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Two Novel Approaches for the Implementation and Assessment of Self-Directed Learning in the Pre-Clinical Medical School Curriculum

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Abstract

Introduction: Self-directed learning (SDL) is a process in which learners diagnose their learning needs, formulate learning goals, and identify appropriate resources to close the knowledge gap. The objective of this study was to assess student satisfaction as well as content mastery after implementing two novel models of SDL into our pre-clinical curriculum.

Methods: In the first model, instructors provided a detailed clinical vignette (topic: anticoagulants) to the students, who had to identify a learning objective, and appropriate resources to address that and submit their findings. In the second model, the faculty provided learning objectives for a chosen topic (COVID-19). The students, divided into small groups, had to choose an objective, find an original research paper that addresses it, and then present the findings. The faculty provided narrative feedback guided by a rubric in both instances. The authors conducted a cross-sectional survey of the students who participated in the program (n=158/175; 90%). Additionally, we analyzed students' content mastery on COVID-19 in the internal assessments, using a cognitively diagnostic assessment called the Deterministic Input, Noisy "And" Gate (DINA) model.

Results and Conclusions: Students reacted positively in the survey with 69% percent of the respondents reporting that SDL reinforced their learning and 66% agreeing that it helped their development as lifelong learners. The success of the method is evident from the DINA model analysis which showed that 91% of the students attained the skills necessary to answer questions on "COVID-19". The two innovative approaches described here can be easily adapted by other institutions.

Keywords: Undergraduate Medical Education (UME); Self Directed Learning; Lifelong Learning; Master Adaptive Learner

Introduction

Spiro and colleagues introduced a Cognitive Flexibility Theory that articulates how the human mind can acquire, manage, and restructure our existing knowledge based on new information learned [1]. Their seminal work inspired a deeper process of learning that highlighted the importance of being adaptive, flexible, and self-reflective in thinking during learning activities to develop greater efficacy in higher-order thinking and problem-solving. A fundamental tenet of advancing knowledge acquisition is self-directed learning (SDL) which has been shown to refine and develop presentation, communication, collaborative learning, and information-handling skills [2, 3]. Medical educators acknowledge the importance of medical students, as future physicians, acquiring the skills necessary for identifying learning

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needs and developing lifelong learning habits due to the constantly changing landscape of knowledge and practice of medicine. The Liaison Committee on Medical Education for Accreditation (LCME) requires medical schools to provide opportunities for students to participate in SDL activities as described in Standard 6.3 (The faculty of a medical school ensures that the medical curriculum includes self-directed learning experiences and time for independent study to allow medical students to develop the skills of lifelong learning). Skills that embody a lifelong learner include the ability to recognize one's knowledge gaps, to know where and how to find credible sources with relevant information, and then synthesize this information and apply it to one's clinical practice (http://lcme.org/publications). There are similar requirements from the Accreditation Council for Graduate Medical Education (ACGME) that residents should have the ability to identify their knowledge deficiencies, and set learning goals and be able to locate, appraise, and assimilate evidence from scientific studies [4].

However, recent studies show that despite the proven advantages and the concurrent emphasis on SDL in the undergraduate and graduate medical curriculum, institutions are found to face several challenges in implementation [5, 6]. Studies show that these challenges could either be of the method/methods applied for SDL or based on the readiness scale, taking the perception of students, teachers' viewpoints, and the challenges faced by self-regulated learning studies [5]. We have designed our models based on the SDL in Medical Education, (SDL-ME) construct which builds on the foundations of self-directed and self-regulated learning theories and is specifically contextualized in the context of medical education with the purpose of health professional identity formation [7]. SDL, as defined by LCME, involves 'self-assessment of learning needs; the independent identification, analysis, and synthesis of relevant information; and the appraisal of the credibility of information sources' is a necessary part of a medical education program (www.lcme.org/publications/2015-16-functions-and-structure-with-appendix.pdf). We have tried to incorporate all these aspects into both our models. In addition, we are assessing the success of the process by measuring student satisfaction through a survey. Survey items measured students' approach towards SDL, thoughts on the role of SDL in their learning process, and factors influencing their engagement and satisfaction. We also evaluated the role of SDL in enhancing their content mastery by analyzing the internal assessments. For this purpose, we used a novel method of "cognitive diagnostic assessment" namely the DINA method which has been used and tested by us previously [7]. This study is the first of its kind to use this multidimensional, implementation and assessment, approach.

