Qualitative Analysis of the Use of Mind Mapping in Physician Assistant Students

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Abstract-Critical Thinking (CT) is essential for the Physician Assistant (PA) as they seek to provide patientcentered treatment. Mind Mapping (MM) is an innovative learning strategy used to enhance critical thinking skills. This paper describes the effectiveness of mind mapping as a learning strategy and the different aspects of promoting critical thinking in PA students. PA students who made mind maps for nine weeks indicated that mind mapping assisted in memory, analysis, understanding, organization, and integration of information. All of which are essential for CT.PA students emphasized the vital role faculty play in promoting CT by employing active and innovative learning strategies to facilitate learning and reinforce ideas. PA students reported that active learning strategies contribute to the development of CT skills, and they are interested in learning new strategies primarily to improve learning, performance, and retention of knowledge. Together these findings suggest that PA educators can optimize Learning that fosters CT using strategies like mind mapping.

Index Terms—critical thinking, mind mapping, learning strategy, physician assistants

I. INTRODUCTION

In Physician Assistant (PA) programs, the volume and rate of information transmitted to students are more indepth than undergraduate education and comparable to other health professional programs such as PT, MD, and NP. PA students feel overwhelmed by the sheer amount of information they must learn. However, students in these environments are required to organize, memorize, recall, analyze, and apply enormous amounts of information in a comparatively short span [1]. Often students are not familiar with how to learn effectively and improve memory, thus compromising their learning further [2].

To be successful, the physician assistant student must critically integrate information quickly and effectively. To promote the critical integration of volumes of information in a short time, educators need to utilize learning strategies that foster critical thinking among PA students and enable them to emerge as sound clinicians who deliver competent care [3 &1]. A **learning strategy** is a thinking tool that a student can use to acquire information actively, and some examples include mnemonics, charts, or maps [4].

Standard learning processes involve using notes and outlines. Although these practices are helpful, they lack creativity and associations. Apperson [5] states that the key to educational and learning processes is one's ability to organize information. Organizing information involves creating frameworks like concept and mind maps that facilitate analysis, memorization, and understanding the relationship between concepts [6]. The creative association established in maps improves knowledge and develops critical thinking [7]. Mind mapping (MM)may be such a strategy to achieve this goal [8 &9]. However, the mind map is an underused tool in medical education [7]. A mind map [Fig. 1] is a specific type of map, as it is a non-linear visual representation of a network of connected and related concepts [6].



Figure 1. Mind map on the concept of health [10]

A. Mind Mapping in PA Education

Tony Buzan pioneered mind mapping in the 1970s. A mind map consists of a central topic placed in the middle of the page. It has categories and subcategories that radiate peripherally and are usually pictorial and uses color [11]. Concept mapping (Fig. 2), on the other hand, is unicolor, uses hierarchical order to link concepts

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together with propositions or linking words between ideas, and does not use pictures [12]. Interestingly, both learning strategies are rooted in a conceptual framework called the constructivist Theory of Learning, which states that meaningful learning or learning with understanding occurs when learners assimilate new information within their existing framework [13&14].



Figure 2. Concept map of matter. Adapted from Ann [15]

II. LITERATURE REVIEW

Research in higher education has recognized mind mapping as a potential teaching and learning strategy that actively engages the learner in synthesizing and integrating information in a meaningful, non-linear manner. Meaningful Learning is essential for critical thinking [16]. Mind maps boost memory in medical students [17], foster creativity [18], and enhance learning in nursing students [19]. Mind maps help in planning, organizing information, and encourage critical thinking, problem-solving, and the integration of information [20] in physical therapy students and promotes radiant thinking [7] in graduate nursing education. Likewise, mind mapped care plans enabled nursing students to focus on the patient and provided a better understanding of the treatment process [9, 8, & 21]

The outcomes of mind mapping are all very relevant, essential, and valuable for physician assistant students and future practicing PAs. However, there is no data on MM as a learning strategy to promote critical thinking in PA students. Literature does suggest that MM may benefit students with diverse learning styles, given its multi-sensory approach to learning, which provides a 360-degree perspective and fosters the development of critical thinking [22]. Therefore, the purpose of this study was to evaluate mind mapping as an effective learning strategy and to understand better the different aspects of promoting critical thinking in physician assistant students.

