Disrupting Students’ Learning Micro-Culture in a Graduate Pharmaceutics Course: Perceived Impact of Deep Learning Strategies on Self-Efficacy

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Abstract

In an attempt to break a micro-culture of shallow learning associated with problem-solving, this study describes the impact of two complementary instructional deep-learning strategies, productive failure and instructor-designed concept maps on pharmacy students’ perceptions and beliefs. The analysis of a proposed path model indicated that students’ perceived impact of the two instructional strategies were significant predictors of self-efficacy. Future research will focus on the impact student-generated concept maps for transfer problems associated productive failure.

Motivation and Objective of the Study

Pharmacy students are expected to assume diverse roles that extend beyond the traditional roles of dispensing medications and medication management for patients. They are increasingly expected to analyze new information and use the conclusions drawn to solve complex problems. Current ACPE pharmacy accreditation standards emphasize problem-solving competencies needed to integrate knowledge from foundational sciences (Medina et al., 2013). The instructional strategy commonly used in fundamental and applied sciences is scaffolding through worked examples (e.g. Jonassen, 2004, 2011). One of the major shortcomings of this strategy is its tendency to prompt learners to focus on the procedural aspects of the problem solving. That is, students are often missing the conceptual integration of foundational knowledge that experts convey as they work through problems (Darabi et al., 2007; van Gog et al., 2015).

This shortcoming become even more critical, especially as pre-pharmacy students create a micro-culture of shallow learning. As these students move into the entry level pharmacy courses, some of their gaps in knowledge pose challenges that could hinder their academic performance. The major objective of this study was to analyze to what degree instructional strategies focused on stimulating deep conceptual understanding through the use of concept mapping integrated with productive failure in-class strategies can alter the above described micro-culture of shallow learning.

Instructional Intervention

“Pharmaceutics I” is a foundation course in the Pharmacy Doctorate (PharmD) program that strives to bridge the foundational chemistry knowledge form pre-pharm curricula and the applicative clinical skills by building strong analytical and problem-solving skills. The instructor found that for some topics for which students consistently performed below expectations and identified as one major reason the fact that students failed to make the required connection between the conceptual aspects of chemical equations and the algebraic equations used to model them.
For a couple of semesters, the instructor worked with an instructional designer to adapt and implement a productive failure instructional strategy (Kapur, 2008, 2010, 2013). Using a design-based research methodology (Cernusca & Ionas, 2014) with two iterative DBR cycles, the researchers found that students in the treatment cohort scored significantly higher on the exam that was the focus of this strategy (Cernusca & Mallik, 2018). However, the instructor observed a lack of consistency in students’ ability to analyze the conceptual structure behind the problem information and decide on the nature of the analysis that needs to be performed. To address this gap, during spring 2019 semester the instructor, working with the instructional designer, started to integrate in the instructional process a series of instructor-designed concepts maps associated with the worked examples prior to and part of the productive failure strategy.

Concept mapping is an effective mindtool (Jonassen, 2000) that helps engage learners in critical thinking and deep learning (Bilik et al., 2020; Hay, 2007) and effectively assess learning (Weinerth et al., 2014). While concept mapping was introduced at a larger scale in education during 70’s, more current reviews of the literature show the potential impact of this tool across various areas of health professions such as medicine (Daley & Torre, 2010), nursing (Daley et al., 2016) and pharmacy (Hill, 2004; Noble et al., 2011). Finally, concept mapping proved to be an effective tool when integrated with other deep-learning instructional tool and strategies. For example, concept mapping was integrated with the use of a photograph association technique (Byrne & Grace, 2010). While this integration was used to elicit children’s ideas about a specific science topic, concept mapping can be useful in pharmacy educational research associated with sensitive topics. For example, adding concept mapping to the use of photovoice strategy (Werremeyer et al., 2017) can enhance the quality of the outcome resulted from the photovoice intervention. At a deeper level, Addae et al., (2012) proposed a modified Problem Based Learning (PBL) strategy where concept mapping was combined with the traditional PBL phases to produce a new 5-phase leaning approach in which three of the phases were designed as identifiable concept mapping tasks. In this strategy the first concept map was developed as a group map focused on the structure of the clinical problem and served as the center of the overall map that was developed in the other two concept mapping tasks.