Methods

Curriculum

The MD program at University of Toledo College of Medicine begins with the 18-month systems-based foundational sciences curriculum (curriculum scheme is presented in supplementary figure 1). Across the continuum of the preclinical phase, 4 courses are designated as curricular "threads." Each thread constitutes a summation of integrated systems (i.e. Thread 3 includes Building Foundations, Cardio-Renal, and Cardio-Pulmonary). Both the SDLs were introduced in the academic year (AY) 2021-2022 in thread 3 and again repeated the following year with small modifications. The survey was done in the second year (AY 2022-2023).

Research design

The target population was the second-year medical students at our institution. The SDLs were "required" sessions in their curriculum. Hence, all the (n=175) students participated in the SDL process. The survey was distributed to the entire population and 90% of the eligible students participated in it. The content mastery in "Covid-19" was measured for the entire cohort after obtaining IRB approval. The rubrics for assessment were developed by the faculty.

SDL Model 1:

The first SDL model was implemented in the Cardiovascular-Renal System in the second year of medical school. In the Hematology Oncology system of the first year, students learned about anticoagulants and the coagulation cascade. The goal of SDL in this context was to reactivate and expand previous knowledge about anticoagulants through their application to the cardiovascular system. Through the SDL process, students self-assess their own learning needs and identify deficits in knowledge and understanding. For this purpose, the faculty assigned a detailed clinical vignette based on the topic (anticoagulants) to the students through our learning management system (LMS), Blackboard. Each student was asked to identify a specific learning objective based on the case, identify appropriate resources to answer their clinical questions and submit their findings on Blackboard. The faculty also provided modules and suggested other sources of information including a sample worksheet (Supplementary Figure 2) to help the students. A group of faculty experts analyzed and scored the reports based on a well-defined rubric (Figure 1). They also provided detailed narrative feedback to each student with further specific suggestions for reflection, and revision, if needed. In addition to this, each student was required to provide feedback on at least 5 of their peer's assignments on Blackboard. The completion of this was also part of their SDL grade which in turn comprised 10% of their total system grade. The concept of SDL was introduced on the first day of the system and

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Figure 1: The rubric for evaluation of SDL model 1. The faculty evaluated the SDL reports submitted by the students based on this rubric. A group of faculty, who were content experts, took charge of grading the reports and started with a clear consensus to avoid variations in the grading pattern and narrative. The students (n=175) were divided into separate groups so that each faculty had about 15-16 students to grade.

	Novice	Competent	Proficient
Self-assessment of learning needs: Was the clinical question or learning objective relevant and measurable?	**0 (0.00 %)**	**1 (12.50 %)**	**2 (25.00 %)**
	Was neither relevant nor measurable	Was relevant but not measurable OR Was measurable but not relevant	Was both relevant and measurable
Identification, analysis, and synthesis of information: What resources were used?	**0 (0.00 %)**	**1 (12.50 %)**	**2 (25.00 %)**
	Limited resources were used (student did not explore multiple resources)	Various resources were used, but important resource(s) was/were missed	Student explored various resources and identified most pertinent ones for this topic
Was the student able to appraise the credibility of sources used? Any irrelevant/ inaccurate resources cited? Any resources which could have been useful that were missed?	**0 (0.00 %)**	**1 (12.50 %)**	**2 (25.00 %)**
	Student utilized inaccurate or irrelevant resources in formulating information	Resources were mostly accurate and relevant, but incomplete	Student was able to identify credible resources and differentiate them from irrelevant/ inaccurate ones
Was the information relevant and shared in a useful manner? Was information shared in a useful, understandable way?	**0 (0.00 %)**	**1 (12.50 %)**	**2 (25.00 %)**
	Student did not share information in a useful or understandable manner	Information shared was useful but not understandable OR was understandable but not useful	Information shared was useful and understandable

