2020

DDx 2.0: Efficacy of a Differential Diagnosis Course for MS3s Considering Primary Care and Non-Primary Care Specialties

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Track: Medical Education

Scholarship in Medicine Final Report

☒ **By checking this box, I indicate that my mentor has read and reviewed my draft proposal prior to submission**

Abstract

Objective: To assess if medical students interested in pursuing a primary care specialty are more receptive and have a more positive attitude towards formulating differential diagnoses (DDx) using metamemory techniques (MMTs). *Methods:* Cross-sectional analysis of data obtained from 113 MS3 students from the Boonshoft School of Medicine. Students generated timed DDx for a clinical case before and after an instructional didactic session about MMTs. Demographic data (including intended medical specialty and attitudes towards the overall process) were collected. Paired t-test compared screened and unscreened DDx before and after the intervention. Mixed-repeated measures ANOVA compared pre- and post- intervention screened and unscreened scores by intended specialty. *Results:* There is a 35.7% increase in DDx before and after the MMT intervention, supporting the hypothesis that a structured course is beneficial for enhancing DDx skills. There are no significant differences in DDx increases between the PC and NPC groups (30% compared to 40%), supporting the idea that both PC and NPC-bound students benefited from the course.

Key Words: Medical Education, Differential Diagnosis, Primary Care, Meta Memory Techniques

Introduction/Literature Review

Optimal care in any medical field is dependent on physicians' skills to formulate accurate and timely diagnoses and to recommend an appropriate management plan. We propose that this skill hinges on the concept of differential diagnoses (DDx), or the ability of the physician to generate, order, and filter possible diagnoses for a given clinical scenario. This ability to create broad DDx has both clinical and economic outcomes. When a diagnosis is accurate and timely, patients have the best opportunities for positive health outcomes.[1] By extension, DDx also play a critical role in influencing healthcare spending; public policy decisions are often influenced by diagnostic information, from payment policies to deciding where to allocate resources, to research priorities.[1–3] Despite the clear financial and prognostic importance that DDx have in the healthcare system, very few medical schools have incorporated formal DDx teaching in their curriculum, and fewer still have evaluated effective methods of teaching clinical reasoning.[4–9] Methods currently described in the literature include passive clinical observation by medical students, case studies, and problem based learning. [5–9]

A novel way in which the literature describes overcoming the trap of pattern recognition and easy associations is by practicing metamemory techniques (MMTs), a form of metacognition that utilizes conscious methods and mechanisms to creating memory operations.[9–11] The use of metacognition in creating mental shortcuts has been extensively studied in the literature, particularly in the fields of psychology and psychiatry[12–14]. While MMTs can be applied to any profession, they have especially far-reaching and positive implications for the field of healthcare. The growing body of literature evaluating the efficacy of MMTs reveals that these mental shortcuts can help healthcare practitioners with recalling, organizing, and integrating information they already know, thus preventing medical errors in clinical settings.[6,10,11] Although medical governing bodies such as the AAMC recognize metacognition as a critical aspect of health professional training, that there are currently no specific spaces carved out for formal MMT training amongst healthcare professionals.[11]

Our previous study began to fill this hole in the literature by proposing a model for DDx clinical reasoning (the generation-filtration-ordering or GFO model), evaluating the efficacy of a structured instructional session teaching MMTs. The GFO model focuses on three sequential yet interrelated components; generation refers to the process of creating a large inclusive list for a given patient scenario, filtration refers to the process of removing unlikely and incorrect diagnoses from the generated list, and ordering refers to the process of ranking the remaining diagnoses by likelihood and severity.[9] The study demonstrated that the MMT session led to increased DDx generation for a given patient case.[9] MMT's that were studied included Constellations (summing up of sub-DDx, allowing pattern recognition for clusters of clinical information), the Mental CT Scan (DDx driven by anatomical visualization), VINDICATES (mnemonic for DDx by pathophysiology), and Bundling (recognizing commonly-occurring diagnostic clusters). The selection was based on MMTs proven successful in the literature and upon study directors' preference and experience.[9] Findings of this initial study also revealed that students exhibited positive attitudes towards both the process of DDx generation and an instructional course.