III. MATERIALS AND METHODS

A. Design

A mixed-methods embedded design allowed concurrent data collection for both qualitative and quantitative analysis. The randomized control study (RCT) formed the quantitative part. The RCT determined that Mind Mapping Group (MMG) had significantly (<.05) stronger overall critical thinking skills than the standard notetaking group (SNTG) after nine weeks of following their learning strategy (discussed in another paper). The critical thinking skills were determined using the Health Science Reasoning Test. The qualitative part involved a survey that contained open-ended (OED) questions. The private investigator (PI) prepared the questions. After nine weeks of following their particular learning strategy (mind mapping or standard notetaking), the participants completed the survey. This paper focuses on the qualitative part of the study.

Specifically, the survey had three OED questions in the pre-test, and three OED questions in the post-test. Both groups responded to the five questions (three preand two post-). The SNTG had an additional post-test question. These questions followed the HSRT pre- and post-tests. The following were the Pre-test questions for both groups:

1. What learning strategies do PA students use to support their Learning in PA school?

2. How would you define critical thinking?

3. What contributes to the development of your critical thinking skills?

The following were the Post-test question for both groups:

1. What persuades you to be interested in a new learning strategy?

2. How can faculty contribute to critical thinking in students?

The following was a post-test question to the SNTG ONLY:

1. What do you know about the use of mind mapping as a learning strategy?

For the MMG, an additional post-test Likert-type questionnaire developed by the PI. assessed statements regarding mind mapping. The scale offered a choice of five pre-coded responses ranging from strongly agree to agree, uncertain, disagree, and strongly disagree. The Likert questionnaire evaluated items like "Mind mapping can help organize information" and "Mind mapping helps in integration of information." The Likert survey had positive statements on mind mapping.

B. Sample and Settings

First-, second-, and third-year PA students in three institutions in the eastern US voluntarily participated in the study. The institutional review board approved the study. Participants who had prior experience or knowledge about mind mapping did not participate in the study.

C. Study Process (Fig-3)

PI. recruited participants via on-site recruitment following an oral presentation discussing the study protocol. The PI. (blinded) then randomly assigned volunteer study participants to either the MMG or the SNTG (by odd/even index cards). The SNTG was the control group, and the MMG was the experimental group. Standard notetaking refers to strategies that do not resemble concept or mind mapping in the organization of information. It includes notes that are arranged from top to bottom or from left to right, index cards, and using study methods that students have been using in their academic career.

Index cards had email links for the appropriate pre-HSRT for the assigned groups. The index cards also had participant code numbers for future study correspondence. The participants listed their emails and group assignment in a study participant data sheet that was pre-coded. Participants have a week to complete the demographic survey, open-ended questions, and pre-HSRT at their convenience in a quiet location with access to a computer, following which the MMG was invited back for an instructional session on how to construct mind maps given by the PI. MMG participants were instructed to create mind maps weekly and drop of their mind maps at a drop-off box in their PA department every three weeks for the next nine weeks. The SNTG was asked not to mind map and to maintain a log of their learning strategies used and email their record every three weeks to the PI. After nine weeks, the PI. emailed both groups the link to the appropriately coded post-HSRT and instructions for completion within six days. The PI. then compiled the demographic data, responses to open-ended questions, and critical thinking scores. Likert type questions determined the utility of mind maps in promoting critical thinking skills in physician assistant students.



Figure 3. Study process

IV. DATA ANALYSIS

Data analysis of open-ended questions consisted of coding and organizing information from the responses

into themes. Microanalysis or line -by -line analysis by reading through the entire text was first employed. Themes were identified within the text using the comment tool in Microsoft word. Depending on the responses, some questions had pre-determined and emergent themes, while others had only emergent themes. The literature provided pre-determined themes (Fig. 4).



