Implementation of Deep-Learning Strategies that Support Development of Adaptive Expertise in Two First-Year Pharmacy Courses

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The objective of this study was to describe the implementation of two deep-learning strategies targeting the development of adaptive expertise skills in two first-year Doctor of Pharmacy courses. To stimulate the development of an environment conductive to building adaptive expertise skills, productive failure and concept mapping were integrated in two courses. The results showed the benefits of building an instructional structure that supports the development of adaptive expertise skills through high self efficacy and perceived value of the two tools on own learning.

Motivation and conceptual framework

Pharmacy doctoral (PharmD) programs are preparing professionals in a healthcare field which is continuously evolving. PharmD programs are required by the external accrediting agency to equip future pharmacists with transferable skills needed to analyze and synthesize new information, draw valid conclusions, and collaboratively solve new, complex, emerging tasks in their healthcare field. To meet these requirements pharmacy instructors need to help students switch their focus toward transferable skills aligned with their professional dynamics.

The conceptual model of adaptive expertise proposed by Hatano and Inagaki (1986) provides a framework which can help instructors achieve this goal. According to this model, learners need to move from procedural knowledge (what, how), useful in stable, routine-type of environments, to conceptual knowledge, needed to explain why something works, in new contextual constraints.The adaptive expertise model stimulated a series of studies in pharmacy education to identify and define strategies to support the development of adaptive expertise (Mylopoulosa et al., 2018; Steenhof, 2020). Three critical strategies were proposed (Steenhof, 2020): (a) engaging students in explaining why questions, (b) encouraging struggle in a safe environment, and (c) asking what if questions. Concept mapping and productive failure align with these strategies. Concept maps are mindtools which engage students in the process of building complex mental models by helping them to build structural knowledge needed to answer why questions (Bilik et al., 2020; Jonassen, 2000). Productive failure is an instructional strategy developed around the role acknowledgment of errors by the learner plays during problem solving while providing a safe learning environment. It builds on the assumption that when a learner is confronted with a task which is similar to a previously failed one, that previous failure will activate needed prior knowledge and skills (Kapur, 2008). Researchers also found productive failure promoted future learning better than both direct instruction (Steenhof et al., 2019) and indirect failure (Steenhof, 2020).

The objective of this study was to describe the implementation of two deep-learning strategies, concept mapping and productive failure, targeting the development of adaptive expertise skills in two first-year PharmD courses.

Instructional context and interventions

Foundational courses in PharmD programs help students building strong competencies which integrate foundational pharmaceutical and pharmacy practice knowledge (Medina et al. 2023). Pharmaceutics I is a course focused on helping first-year students (P1) to bridge the foundational chemistry course in pre-pharmacy curriculum and clinical courses and build transferable problem-solving skills. Pathophysiology I, on the other hand, is a course which focuses on the comprehensive study of physiological processes and the mechanisms of disease important to the understanding of pharmacology and drug therapy.

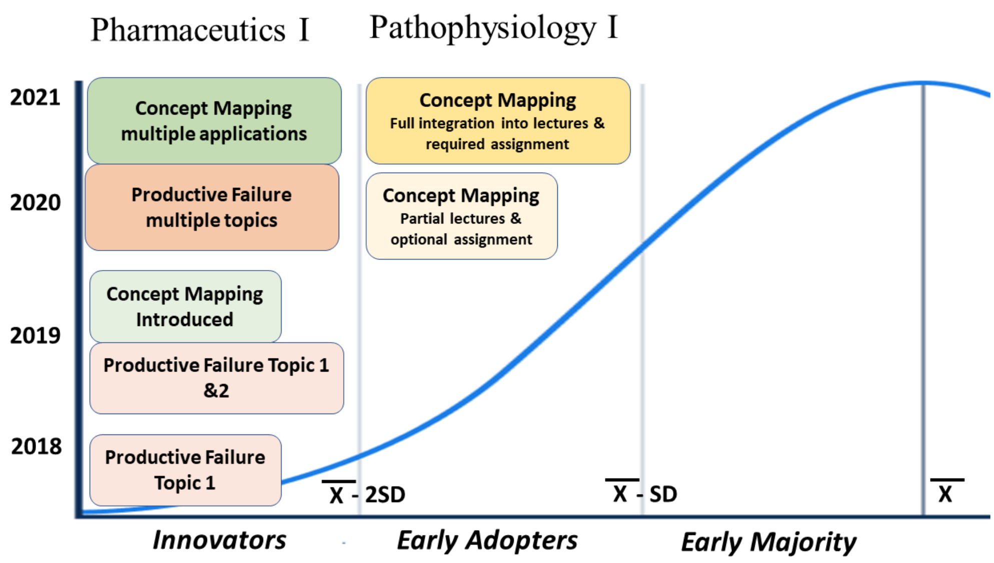
The implementation of concept mapping and productive failure, two instructional strategies focused on stimulating the development of adaptive expertise skills, followed the adopter categories proposed by the Diffusion of Innovation Theory (Rogers, 2003). The instructor in Pharmaceutics I, an innovator, is continuously interested in implementing new instructional ideas which can positively impact the learning process (Rogers, 2003). He initiated a collaboration with an instructional designer (ID) to address students' failure to connect the conceptual aspects of chemical structures with the corresponding algebraic equations.