Table 1: The topics which were chosen for the COVID-19 SDL. The students (n=175) were divided into 18 separate groups for their TBL sessions from day 1 of their medical school. Each TBL group, which had 5-6 students, were asked to select a topic from this given list to prepare for their SDL experience.

1.	Does vaccination decrease the risk of a vaccinated individual transmitting COVID-19 to other individuals? ARTICLE MUST BE DATED PRIOR TO FEBRUARY 1, 2021.
2.	Does vaccination decrease the risk of a vaccinated individual transmitting COVID-19 to other individuals? ARTICLE MUST BE DATED AFTER JUNE 1, 2021.
3.	Does administration of steroids alter the course of COVID-19 disease? ARTICLE MUST BE DATED PRIOR TO JUNE 1, 2020.
4.	Does administration of steroids alter the course of COVID-19 disease? ARTICLE MUST BE DATED AFTER SEPTEMBER 1, 2020.
5.	Do athletes who contract COVID-19 require additional testing for myocarditis prior to returning to play?
6.	Does vaccination increase risk of myocarditis in otherwise healthy athletes?
7.	Does remdesivir treatment improve outcomes in patients admitted to the ICU?
8.	Does remdesivir treatment improve outcomes in patients in the outpatient setting?
9.	What is the best approach to management of hypoxia in COVID-19 infected patients? (high flow oxygen vs. intubation) ARTICLE MUST BE DATED PRIOR TO JUNE 1, 2020.
10.	What is the best approach to management of hypoxia in COVID-19 infected patients? (high flow oxygen vs. intubation) ARTICLE MUST BE DATED AFTER JANUARY 1, 2021.
11.	What is the role of monoclonal (passive) antibodies in the treatment of COVID-19 infection in the inpatient setting? ARTICLE MUST BE DATED PRIOR TO JUNE 1, 2020.
12.	What is the role of monoclonal (passive) antibodies in the treatment of COVID-19 infection in the inpatient setting? ARTICLE MUST BE DATED AFTER JANUARY 1, 2021.
13.	Is there a role for anticoagulation to prevent thrombotic complications in hospitalized patients with COVID-19 infection?
14.	Is there a role for anticoagulation to prevent thrombotic complications in outpatients with COVID-19 infection (those whose illness is not severe enough to be hospitalized)?
15.	What is the role of hydroxychloroquine in the treatment of COVID-19 infection? ARTICLE MUST BE DATED PRIOR TO JUNE 1, 2020.
16.	What is the role of hydroxychloroquine in the treatment of COVID-19 infection? ARTICLE MUST BE DATED AFTER SEPTEMBER 1, 2020.
17.	Is vaccination safe and effective during pregnancy?
18.	Is vaccination safe and effective while breastfeeding?

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the students were given approximately 4 weeks to complete the assignment. The rubric and the assessment criteria were provided to the students on the learning management software.

SDL Model 2:

This model was introduced in the Cardio-pulmonary system. The intent of this SDL was to introduce the concept of "how to read medical literature and use it appropriately in clinical practice." We chose to explore the topic of COVID-19 as it demonstrates well the importance of physicians as master adaptive/ self-directed learners during times of uncertainty within healthcare. The faculty designed a series of questions/ learning objectives based on the chosen topic (COVID-19; questions shown in Table 1). The students were divided into small groups of 5-6 students, and each group was asked to select one question to investigate. Groups were given specific instructions such as how to find a credible original research paper that addressed their clinical question.