Figure 4. Content analysis of open-ended questions

The intercoder agreement used to ensure objectivity and validity of the data analysis was conducted by two researchers who independently coded like statements in the data and established themes [23]. Cohen's kappa reported intercoder reliability. Cohen's kappa is an index that measures interrater agreement for categorical (qualitative) items. Cohen's kappa considers the possibility of the agreement occurring by chance. A kappa value of .70 is satisfactory [24].

V. RESULTS

The PI. organized the themes from the different questions into a series of data Tables I-VI.

Tables I-III illustrate the themes for the following **pre-HSRT open-ended questions:**

Q1. What learning strategies do PA students use to support their Learning in PA school?

Q2. How would you define critical thinking?

Q3. What contributes to the development of your critical thinking?

Based upon the participant's responses to Q1, the preferred learning strategy identified was a combination of visual, auditory, and verbal (49%) followed by visual (35%) and verbal (16%). Table I illustrates the three themes obtained for the "learning strategies employed by the PA students" and the interrater reliability scores.

 TABLE I. LEARNING STRATEGIES OF PA STUDENTS (N=74)

	TABLE 1. LEARNING STRATEGIES OF TABLENIS $(1-74)$	
Theme 1: Visual	Theme 2: Verbal	Emergent Theme 3: Combination
Based on VARK (25)	Based on VARK (25)	Based on VARK (25)
Prefer using flashcards, map,	Prefer using words, written and spoken, use study groups, benefit	Visual, Auditory, Verbal, &
charts, notes, pictures, and images	from oral and written reports, use mnemonics and read aloud	Emergent
"Making notes."	"Textbook reading and flashcards."	"Outlines, flashcards, question banks, videos, PowerPoints."
"tables, graphs, flow charts, pictures."	"repetition, writing."	"Flashcards and diagrams."
"Flashcards, color coding, charts."	"writing notes, reading textbook."	"notes, flashcards, outlines, videos."
	Percentage of respondents for each of the identified themes	
35%	16%	49%

Note: Interrater reliability = 87%

Q2 and Q3 had 74 respondents. There were three themes established in "Defining critical thinking" in question 2, shown in Table II. The themes included those

defined by Facione [26], themes identified by Facione and additional emergent themes, and emergent themes only. The interrater reliability was 91%.

(TT) 1			
Theme 1:	Theme 2:	Emergent Themes 3:	
Components of Critical thinking (26): Induction, Deduction, Analysis, Evaluation, Inference, problem- solving, decision making reasoning	Components of critical thinking (26) + Additional (emergent) themes: application, memory, synthesis, understanding, and judgment	(Synthesis, application understanding and interpretation)	
"evaluation and analysis of a specific matter."	"problem-solving with a true understanding of all aspects."	"Using your knowledge and applying it to a situation in which the knowledge can be integrated."	
"deep analysis of a given topic."	"analyzing and applying knowledge to come up with a solution/outcome."	"integration of information to see the big picture when assessing a situation."	
"evidence-based, analytical solving of a problem."	"being able to form conclusions based on multiple sources of information and putting them all together."	"Being able to think about a topic in a greater context than the individual topic itself."	
Percentage of respondents for each of the identified themes			
36.6%	16.2%	47.3%	

TABLE II. DEFINITION OF CRITICAL THINKING (N=74)

Note: Interrater reliability= 91%

Table III highlights the four themes established for "the development of critical thinking." Attitudes and

knowledge, Active learning strategies, understanding, and active learning strategies and understanding.

TABLE III.	DEVELOPMENT	OF CRITICAL	THINKING ((N=74)
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Theme 1:	Theme 2:	Theme 3:	Emergent Theme 4:
Attitudes and	Active Learning Strategies (28)	Understanding	Active learning strategies and
Knowledge (27) Rest, receptive	Situational experiences, writing, discussion, problem-solving	(27)	Understanding
"knowledge of concepts."	"problem-solving skills & analyzing literature."	"How well you understand the information."	"understanding the topic and ability to use context to answer."
"sleep"	"to think quickly and make decisions."	"understanding concepts instead of memorizing information."	"Practice questions, understanding or concepts, and being able to relate similar concepts."
"learning"	"Taking knowledge and education apply to clinical training and patient encounters."	"Trying to understand on my own"	"understanding of the concept in differing scenarios."
	Percentage of responden	ts for each of the identified theme	es
12%	66 %	11%	11%

Note: Interrater reliability = 95%.