To address this lack of knowledge transfer, the decision was made to implement productive failure as one of the course strategies. A quasi-experimental research showed students in the productive failure intervention scored significantly higher on the examination than students in the previous cohort, serving as control (Cernusca & Mallik, 2018). The use of productive failure was then expanded to a second challenging topic; however, the instructor observed students were not able to consistently analyze the structural chemistry concepts for the problem to decide on the appropriate analysis. In 2019, the instructor started to integrate a series of structural concepts maps in the instructional process. The positive impact of this strategy on students' self-efficacy convinced him to expand the use of concept maps (Cernusca & Mallik, 2022). After an informal presentation of the results from Pharmaceutics I, the instructor of a module in another P1 course, Pathophysiology I, was interested in the potential of concept mapping. She had a course-coordinating role and played a leadership role in adopting of new ideas in her professional field, an early adopter according to Rogers (2003).

In 2021, the second instructor started to implement concept mapping by: (a) using concept maps in lectures to connect introduced topics and (b) introducing an optional concept mapping activity for students. Encouraged by the implementation results, the instructor decided, in 2022, to formalize the use of concept mapping by: (a) completing the integration of concept mapping for all lectures; (b) inviting the ID to introduce effective concept mapping how-to tips in class, and (c) introducing a required concept mapping assignment. Figure 1 synthesizes the adoption process of the two expansive learning strategies for the two courses.

Figure 1

Stages of Adoption of Productive Failure and Concept Mapping



Research methodology

An exploratory quantitative design research was used to analyze: (a) the change between 2020 and 2021 in student self-efficacy, perceived impact of productive failure, and concept mapping for each of the two courses, and (b) the differences in self-efficacy and perceived impact of concept mapping between the two courses.

A convenience sampling strategy was used, all students in the two courses being invited to participate in the study. Online end of module (Pathophysiology I) and end-of-course (Pharmaceutics I) surveys were administered. Survey items were adapted from constructs validated in the literature for: (a) perceived impact of productive failure/concept mapping on own learning (Grasman & Cernusca, 2015), (b) self-efficacy (Cernusca & Price, 2013), and (c) perceived engagement due to concept mapping (Gebre et al., 2014). All constructs used a 5-point Likert scale. Internal reliability for all three constructs was very strong with Cronbach's Alpha scores ranging between 0.89 and 0.97.

Summary of findings and conclusions

For Pharmaceutics I course, as shown in Table 1, while the values for the 2022 cohort were very slightly higher than for the 2021 cohort, an independent-samples t-test showed no statistically significant differences.

Table 1

Comparing two consecutive implementations in Pharmaceutics I

	2021		2022		df	t	p
M	SD	M	SD				
Self-efficacy	4.06	0.52	4.09	0.78	95	-0.19	0.85
Concept mapping impact	4.02	0.78	4.05	0.90	95	-0.17	0.87
Product failure impact	3.82	0.81	3.88	1.04	90.4	-0.28	0.78

The results were similar for concept mapping impact on own learning and engagement due to the use of concept mapping in Pathophysiology I course (Table 2). However, the self-efficacy for the 2022 Pathophysiology I cohort was statistically significantly higher than for the 2021 cohort (see Table 2). Also, a one-sample t-test indicated the mean values for all constructs across the two years were significantly statistically higher than the neutral value of the evaluation scale ($p < 0.01$).

Table 2

Comparing two consecutive implementations in Pathophysiology

	2021		2022		df	t	p
M	SD	M	SD				
Module self-efficacy	4.11	0.55	4.40	0.49	104	-2.87	<0.01
Concept mapping impact	3.25	0.97	3.30	1.04	106	-0,23	0.82
Engagement due to concept mapping	3.33	0.93	3.60	0.94	106	-1.15	0.15

Finally, perceived impact of concept mapping for the Pharmaceutics I implementation was statistically significantly higher than for Pathophysiology I implementation for both years of implementation (Table 3). On the other hand, for self-efficacy the significant increase in mean values in Pathophysiology I from 2021 to 2022 previously discussed was reflected also in a statistically significantly higher mean for self-efficacy when compared to Pharmaceutics I course (Table 3).

Table 3

Comparing Pathophysiology I and Pharmaceutics I for two consecutive years

	2021				2022			
M	SD	t(100)	p	M	SD	t(101)	p	
	Self-efficacy							
Pharmaceutics I	4.06	0.52	0.10	0.92	4.09	0.78	-2.48	< 0.05
Pathophysiology	4.05	0.69			4.40	0.49		
	Concept mapping impact							
Pharmaceutics I	4.02	0.78	4.39	< 0.001	4.05	0.90	3.92	< 0.001
Pathophysiology	3.25	0.97			3.30	1.04		

To summarize, the results from this study indicate a cross-courses implementation for the same cohort produced high self-efficacy and perceived values on own learning. That is, both self-efficacy, a proxy for future performance, and perceived impact on own learning were scored toward the higher end of the evaluation scale.

Limitations and Future Research

There are two major limitations for this study. First, we compared a full course with a module which covered about one third of the course. This could impact students' perceptions and beliefs related to the use of the two adaptive expertise strategies used in this study. Second, due to the exploratory nature of this study we focused on self-reported measures rather than student outcomes.

The results also indicate increased length and the depth in the implementation process increased students' perceived benefits of the instructional tools and strategies on own learning. This finding suggests the potential of future research built on expanding the adoption of concept mapping in the other modules of Pathophysiology I course. Future research might be also focus on the impact of the use of these two adaptive expertise strategies in future courses by using coincidence analysis which allows the study of implementation of multifaced interventions which involve multiple elements working together.

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