They were redirected to resources from the MD program research curriculum to help them identify an appropriate and credible research article. The group members then presented their findings to the entire class. The faculty graded the presentations based on a well-defined rubric (Figure 2) and provided detailed feedback with helpful suggestions for reflection and revision. In the second year of its iteration, the student presentations were changed to the Pecha Kucha forma to consolidate the time required for presentations and make it more efficient. The concept of SDL was introduced in the first day of the system and the students were given approximately 3 weeks to complete the assignment and prepare the presentation. The rubric and the assessment criteria were provided to the students on the learning management software.

Survey

A descriptive survey was used to understand student discernment about SDL. The questions focused on whether one or both approaches attained the goals and helped the students in fulfilling their learning needs as well as their development of lifelong learning skills. The survey, conducted anonymously, was administered via a Qualtrics

Figure 2: The rubric for evaluation of SDL model 2. The faculty, who were content experts, evaluated the SDL presentations by the students based on this rubric. The students (n=175) were divided into separate groups (4-5 students) and each presentation involved participation of all the members of the team.

	Items	Score	Comments
1	**Did the group chose an article that addresses the clinical question (relevant) and provides information that is pertinent to the case (applicable)?**		
	The article addresses the clinical question and is applicable to the case (2 pts)		
	Was relevant but not applicable OR was applicable but not relevant (1 pt.)		
	Was neither relevant nor applicable (0 pts)		
2	**Did the group analyze the results and conclusion appropriately and present it clearly?**		
	Analysis was appropriate and presentation was clear and understandable (2 pts)		
	Analysis was appropriate OR presentation was clear and understandable (missing one element) (1 pt.)		
	Analysis and presentation did not meet expectations (0 pts)		
3	**Did the article follow scientific method and were the conclusions supported by evidence?**		
	The article followed scientific method and conclusions were supported by evidence (2 pts)		
	The article followed scientific method OR conclusions were not supported by the evidence (missing one element) (1 pt)		
	The article did not follow scientific method and conclusions were not supported by evidence (0 pts)		
4	**Was the presentation completed in < 5 min? (1 pt)**		
TBL Team Number:	**Total Score:**		

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survey link sent to the entire second-year MD class (175 students). Responses were collected over a period of one month. The survey instrument (Supplementary Figure 3) had five closed-ended questions and one open-ended question for each model. The quantitative data was analyzed using Qualtrics and Microsoft Excel. The qualitative responses were coded manually. The common terms were grouped and ranked from most to least cited. We employed a frequency threshold of 20% for identifying themes in the qualitative responses.

DINA model analysis:

A cognitive diagnostic assessment method was selected to assess skill mastery comparatively [8]. For this study, we analyzed content mastery in the major content area (COVID-19) that came under the SDL curriculum, by using the deterministic input, noisy "and" gate (DINA) model [9-11]. The DINA model is a type of cognitive diagnostic model that predicts the probability of mastery of latent variables such as skills or attributes. Any instances of a student answering a question without mastery of all required skills were considered to be correct by chance (i.e., guessing). To identify which skills were required for each question, a Q-matrix had to first be developed. A Q-matrix [12] is a confirmatory matrix that identifies the skills required to answer each item in an assessment in a binary format, where "1" indicates the requirement of skill to answer the item, and "0" indicates that skill is not required by an item. We developed an $I \times J$ Q-matrix, where j different skills or attributes were required to correctly answer a question from the internal assessments. For example, to correctly answer the question *is* on the given topic "Covid-19," we determined that students needed to possess knowledge or "skill" in 2 content areas: j_1, respiratory system; j_2, infectious diseases; and j_3, COVID-19 infection. Similarly, each question had 3-5 skills matched to them. This method has been described in detail in our previous publication [8].