While the experiment supported the usefulness of MMT use in medical education, one concept that was not explored was why some medical students respond better to MMT training than others. Further, what are the future indications for medical students who perform well? This brings up an interesting question: is there a relationship between DDx skills and future career? In other words, do medical students who are successful at DDx generation and who find the process enjoyable prefer career fields where DDx is a predominant aspect of his/her practice? These are not questions that have been extensively explored in the literature.[15,16]

A stronger understanding of these questions will aid us in providing guidelines for more effective medical student teaching. In the present study, this idea was expanded upon by analyzing the relationship between the self-proclaimed desire to pursue a primary care medical specialty (defined in this study as Family Medicine, general Internal Medicine, and Pediatrics) and attitudes toward DDx.

Hypothesis/Specific Aims/Research Questions

- Students planning to pursue a PC specialty exhibit more positive attitudes regarding DDx generation, or are more adept (able to generate a higher volume and higher number of differentials) at DDx compared to students interested in NPC fields, including surgical fields, emergency medicine, and anesthesiology.

Methods

Context/Protocol

A four-hour workshop was given to rising third year medical students at the Boonshoft School of Medicine, a medium-sized Midwestern community-based medical school. There were no exclusion criteria, and the population studied (N=113) consisted of the entire MS3 class (Class of 2021) and several members of the MS4 class (Class of 2020). The demographics of population study consisted primarily of students with limited prior healthcare experience and a 58% female predominance. Study participants were anonymized using a unique identifier comprising of a self-assigned word and number, which was used on all documents over the course of this study.

Data Collection

Students were allotted 5 minutes to generate as many DDx as possible for a standardized case before and after an instructional MMT presentation. During this time, students were also asked to rank their top three DDx by severity (A-C, with A being most severe), and likelihood (1-3, with 1 being most likely). Number of DDx were measured before and after a faculty member gave the MMT presentation. At the end of the session, all students completed a post-encounter questionnaire, which included a demographic questionnaire and a subjective utility ranking of the MMTs, as well as Likert-scale and free-text sections for appraisal of the overall course. DDx were subsequently screened by two student researchers for gross size (unscreened) and size of clinically probable diagnoses (screened).

Data Analysis

Case data was organized and indexed in a Microsoft Excel spreadsheet. DDx were scored using the following criteria: gross size of the DDx for the unscreened data set, and size of clinically plausible DDx for the screened data set using a pre-made sheet with appropriate diagnoses created by the faculty researchers. Subjective questionnaire data was collected and indexed in a separate spreadsheet.

All data were analyzed using SAS version 9.4 and an alpha of .05 was used. Descriptive statistics were conducted to describe the sample with frequencies and percentages for all categorical variables and means, standard deviations, and 95% confidence intervals for all continuous variables. To examine changes in screened and unscreened differential diagnosis scores, paired t-tests were conducted. In addition, paired t-tests were conducted separately for those who were interested in primary care as a specialty versus NPC.

Results

Of the 113 students surveyed, all completed pre- and post-intervention sheets and questionnaires. Approximately 32.0% of participants demonstrated interest in a primary care specialty, compared to 43% of participants who showed interest in surgical or other non-primary care specialties(Table 1).

Overall, there was a statistically significant increase in mean number of screened and unscreened DDx generated by the overall class (PC and NPC) after the MMT intervention, when compared to before the intervention (Table 2). The average number of unscreened DDx generated before and after the intervention was 8.2 and 12, respectively, with a p value < 0.0001. The average number of screened DDx generated after the intervention was 7.6, compared to 5.6 DDx before the intervention, with a p value < 0.0001. There was not a statistically significant difference between average numbers of differentials generated by NPC students when compared to PC students (5.5 and 5.7 for NPC and PC for the pre-intervention case, respectively compared to 7.7 and 7.4 for NPC and PC for the post-interventional case). Further analysis showed that the maximum number of screened DDx generated was 13 for NPC and 15 for PC.

The questionnaire administered after the intervention assessed the subjects' demographics, and specialty interests (Table 2). The questionnaire also included eight Likert-style questions assessing students' attitudes towards DDx and the perceived usefulness of the MMTs. Table 3 depicts the questions and the students' responses. The overall average was 3.35/5, with no significant differences between PC and NPC students. In terms of perceived usefulness, students rated the Mental CT Scan highest, with 46% of those surveyed favoring this MMT. The MMT with the lowest perceived usefulness was VINDICATES, with only 10% of those surveyed in favor.

