). A quasi-experimental design was used with one class (n = 8) assigned to the 'productive failure' (PF) condition and the other class (n = 9) assigned to the 'lecture and practice' (LP) condition. Both classes participated in the same number of tutorial hours for the targeted concept totaling two hours of tutorial class each. Thus, the amount of instructional time was held constant for the two conditions. Before the unit, all students wrote a 20-min, 7-item pre-test (Cronbach alpha = .70) as a measure of prior knowledge of the targeted concepts. There was no significant difference between the two conditions on the pre-test, $p < 0.05$. At the end of their two-hour tutorial class, all students took a post-test (described later in the paper).

Productive Failure (PF) Class

The eight students in the PF class were assigned into groups. The instructor had given the students the freedom to form their groups resulting in 3 groups (2 triads, 1 dyad). In the PF instructional design cycle, the student groups took 45 minutes to work face-to-face on the ill-structured problem. Following this, the students took 15 minutes to solve one problem individually. The individual problems were designed as an extension of the problem based on the ill-structured problem discussed earlier by the learners in group. This extension problem requires the students to write brief programming codes. No extra support or scaffolds were provided during the group or individual problem-solving. The consolidation lecture was held towards the last one hour of the class where the instructor led a discussion of the targeted concepts. One ill-structured problem scenario was developed for the concept on *object* and *class*. The problem in the task acts as a stimuli for the learning to take place and represent a platform for the learners to engage in the collaborative learning in their group. The following guidelines for the preparation of a good "ill-structured" question in the form of a task have been applied in order to ensure effective collaborative learning among the learners (Johnson and Johnson, 1994). They are:

- The task is conceptual
- The task requires problem solving approach
- The task requires higher-level reasoning and critical thinking
- The task emphasizes mastery
- The quality of performance is needed

The group discussion in the PF class is also conducted on the premise of that the learners' learning is not so much a matter of building up correct responses or eliminating incorrect responses. The most important thing is for students to have the opportunity in a group to test the adequacy of their ideas. It is the process of how the learners "*persist*" in the problem solving activity rather than on actually being able to solve the problem successfully (Kapur, 2010).

Lecture & Practice Class (LP)

The nine students in the LP class were involved in instructor-led lectures guided by the same question discussed by the PF group but in a more structured manner. The teacher introduced the same concepts taught in the PF class, formulate a solution and encourage students to ask questions. The teacher then discussed the solutions with the class using the guided hands-on approach. In short, the LP condition represented a design that was highly structured from the very beginning with the teacher leading the students through a set of well-structured problems with feedback and practice sessions.

The PF condition represented a design that delayed structure (in the form of the consolidation lecture) up until the time when the students had completed the one ill-structured problem scenario and the corresponding individual problem solving problems *without* any instructional facilitation, support structures, or scaffolds. Table 1 shows the PF and LP instructional cycle.

Table 1: PF versus LP

PF Class	**LP**
PreTest	PreTest
45 minutes: Complex Problem Solving (group)	**120 minutes**: Lecture and feedback with
15 minutes: Exercise (individual)	hands-on session
60 minutes: Consolidation Lecture	Post-test
Post-test	
Total: 120 minutes (2 hours)	

Data Sources and Analysis

The data analysis procedures and the results are described in the following section. The problem solving process by the adult learners were analyzed using both process and outcome measures with qualitative and quantitative means. For qualitative process measures, we analyzed the program codes produced by groups and also the group discussions. We have audio taped the PF group's discussion. Group discussions were analyzed to understand how solutions produced by the groups related to the various qualitative and quantitative methods—both domain-general and domain-specific—that groups used in their attempt to solve the problems. Quantitative process measures included analyses of group solutions, individual solutions to the extension problems and the corresponding confidence ratings. Outcome measures will focus on the performance on the post-test.

Process Analyses and Results

A qualitative analysis of the group discussions revealed that groups, in general, generated several concepts and methods for solving the problems. These concepts and methods can be seen as structures generated and developed by the group to solve the problem (Anderson, 2000; Chi et al., 1981; Schwartz and Martin, 2004). The focus of analyzing group discussions was limited to an analysis of the relationship between these student-generated structures, that is, how the solutions produced by the groups related to the various qualitative and quantitative methods—both domain general and domain-specific—that groups discussed and used in their attempt to solve the problem. Here is a solution submitted by one of the groups:

```
public class student {

        int[] marks = new int[30];
        int numPass=0;
        int numFail=0;

        public static int getMarks(int numPass, int numFail){

        int marks;
        if (numPass>=50)
        System.out.println.("pass" + marks);
        else if (numfail<=50)
        System.out.println ("fail" + marks);
```

Figure 3: Solution of the one of the groups

Excerpt 1
S1: How to start
S2: Let us read the question
S3: I think we need to write one program
S2: Then how?
S1: I think we need to write two programs

Excerpt starts with s1 asking how to start. S2 advises the members to read the question so that the group understands the problem better. After reading the question, s3 in opined that they should write one program followed by S2 who sounds confused on this. S1 countered that the group should write two programs. Obviously, in his except, the group is still confused on how to solve the problem.