Tables IV-VI exemplify the themes to **Post-HSRT Open-Ended** Questions

Table IV Displays the five **emergent themes** generated for "What persuades you to be interested in a new learning strategy?"

Theme 1:	Theme 2:	Theme 3:	Theme 4:	Theme 5:
Improve Learning,	Efficient & Quick:	Recall Information:	Novelty:	Type of learner:
performance & retention:	Volume, quicker,	recall	Curiosity, try new methods	Visual
Recall information,	efficient, effective			
"Struggling with new	"efficient studying	"recall the information."	"new strategy could only	"visual learner."
information."			benefit me."	
To be able to integrate and	"To be more	"Ease of recall."	"I find normal studying	"study
understand topics better."	efficient."		difficult/boring."	Method"
The ability to	"My methods not	"possibility to improve	"Incorporating new	"integrates into my study

retain long term information."	effective in time and success."	my recall."	learning strategies can help promote mastery of concepts."	technique."
Percentage of respondents for each of the identified themes				
61%	11%	5%	20%	3%
Note: Interrater reliability = 95%.				

Table V illustrates the three themes generated for the question: How can faculty contribute to critical thinking? Table VI highlights the five emergent themes

obtained from the SNTG for the question: "What do you know about the use of mind mapping as a learning strategy?"

Case studies/real situations/practical problems, team-based Learning: demonstrate the integration of information, Practice Questions & Answers: Pre/post, guided questions Innovative strategies: mind mapping, learning from different sources "show how topics are intertwined by helping us integrate them." "Pre/Post questions during lectures are also helpful." "assign each student to make a mind map and present it to the rest of the class." "They could go over problems with the class and discuss how students should think and problem solve." "Provide resources that guide you through the process of critically thinking through a guestion." "By educating students on new learning techniques." "Do concept analysis exercises in class." "class discussion with guided questions about in-depth topics." "By educating students on new learning techniques." Percentage of respondents for each of the identified themes 27% 20% 53%	Theme 1	Theme 2	Theme 3
 "show how topics are intertwined by helping us integrate them." "They could go over problems with the class and discuss how students should think and problem solve." "Do concept analysis exercises in class." "Previde resources that guide you through the process of critically thinking through a question." "Do concept analysis exercises in class." "Class discussion with guided questions about in-depth topics." "By educating students on new learning techniques." "By educating students on new learning techniques." 	Case studies/real situations/practical problems, team-based Learning: demonstrate the integration of information,	Practice Questions & Answers: Pre/post, guided questions	Innovative strategies: mind mapping, learning from different sources
 "They could go over problems with the class and discuss how students should think and problem solve." "Do concept analysis exercises in class." "Class discussion with guided questions about in-depth topics." "By educating students on new learning techniques." "By educating students on new learning techniques." 	"show how topics are intertwined by helping us integrate them."	"Pre/Post questions during lectures are also helpful."	"assign each student to make a mind map and present it to the rest of the class."
"Do concept analysis exercises in class." "class discussion with guided questions about in-depth topics." "By educating students on new learning techniques." Percentage of respondents for each of the identified themes 27% 20% 53%	"They could go over problems with the class and discuss how students should think and problem solve."	"Provide resources that guide you through the process of critically thinking through a question."	"presenting information first & then adding the details."
Percentage of respondents for each of the identified themes 27% 20% 53%	"Do concept analysis exercises in class."	"class discussion with guided questions about in-depth topics."	"By educating students on new learning techniques."
27% 20% 53%	Percenta	ge of respondents for each of the identified then	nes
	27%	20%	53%
	TABLE VI.	KNOWLEDGE OF MIND MAPPING IN THE SNTG (N=38)

Theme1 Theme 2 Theme 3 Theme 4 Theme 5 Organizational tool: Not much, none organize thoughts. Integration Visual Memory Tool tool tool "I do not know "helps in organizing the "use different parts of "provide a visual of a lot "It helped to remember much about it." content for visual learners." your brain to learn the of different pieces of information." material." information." "Not much." "more visual way to "organizing topics & "It helped me to write learning new material." papers." remember information "none" "an organized way of "help incorporate uses visuals to assist with studying" Everything' studying