Results

The details of the survey results are presented in Figures 3 and 4. There was a solid engagement in the survey with a robust 90% participation by the entire cohort who was part of the study. We have only included the strongly agree/agree and strongly disagree/disagree percentages in the graphs. The neutral category responses are not represented in the figures to keep it simple. Figure 3 shows the results for SDL model 1. We found that 66% percent of respondents agreed/or strongly agreed that the SDL model "anticoagulants" helped them to identify critical knowledge gaps and that it helped their development as lifelong learners. 69% of the respondents found that the SDL experience helped them to reinforce their learning of the specific content matter. Interestingly, almost half of the students found the experience to help identify their weaknesses and help to improve their SDL style.

The survey results for COVID-19 SDL, depicted in Figure 4, show that this experience had comparatively less student satisfaction in all elements than the first model. Despite that,

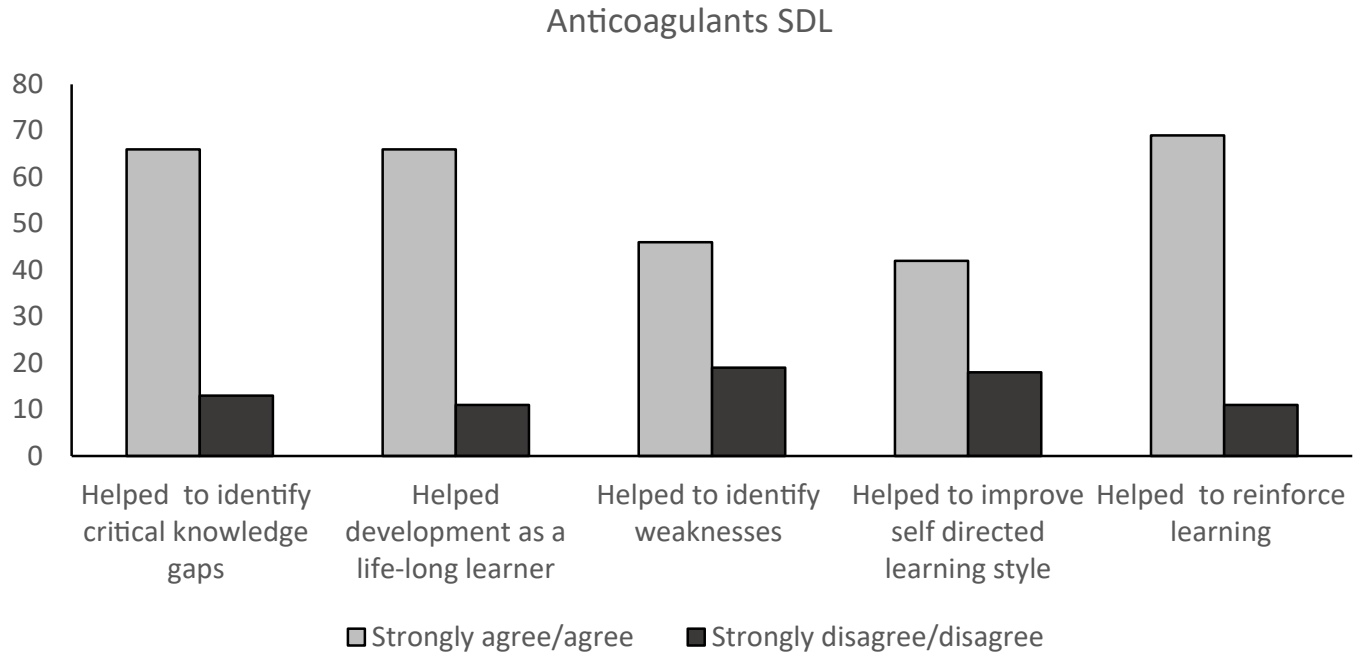

Figure 3: The results of the Qualtrics survey for anticoagulants SDL. The survey was distributed to the entire student body (second year medical students) at University of Toledo College of Medicine with a response rate of 90% (n=158/175). Some stems have been condensed for presentation here. The full survey is provided in supplementary Figure 3.