Excerpt 2
S2: Then declare the numbers
S1: I think we should declare the numbers first
S3: Let us declare the numbers first
S1: Let me type in the computer

In the second excerpt, S2 asks the members to type the "numbers". S1 and S3 agreed that "numbers" need to be typed first. S1 volunteered to type the program. From excerpt 2, it is obvious the group did not follow the "class-object" approach as instructed in the question. The group tried to write the codes in an "ad-hoc" manner by creating disconnected code links.

Excerpt 3
S3: Type the class and the name first
S3: We name the class as student
S1: Are you sure we need to declare the numbers first?
S1: Because we suppose to have the member method
S2: Why not we look on the program that we write last week?
S1: Is the program interactive?

In excerpt 3, S3 asks the member to type the class name. Then, there is confusion whether to declare the "numbers" or to declare the "methods". Then, S1 comes in with another question on whether the program should be interactive. Excerpt 3 shows that the group ends up in more confusion as the codes are expanding.

The analyses of group solutions together with that of the group discussions suggest that the group was ultimately unable to succeed in developing a solution to the problem although they brought in various constructs and ideas during the discussion. Some of these structures were rejected quickly through a guess-and-check method while others were ''abandoned'' when new ideas resulted in an understanding that the solution was either not suitable for the problem. Classroom observations also suggested that groups were quite engaged and tended to persist in the problem-solving process although they were not able to solve the problem correctly.

Group Solution

Analysis of the groups' solutions suggested that all groups were able to come up with an incomplete solution and it does not answer the problem's requirement. Based on the analysis done by the instructor, no group submitted an acceptable solution.

Confidence Ratings

After solving the individual extension problems, students in the PF design condition rated the confidence they had in their solutions using a 5-point Likert scale from 1 (not strongly confident) to 5 (strongly confident). The average confidence reported by students was low, M = 2.67, SD = 0.89. This is reflective of the poor group performance as discussed earlier.

Outcome Analyses and Results

Individual outcomes were measured using one post-test. The post-test targeted content/concept (i.e. object and classes) covered during the 2-hours tutorial for the both PF and LP groups.

Post-test Result

Students from both the PF and LP classes were given 20 min to complete a 7-item post-test (Cronbach alpha = .71) comprising six well-structured problem items (in the form of multiple choice questions) similar (not same) to those on the pre-test as well as one item on higher-order application-based problem. Students need to write a brief program codes for this high-order application-based questions.

Controlling for the effect of prior knowledge (as measured by the pre-test), an ANCOVA revealed a statistically significant effect of condition (PF vs. LP) on post-test scores, $F(1, 14) = 7.65$, $p = 0.0152$, ES (effect size) = 0.35. The adjusted (i.e., after controlling for prior knowledge) mean performance of students in the PF class, M = 6.56, SD = 2.72, was better than those in the LP class, M = 3.67, SD = 3.423 an average difference of 41% points given that the maximum score possible on post-test was 10. Levene's test for homogeneity of variance was not significant.

We also conducted further analysis by considering the well-structured and higher-order application items on post-test separately. Findings are highlighted below:

1. On the well-structured items, students from the PF class scored higher, M = 4.13, SD = 1.46, than those from the LP class, M = 2.56, SD = 1.88. This effect was statistically significant, $F(1, 14) = 5.22$, $p = 0.038$, ES = 0.27. This difference amounted to 45% points (maximum score on these items was 6) with a low effect size. Notwithstanding, it was remarkable that PF students who were not able to come with a proper solution during the group discussion still managed to outperform LP students on the well-

structured items; the type of items that the LP students were introduced during the lecture in their 2-hours session.