We decided to integrated concept mapping with the active learning in-class activities with a focus on increasing students’ ability to solve problems that were scaffolded with a productive failure strategy previously implemented in this course (Cernusca & Mallik, 2018). While the fully student-generated and partially student-generated concept maps proved to be more effective than the expert-generated concept maps (e.g. Lim et al. 2009) we decided to start this integration process with later type, expert-generated type with the instructor being the expert in this case. From an instructional impact perspective, the inclusion of instructor-designed maps was selected because it is a low-impact strategy that has a main goal to introduce students to the basic structure of the mental models associated with various stages in the problem-solving process. That is, this strategy was not expected to significantly increase the anxiety associated with the changes in the instructional process, reducing therefore the chances to create student resistance to the change.

Examples of topics that were augmented with instructor’s concept maps were the identification of functional groups, molecule type identification or compound identification (see Figures 1 to 3).
Figure 1
*State of Matter concept map*

Figure 2
*Physical Properties of Molecules concept map*

Figure 3
*Acid Base concept map*
Because the structure of the instructor-generated concept maps was dependent of the context of the problem to be solved, the instructor encouraged students to try to adapt his maps for the problem that was solved during the classroom activities or as part of the assigned homework.

**Research Focus and Methodology**

Due to the relatively low impact of the use of instructor-driven concept maps, the major goal of this study was to explore the perceived impact of the integration of productive failure and concept mapping on pharmacy students’ self-efficacy (used as a proxy for students’ future performance).

**Research Design**

An exploratory quantitative design research was used to analyze if perceived impact of concept mapping and productive failure were significant predictors of student perceived self-efficacy. The proposed structural model is presented in Figure 4.

**Figure 4**

*Proposed conceptual model related to the implemented instructional intervention*

![Proposed conceptual model related to the implemented instructional intervention](image)

As shown in Figure 1, the expectation is that both the perceived impact of concept mapping and productive failure tasks on own learning increase student self-efficacy beliefs while the two types of strategies perceptions will interact with each other.

**Participants**

The course used for this study had an enrollment of 84 students in their first year of the Doctor of Pharmacy program. A convenience sampling strategy was used, all students in the course being invited to participate in the study. A number of 56 (67%) students volunteered to participate in this study.

**Data Collection**

The instructor collaborated with an instructional designer to administer, using Qualtrics®, an online an end-of-course survey with items adapted for three constructs validated in the literature.
The perceived impact of productive failure on own learning and the perceived impact of concept maps on own learning were implemented from Grasman & Cernusca (2015) with minor changes related to the course name and focal topic to customize them for this study (Appendix 1). The self-efficacy construct was adapted from Cernusca & Price (2013). All three constructs used a 9-point Likert evaluation scale ranging from 1 for Strongly Disagree to 9 for Strongly Agree. Scores for each construct were computed as the average of the scores of its individual questions, resulting in a continuous score ranging from 1 to 9. The online survey was administered during the last two weeks of the course and students had 10 days to complete the survey. No bonus points were given for those that participated in this research study. This study was approved by the local Institutional Review Board and the informed consent form was posted at the onset of the survey indicating the voluntary participation in the study and the alternative task available for those interested in earning the bonus points but not participate in this study.

Data Analysis

Data collected were analyzed for basic statistics and correlations among proposed variables using SPSS v25. Analysis of raw data did not reveal outliers and the analysis of z-scores (< +/-2.5), skewness and kurtosis (< +/- 0.5) indicated an accepted level for the normality of the dataset. All three constructs adapted from the literature showed a very strong internal reliability with Cronbach’s Alpha values of 0.99 for perceived impact of productive failure on own learning and 0.95 for self-efficacy and impact of concept mapping on own learning. A path analysis model for the three proposed variables, perceived impact of productive failure on own learning, perceived impact of concept mapping on own learning and self-efficacy was tested using IBM SPSS Amos v25 software.