Table 1. Demographic Characteristics (N = 113)	
Variables	n (%)
Age[a]	
23	12 (12.1)
24	40 (40.4)
25	15 (15.2)
26	14 (14.1)
27+	18 (19.2)
Gender[a]	
Male	41 (41.1)
Female	58 (58.6)
Specialty[b]	
Primary Care	30 (28.6)
Family Medicine	6 (5.7)
Undecided	13 (12.4)
Surgical	11 (10.5)
Other	32 (30.5)
No Answer	13 (12.4)
Primary Care Specialty[c]	
Yes	36 (31.9)
No	77 (68.1)

*n = 14 with missing data
[b]n = 8 with missing data
[c]Individuals that had missing values for specialty were moved to the 'no' category
Note: Family Medicine was grouped with Primary Care

	Table 2. Pre and Post Scores Overall and by Primary Care Specialty (N = 113)[a]								
		Pre – Test		Post – Test		Difference[b]		t[c]	p-value
		Mean (SD)	95% CI	Mean (SD)	95% CI	Mean (SD)	95% CI		
All	Unscreened	8.2 (2.2)	7.8 – 8.6	12.0 (4.1)	11.3 – 12.8	3.9 (3.2)	3.3 – 4.4	12.87	<.0001
	Screened	5.6 (1.9)	5.2 – 5.9	7.6 (2.5)	7.1 – 8.1	2.0 (2.3)	1.6 – 2.4	9.34	<.0001
PC	Unscreened	8.5 (2.7)	7.6 – 9.5	12.1 (4.5)	10.6 – 13.7	3.6 (2.7)	10.6 – 13.7	8.10	<.0001

	Screened	5.7 (2.1)	5.0 – 6.4	7.4 (2.3)	6.6 – 8.2	1.7 (1.8)	1.1 – 2.3	5.64	<.0001
NPC	Unscreened	8.0 (2.0)	7.6 – 8.5	12.0 (3.9)	11.1 – 12.9	4.0 (3.4)	3.2 – 4.7	10.22	<.0001
	Screened	5.5 (1.8)	5.1 – 5.9	7.7 (2.6)	7.1 – 8.3	2.2 (2.5)	1.6 – 2.7	7.66	<.0001
	[a]Includes individuals with pre and post data [b]Difference = Post – Pre [c]paired t-test								

Table 3: Likert Questions

	Overall (N = 110)		Primary Care Specialty (n = 36)		Non-Primary Care Specialty (n = 74)		
	Mean (std)	Median (q1, q2)	Mean (std)	Median (q1, q2)	Mean (std)	Median (q1, q2)	p
Q1	4.1 (0.9)	4.0 (4.0, 5.0)	4.2 (1.0)	4.5 (4.0, 5.0)	4.0 (0.9)	4.0 (4.0, 5.0)	.15
Q2	4.0 (0.8)	4.0 (3.0, 5.0)	4.2 (0.9)	4.0 (3.0, 5.0)	3.9 (0.8)	4.0 (3.0, 4.0)	.08
Q3	2.8 (1.1)	3.0 (2.0, 4.0)	2.8 (1.1)	3.0 (2.0, 3.0)	2.9 (1.1)	3.0 (2.0, 4.0)	.50
Q4	3.8 (0.8)	4.0 (3.0, 4.0)	3.8 (0.8)	4.0 (3.0, 4.0)	3.7 (0.9)	4.0 (3.0, 4.0)	.80
Q5	2.8 (1.2)	3.0 (2.0, 4.0)	2.9 (1.2)	3.0 (2.0, 4.0)	2.7 (1.2)	3.0 (2.0, 4.0)	.56
Q6	3.3 (1.2)	4.0 (2.0, 4.0)	3.5 (1.1)	4.0 (3.0, 4.0)	3.2 (1.2)	4.0 (2.0, 4.0)	.35
Q7	2.6 (1.2)	2.0 (2.0, 4.0)	2.9 (1.2)	3.0 (2.0, 4.0)	2.5 (1.2)	2.0 (1.0, 3.0)	.10
Q8	3.4 (1.1)	4.0 (3.0, 4.0)	3.5 (1.1)	4.0 (3.0, 4.0)	3.4 (1.1)	4.0 (2.0, 4.0)	.50