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61 percent of respondents agreed/strongly agreed that this SDL model helped their development as lifelong learners and was helpful to reinforce their learning of the specific content matter. Furthermore, 59% of the students who took the survey found that it helped them to identify critical knowledge gaps while 46% believed that it helped their development as lifelong learners. The qualitative part of the survey showed that students found many aspects of both exercises extremely useful. For example, there was a comment on how the most valuable part of anticoagulant SDL was "reading over how other students approached the project and seeing the conflicting evidence and opinions." Another comment read "Covid-19 SDL showed how important it is to have good research skills as a physician so you can correctly interpret new evidence". There were comments on the peer feedback component such as "I had to learn about the medications well enough to ask a meaningful question and respond to other student's posts." Some of the challenges described by the students included difficulty in "identifying and classifying sources according to the levels of evidence criteria." A representation of the major comments are summarized in Table 2.

DINA model analysis was conducted [8] for the content "COVID-19" in the internal assessment done at the end of the system for both academic years 2021-2022 and 2022-2023. We found that 91% of the students from both years attained mastery of this content. The average grade of the students in the respective end-of-the-system internal assessments were 78.49±8.57% (AY 2022-2023) and 86±6.3% (2021-2022).

Discussion

Principles of "cognitive flexibility theory of knowledge acquisition," show that learners are better able to acquire and retain knowledge if they develop their own representation of information. Self-directed learning (SDL) is an "approach where learners are motivated to assume personal responsibility and collaborative control of the cognitive and contextual processes in constructing and confirming meaningful and worthwhile learning outcomes". It is important to note that SDL is different from self-regulated learning (SRL) [13]. While SRL involves "The process of a learner controlling their cognition, motivation, emotion, and behavior to achieve specific learning tasks or goals in a given context" [13],

Table 2: The results of the qualitative segment of the Qualtrics survey for anticoagulants (**a**) and Covid-19 (**b**) SDL. Selected comments are presented without any changes except for formatting.

	Select Comments
	a. Anticoagulants
1	It allowed me to look into new drugs that are used in clinics that I have not been too exposed to yet
2	Had me practice looking through info on a clinical topic to see the efficacy in real life, consulting guidelines, and so on
3	It helped me understand how to form a clinical question, and then where to find more information about that topic.
4	The SDL forced me to critically evaluate research articles and come to a conclusion that would help me make a recommendation. I feel more comfortable with critically reading research now, and feel that I am more prepared for this part of my medical career
5	The anticoagulants SDL was useful because we were asked to synthesize the results of multiple studies to answer one clinical question. It forced us to reconcile contradictory evidence and select the most rigorous research to answer our questions.
6	It helped me connect the concepts learned in thread 1 with what was being taught in thread 3. It was a good way to realize the importance to refresh on the material we've learned in the past
7	The SDL helped me to practice searching for relevant information and to discern what level type of research supported the conclusions made in an article.
8	I did some critical reading which continued to develop my skills
9	Anticoagulants being an independent learning activity aided in my understanding of a topic I hadn't reviewed in a long time, allowing me to pick and choose a topic that best supplemented my knowledge gaps and understanding of the material.
10	Having the anticoagulant SDL was useful because it prompted me to review the coagulation cascade on my own, which was better than redoing an entire course on coagulation
11	It challenged me to dig deeper into resources than I normally would. When I thought I found an answer, I ended up having more questions, and I had to look up the answers. This helped stretch my skills.
12	It helped me solidify my ability to go through different journals and decipher that some may be better than others in terms of trying to learn more about specific learning objectives. it was also good practice for citing and searching for them, and will make it easier for me in the future
13*	I think it would have been nice to get a table or graph that uses the precise categories of levels of evidence and an a few examples with each one. I ended using google to find charts, but then the charts didn't match exactly. It was helpful to have the example assignment to go off, but I don't think I walked away with a clear understanding as to classifying sources across all levels.
	b. Covid-19
1	It helped me hone my skills regarding researching the literature and summarizing it.
2	It taught me how to critically analyze scientific literature in order to answer a clinical question.
3	It helped my understanding of the unique environment of COVID research and how it changed rapidly