Figure 5. Graph displaying responses to organization (N=36)



16%

13%

Figure 6. Graph displaying responses to understanding (N=36)



Figure 7. Graph displaying responses to integration (N=36)



Figure 8. Graph displaying responses to support (N=36)



Figure 9. Graph demonstrating responses to memory (N=36)

Results of Likert Questions: Frequencies (percentages of responses in each category) were used to analyze the responses. Figures 5-11 illustrate the responses to positive statements on mind mapping.

More than half of the MM participants indicated that MM assisted in the analysis, understanding, organization, and integration of information, aided in memory and supported their Learning. Additionally, they would suggest MM to other students to bolster their Learning in PA school.



Figure 10. Graph presenting responses to suggest (N=36)



Figure 11. Graph demonstrating responses to analysis (N=36)

VI. DISCUSSION

In today's healthcare system, taking care of patients is often a team effort. One vital member of the health care team is the PA. PAs work in all specialties and all settings. As part of the group, they provide comprehensive, coordinated patient care and help to maintain continuity of care [29]. Given the crucial role of the PAs in healthcare delivery, it is the inherent responsibility of the PA educators to prepare students for today's clinical practice, ensuring that their students develop and utilize effective critical thinking skills to make sound clinical decisions. Critical thinking skills must be developed and fostered in their academic career by incorporating them into a variety of contexts and using multiple methodologies. Critical thinking is an essential cognitive skill that PAs must engage in daily, to provide effective patient treatment and patient management [1].

The themes generated allowed for greater insight on how to promote Critical Thinking (CT) in the PA students. The first question sought to understand the learning strategies PA students use to support their Learning in PA school. For most of the subjects, the preferred learning strategy was a combination of visual, auditory, and verbal components, followed by visual and verbal. In this scenario, the possibility arises of supplementing mind maps (a visual technique) to their study strategy repertoire, and it can appeal to a wide variety of learners [22]. The second question queried the student on the definition of critical thinking. There were three themes established in "Defining critical thinking." The results illustrate that the students are conversant with aptitudes of critical thinking and its requirement and development to be a successful PA. The CT themes identified are espoused by Kotcherlakota [30] and Davies [6].

In response to OED question three, "what contributes to the development of your critical thinking skills"? Sixty-six percent of the students identified active learning strategies as contributing to the development of CT; the responses support the findings of Popil [31], Noonan [32], Vilela et al. [18], and Davies [6]. Active Learning encourages interconnectivity and engages the learner in activities that foster meaningful learning. Interestingly, participants noted attitude (12%) and knowledge and understanding (11%) as contributing to CT as well, but to a lesser extent. The participants' comments support Stalheim-Smith's [33] view that critical thinking requires knowledge. Since critical thinking is dependent upon content (domain) knowledge and problem familiarity, MM may facilitate critical thinking because it fosters the retention of factual information, as well as relationships between concepts [17]. The skills and attitudes of critical thinking include retention, comprehension, application, analysis, and evaluation [4]. It is important to note that the critical thinking attitude identified by the PA students not only demonstrates their insight, but it is an essential skill as PAs continue to function as frontline primary care providers.

Five themes emerged in reply to "What persuades you to be interested in a new Learning Strategy (LS)?". The majority (61%) of the students were interested in a new LS to improve their learning, performance, and retention, followed by curiosity (20%) to learn new methods and assimilate the volume of information quickly, efficiently, and effectively (11%). The responses aid in understanding the motivation behind considering a new learning strategy among the PA students. PA educators should seek to motivate students by utilizing LS that facilitate reflection, knowledge building, problemsolving, inquiry, and critical thinking skills [34].