Discussion

DDx is one of the most crucial skills of any physician, testing both one’s cognitive and creative abilities. The ability to generate, order, and filter DDx has wide-ranging implications on the healthcare system, from patient satisfaction, safety, and overall care to healthcare spending as a whole. In spite of being a vital aspect of any healthcare practitioner’s diagnostic arsenal, this is a skill that is rarely formally taught to medical students and physicians. Furthermore, there is no strong consensus on the best method to teach DDx. The literature cites heuristics and acronyms, among other methods to aid in creating DDx. Our previous study produced strong evidence to support the generation-filtration-ordering (GFO) model and the use of MMTs in teaching students to increase the number and quality of DDx generated.

The purpose of the present study is to investigate the potential relationship between DDx generation and intended medical specialty. We hypothesize students desiring the fields where DDx was more commonly used on a day-to-day manner—the primary care specialties—would be more adept and exhibit more positive attitudes towards this process compared to students intending to enter surgical/subspecialty fields. Our findings demonstrate that, regardless of specialty, teaching MMTs to students significantly increased the number of unscreened and screened DDx generated. There is no significant difference in DDx generated by students interested in a PC career compared to an NPC career. Further, overall attitudes towards DDx are not significantly more positive in the PC students compared to the NPC students. This finding highlights while no specialty specific link is elucidated, our results support our previous study and further demonstrate that teaching specific MMTs to 3rd year medical students result in significant improvements in their ability to generate appropriate DDx under a given time constraint.

Consistent with our previous study, our results reveal that the most well perceived MMT is the Mental CT Scan, with 46% of students surveyed stating it was the “most useful” of the MMTs taught(compared to 51.5% in the previous study). This is also the only MMT mentioned in the freehand comments section in the post-intervention questionnaire. Mental CT Scan’s strong popularity is possibly due to its ease of use. Additionally, the opportunity to visualize anatomy and physiology can reassure students of the validity and plausibility of DDx generated. The least useful MMT in both the present study and the previous study was VINDICATES (10% compared to 13.2%). Interestingly, VINDICATES is the most similar to the pathophysiology often emphasized in the 1st and 2nd year medical school curriculums, yet is the least popular MMT. VINDICATES' low popularity is possibly due to students finding it difficult to remember what acronym stands for. VINDICATES may also be a more time-consuming MMT, making it more cognitively bulky compared to the other MMTs. It is evident that not all MMTs are equally well-received, further underscoring the importance of teaching all MMTs to students and allowing them to evaluate which MMTs work for them at their various stages of training.

Our study was constrained by several limitations. One such limitation was that students were asked to designate a medical specialty after just a few days into their MS3 year, the year designed to allow students to explore and experiment with different specialties. Therefore, it may have been premature to ask students what their intended specialty is and use that to explore the relationship between DDx and PC versus NPC. Using a more clinically experienced group of students may allow better elucidation of this potential relationship between DDx generation and specialty. Another possible limitation is that the same case was used for the pre-intervention case and the post-intervention case. Although it is not likely to have impacted the results (as our findings were statistically significant in both this study and the previous study), our next evaluation of MMTs will involve different cases of similar difficulty level to avoid confounding.

As our previous study was among the first to create a course designed to enhance DDx generation, our future studies will continue exploring how MMTs and DDx can be included in medical student education, and the impact that will have on medical students moving forwards. In subsequent studies, we plan to evaluate student's abilities to order and filter the DDx created by which diagnoses are more likely than others, and which diagnoses are more severe than others. Additionally, we plan on further studying DDx generation, filtration, and ordering by following a group of subjects longitudinally. This will better allow us to understand the performance-enhancing effect of DDx generation and allow us to better investigate the effect of teaching MMTs.

Conclusion

In this study, we primarily focused on evaluating if a specific demographic factor (potential future medical specialty) influenced generation of DDx and attitudes towards the process. Our findings reinforce MMTs as an effective and enjoyable structured approach for teaching DDx to medical students. Further, our findings reveal this association is constant regardless of intended specialty. These data build upon our previous study and demonstrate the continued success of a structured course utilizing MMTs in DDx instruction. Effective teaching of this essential yet rarely formally taught medical skill would have far-ranging positive implications for our healthcare system and for patient health.

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