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4	I actually really liked this challenge as my group had to find research about steroids BEFORE we really knew how they impacted COVID-19. I felt like this was one of the best real-life scenarios we've been given and I enjoyed researching it.
5	The COVID assignment helped develop team skills as we worked together to analyze and understand a research article that was key during the development and progression of COVID-19 during the pandemic
5	I found the utilization of post pandemic and during pandemic guidelines and information to be particularly interesting and informative. Seeing the change in perspectives on certain managements across the timeline of the pandemic such as the use of remdesivir in affected patients as seen in literature published during the pandemic vs after was enlightening.
6	This assignment was more of a challenge as I was searching through data that we do not have as much information on so it furthered my ability to really dig through journal articles and find credible data
7	It helped my ability to quickly find the key takeaways from a paper
8	I want to be a lifelong learner. It taught me however that finding focused research on a topic is not as easy as a 2 second google search. It takes a bit more than that.
9*	I already felt confident in my ability to gather information on a specific topic and direct my own learning so this exercise seemed somewhat meaningless to me. It felt like just another hoop to jump through.

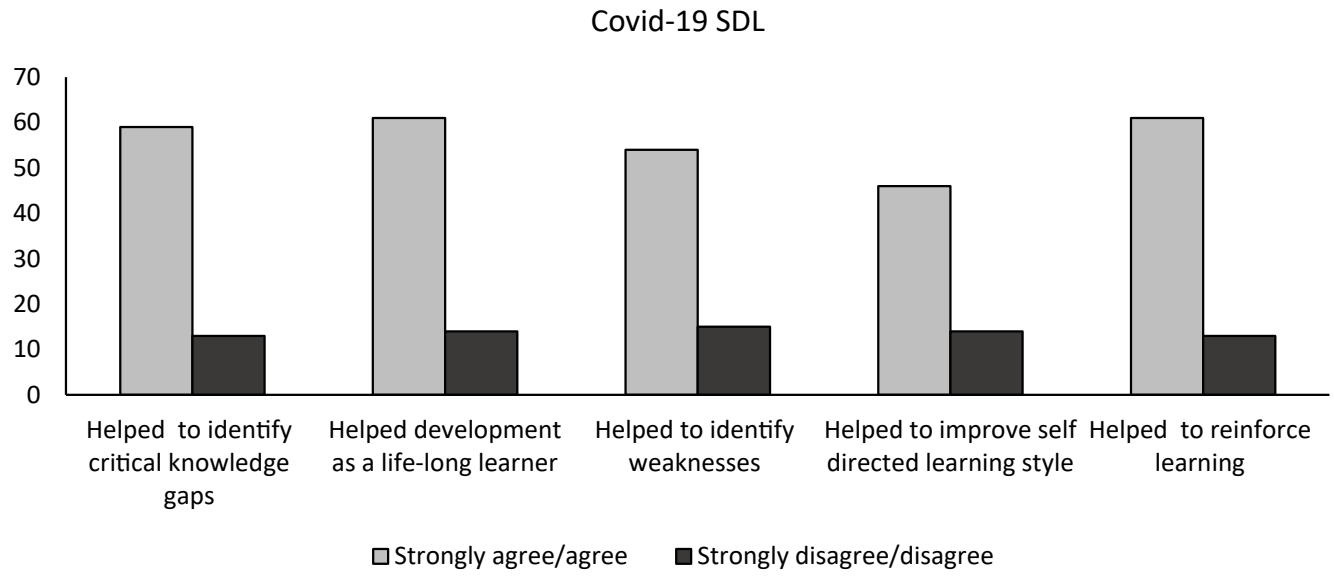

Figure 4: The results of the Qualtrics survey for Covid-19 SDL. The survey was distributed to the entire student body (second-year medical students) at the University of Toledo College of Medicine with a response rate of 90% (n=158/175). Some stems have been condensed for presentation here. The full survey is provided in supplementary figure 3.