Additionally, the students indicated novelty and curiosity, influencing their persuasion in exploring a new learning strategy. Faculty members who are responsible for organizing learning activities should present innovative strategies like mind mapping not only as an alternative strategy to traditional methods of Learning but as a tool to promote the integration of information and critical thinking. The students are curious about the applications of the new learning strategy in terms of the ability to organize and remember information. D'Antoni *et al.* [22] specified that mind mapping assists in the organization of knowledge and memory. They reported that the use of colors, pictures, and dimensions helps to convert information from short-term to long term memory.

Three themes emerged in response to: "How can faculty contribute to critical thinking in students?" Fifty-

three percent identified innovative strategies that faculty can utilize to improve CT in the students, such as mind mapping, and learning from different sources. The responses highlight the importance of a new learning strategy sought by the students to organize, learn, and understand voluminous information. Likewise, they are expecting the faculty to guide and help them in mastering and integrate information via learning strategies. Twenty-seven percent indicated that faculty could plan activities such as case studies, real-life situations, practical problems, and team-based learning. Active learning strategies specified by the students can promote higher Learning and contribute to the development of critical thinking [32]. Twenty percent noted faculty should provide practice questions and questions during the lectures to understand the material better.

To understand the dissemination of MM among the PA students, the SNTG was asked: "What do you know about the use of mind mapping as a learning strategy?" A significant percentage had little or no knowledge of MM as an L.S. Less than 16% identified mind mapping either as an organization, or integrating, or visual or a memory tool. The above responses provide an opportunity for the utilization of mind mapping as an active learning strategy in the PAs. The MMG, on the other hand, had Likerttype questions on the use of MM. More than half of the MM participants indicated that MM assists in the analysis; understanding, organization, and integration of information; aids in memory; supports their Learning, and they would suggest MM to other students to bolster their Learning in PA school. The responses emphasize the strength of mind mapping as an active learning strategy in PAs.

OED question responses thus, provide an understanding of the perceptions of CT among PA students, the aspects that may/can influence the development of CT, and the attitude of the students toward a new learning strategy along with the role the faculty in promoting CT.

VII. CONCLUSION

The projected 37% growth of employment for PAs from 2014 to 2024, which is much higher than the average for all occupations [35], underscores the vital role of PAs in today's healthcare system. PAs must prepare to function as members of a patient-centered interprofessional team. As a productive member of the team, PAs need to develop strong critical thinking skills. The results of the study exemplify how to promote CT in PAs.

PA students are knowledgeable that critical thinking is a process of reasoned and reflective judgment. Additionally, most of the PA students reported that active learning strategies contribute to the development of CT skills. Active Learning promotes meaningful Learning, and meaningful Learning is essential for critical thinking [18]. The students identified case studies, small group discussions, computer-assisted instruction, simulations, and supervised clinical experience as some active learning strategies that faculty could adopt for more in-depth Learning and enhanced understanding.

PA Students are interested in learning new strategies primarily to improve Learning, performance, and retention of knowledge. So, educators need to utilize teaching and learning strategies that promote critical thinking among PA students and enable them to emerge as sound clinicians who deliver competent care. The results of the open-ended questions reinforce the pivotal role of the faculty in preparing future PAs. PA educators can utilize innovative strategies like mind mapping to direct and assist PA students in the learning process and promote critical thinking.

The majority of the SNTG participants reported that they did not know much about the use of mind mapping as a learning strategy. Accordingly, the introduction of mind mapping as an active learning strategy can benefit PA students and future PAs in the assimilation of voluminous information, enhanced memory, integration of knowledge, and development of critical thinking skills.

Considering the essential role PAs have in the evolving healthcare system, PA educators have an inherent responsibility to examine, review, investigate novel and emerging learning strategies that develop strong critical thinking skills [1]. MM is a learning strategy that aids in organization, memory, analysis, and integration of information, all of which contribute to the development of effective critical thinking skills.

The results of the study provide strong support for the utility of mind mapping as an active, innovative learning strategy to promote critical thinking in PAs. MM is a resource that can assist students, and future physician assistants learn, understand, and apply concepts essential for patient-centered care.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS CONTRIBUTIONS

Israel, along with Zipp, conceived the design of the study. Israel performed the study, statistical analyses, and drafted the manuscript. Zipp & Michelle helped draft the manuscript. All authors read and approved the final version.

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