Findings

Table 1 presents the basic statistics for each of the measured continuous variable at the exit point in the course. As shown in Table 1, the proposed conceptual model was supported by the statistically significant (p<0.001) correlations among these variables with a moderate to high strength ranging from 0.58 to 0.64.

Table 1
Means, Standard Deviations, and Pearson Correlations for continuous variables (N=53)

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Perceived impact of concept maps</td>
<td>7.24</td>
<td>1.69</td>
<td>-</td>
<td>.58**</td>
<td>.64**</td>
</tr>
<tr>
<td>2. Perceived impact of productive failure</td>
<td>6.98</td>
<td>1.79</td>
<td>-</td>
<td>-</td>
<td>.59**</td>
</tr>
<tr>
<td>3. Self-efficacy</td>
<td>7.04</td>
<td>1.44</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tbody>
</table>

Note: **p < 0.01 (2-tailed)

The results of the path analysis as resulted from the data generated with AMOS are summarized in Figure 5.
The path analysis indicated that both perception variables were significant predictors of self-efficacy, with perceived impact of productive failure standardized coefficient of $\beta=0.32$, $p<0.01$ and perceived impact of concept maps standardized coefficient of $\beta=0.47$, $p<0.001$. The covariance between the perception variables had a standardized coefficient of $\beta=0.58$, $p<0.001$. The overall model had a good fit (NFI=0.99; CFI=0.99) and the two perception variables explained 49% of the variance in students’ self-efficacy, an acceptable level considering the low-impact nature of the concept mapping instructional intervention.

Because the exams in this course are open-notes, anecdotal data based on instructor’s observation during the exams indicated that students used the instructor-developed concept maps when they worked on the problems during the exam.

Discussions and Further Research

The results of this study indicate that the combination of the two strategies, productive failure and instructor-designed concept maps has the potential to significantly impact students’ perceptions and beliefs on own ability to perform well in the course. The acceptance of the two strategies is also a potential indicator of students’ willingness to move toward the use of deep learning problem-solving strategies as part of this course.

Considering the piloting nature of this study, the research team intends to further explore the identified trends by expanding the use of instructor-driven concept maps and introduction of instructional tasks that will require students to generate their own concept maps for transfer problems associated with the worked examples integrated in the productive failure activities.

References


### Appendix 1

**Instructional engagement constructs**

<table>
<thead>
<tr>
<th>The use of Concept Maps in PSCI 368 helped me to…</th>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>...better retain the material taught in lectures</td>
<td>1 2 … 5 … 8 9</td>
<td></td>
</tr>
<tr>
<td>...better prepare for the exams</td>
<td>1 2 … 5 … 8 9</td>
<td></td>
</tr>
<tr>
<td>...develop a better understanding of the concepts introduced in lectures</td>
<td>1 2 … 5 … 8 9</td>
<td></td>
</tr>
<tr>
<td>...feel more confident in my ability to learn the material introduced in the lectures</td>
<td>1 2 … 5 … 8 9</td>
<td></td>
</tr>
<tr>
<td>...make the time studying for exams and quizzes more effective</td>
<td>1 2 … 5 … 8 9</td>
<td></td>
</tr>
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<table>
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<tr>
<th>The use of Productive Failure in PSCI 368 helped me to…</th>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>...better retain the material taught in Buffered Solution lectures</td>
<td>1 2 … 5 … 8 9</td>
<td></td>
</tr>
<tr>
<td>...better prepare for Exam 2</td>
<td>1 2 … 5 … 8 9</td>
<td></td>
</tr>
<tr>
<td>...develop a better understanding of the concepts introduced in Buffered Solution lectures</td>
<td>1 2 … 5 … 8 9</td>
<td></td>
</tr>
<tr>
<td>...feel more confident in my ability to learn the material for Buffered Solutions</td>
<td>1 2 … 5 … 8 9</td>
<td></td>
</tr>
<tr>
<td>...make the time studying for Buffered Solutions exam more effective</td>
<td>1 2 … 5 … 8 9</td>
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