2. On the higher-order analysis and application item, students from the PF class scored higher, M = 2.56, SD = 1.45, than those from the LP class, M = 1.11, SD = 1.76; an average difference of 36% points (maximum score possible on this item was 4). This effect was statistically significant, F (1, 14) = 4.55, p = 0.043, ES = 0.26. Thus, students from the PF class outperformed those from the LP class on both the well structured items as well as the higher-order application-based item on post-test even in a relatively-short, 2-hours design intervention. These results are also in agreement with the findings from Kapur (2010).

Discussion

This study was designed to compare a productive failure instructional design to a conventional lecture and practice instructional design. We wanted to determine if there is a hidden capacity to produce the desired result in delaying structure in the learning and performance space of adult students by having them engage in unscaffolded problem-solving of complex problems first before direct instruction. Conlusions from the study suggest that despite seemingly failing in their collective and individual problem-solving efforts, students from the productive failure condition significantly outperformed their counterparts from the lecture and practice condition on the targeted concept in the post-test. This is an important finding because an often-made assumption in teaching and learning is that students need structure such as scaffolds to elevate their learning (Kapur, 2010). From the teacher point of view, structuring the lesson start from the beginning is a good pedagogical approach. However, findings of this study suggest that this assumption is not always valid. The productive failure instructional design has enabled the adult learners to generate and develop their own structure such as concepts and method or approach (as demonstrated earlier in the qualitative study of the group discussion) for solving the complex problems (Kapur, 2010). The process of generating a diverse set of structures while exploring the problem and solution spaces may have engendered sufficient knowledge differentiation even though it did not result in a successful solution. Such knowledge differentiation was critical for learning because it prepared students to better discern and understand those very concepts, representation, and methods when presented in a well-assembled, structured form during the consolidation lecture (Gibson and Gibson, 1955; Marton, 2007 as cited by Kapur (2010). In the following section, the implication of the findings in this study is discussed.

Implications of the Study

Though it is difficult to draw implications from one study; what more with a small sample, we believe the findings from this study do lead to some broader implications. We have identified three broad implications that can be concluded from this study in the context of open and distance learning. Firstly learners need to be actively engaged. Learning by doing, analogy and assimilation are important elements in pedagogy and where possible, learning outcomes should relate to real-life experiences through simulation and application. Secondly, the learning environment should include problem-based as well as knowledge based learning. It has been acknowledged that if problem-based assignments are provided it would involve the higher order thinking skills like analysis, synthesis and evaluation while the lower levels of recall, comprehension and application are evidenced in knowledge-based learning. Finally,

learning experiences support interaction and development of community and social interest. Anything that relates to experiences is based on interaction and collaboration which in turn leads to networking and support groups that enhances learning. Multiple interactions, group collaborations and cooperative learning provide the increased level of interaction.

Limitation of the Study

Definitely it is too early to attempt broad generalization of the claims based on a single study. These findings may only be attributed to the productive failure instructional design as a whole and not to its constituent design elements of collaboration, unscaffolded solving complex problem scenarios designed for persistence, and delay of structure (Brown, 1992). The main aim of this paper was to put greater emphasis on a comparison of designs as wholes vis-à-vis causal attribution of effects to design elements (Fishman et al., 2004; Tatar et al. 2008; Tharp and Gallimore, 1982). As such, this study, essentially, presents an evident proof for a productive failure instructional design, and allows much space for future research. The research was done with a limited, small sample and to draw generalizations from it might seem overwhelming. However it is pertinent to realise that this research can be extended to more learners in the ODL mode to draw conclusions on the positive nature of the productive failure instructional design.

Summary

One question that many will ask after reading this paper is why waste time letting learners muddle through (and for a longer duration) when the instructor could easily give them the correct interpretation within a shorter time? Although this is a valid question but what PF suggests is that processes that may seem to be inefficient and divergent in the shorter term potentially have a hidden capacity to produce more sustainable desired results provided one could unpack that efficacy (Kapur, 2010). As we are well aware, learners have their learning styles which differ in the ways learners learn. In catering for adult learners in ODL, it may be beneficial if the early learning experiences provided are not too structured. By not structuring too much the early learning experiences of adult learners in the blended pedagogy, the option to persist in the productive failure may result in honed problem solving skills resulting in better learning options. We should allow the adult learners to persist and possibly fail so that it can be a productive exercise in failure as opposed to “negative failure”. Instructors should resist to structure learning and problem-solving activities as it will be more fruitful to have instructional designs leading to “productive failure” as opposed to just “negative failure” which we do not want it to happen. Thus, is floundering among adult learners in classrooms a fact or fallacy? The answer is certainly a “fact” as proven in this study. The quality of their learning depends very much on quality of experiences that are provided for them in the learning environment.

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