SDL is considered "a general approach to learning in which the learner takes responsibility for self-identifying gaps in knowledge and skills and then applies SRL strategies to remedy those gaps." In SDL, learning is linked to assessment of learning, because learners must monitor their progress and obtain external feedback. This helps them make necessary adjustments, which allows them to progress to higher levels of learning and performance. SDL has been shown to help students improve their presentation skills, communication skills, collaboration, learning skills, and information handling skills [2, 3]. However, recent studies show that despite the proven advantages and the concurrent emphasis on SDL in the undergraduate and graduate medical curriculum, institutions are found to face several challenges in implementation [5, 6]. Faculty guidance and lack of organizational skills were some of the shared challenges faced by institutions [5, 6].

Here, we present two different methods of SDL, both of which address these challenges and meet the requirements defined by the Liaison Committee on Medical Education (LCME). They both focus on two distinct aspects of student learning. The first is focused on encouraging the students to identify learning needs and find resources to contribute to their learning while the second addresses a major challenge faced by future physicians, i.e., how to effectively use scientific literature to reinforce medical knowledge acquisition. Both models are designed to help students develop lifelong learning skills. The survey results showed that the majority of the students are satisfied with the process and that we have been able to achieve the desired consequence. Furthermore, our data show that the majority of students successfully attained content mastery in the topic related to the second SDL. Ricotta et al, in a study conducted by faculty teams from eight major US medical schools in partnership with the Association of American Medical Colleges (AAMC)

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and published in 2021, emphasize that SDLs introduced in medical curricula should capture the unique environment of medical training and clinical education [7]. Their imperative that 'self-directed learning requires placing the construct in the context of patient care and has an obligation to society at large' was instrumental in our conception of both models. It comes from the understanding that learning is a lifelong process for physicians and our learners have to be cognizant of some of the major healthcare challenges and be prepared to adapt their learning approach accordingly. For example, COVID-19 SDL aimed to prepare our students with the best approach to practice evidence-based medicine in unprecedented situations such as those witnessed with the arrival of the pandemic in 2020.

We have based both our SDL models on the SDL in Medical Education, (SDL-ME) framework, which is a construct of learning and pedagogy specific to medical students and physicians in training as described by Ricotta et. al. in their publication [7]. In addition to the most popular elements in SDL, our "anticoagulants" model also focused on the fourth aspect of self-regulated learning described in the SDL-ME framework, viz. applying new knowledge and skills to real-world situations [7]. We had a clinical scenario as the basis of SDL, which required students to apply their knowledge and bridge the gap while keeping in mind the various important aspects of clinical decision-making. SDL-ME emphasizes a "safe, supportive, and rigorous learning environment within the context of the professional obligation and responsibilities of medicine" and we strongly believe that our model captured this essence.

Motivation is a major draw of the SDL-ME model and is described to involve both internal (for example: intrinsically wanting to improve patient care) and external drivers (for example: driven by evaluations or assessments). While the grade component of both of our SDL models specifically targeted the external driver, a faculty grading and feedback based on a rubric that emphasized the quality of the assignment, as well as the peer feedback component attempted to capture the internal driver in the case of the first model (anticoagulants). SDL-ME framework necessitates that the feedback component should be not only meaningful, and timely, but also centered on the process of learning (effort). In this model, each student is expected to think like a physician while assessing the patient described in the clinical case. Therefore, the clinical faculty who evaluated their assignment and provided feedback addresses adaptive expertise, which is the ability to reason from foundational principles to create solutions to problems not previously encountered. By including peer feedback as part of their assignment and grade in this model, we ensured that the students, while giving feedback to their peers on their strengths and weaknesses, have an opportunity to encounter various other approaches to learning, thereby giving themselves an added advantage and opportunity to re-evaluate and adapt their own methods. While our SDL model "anticoagulants" focused more on fostering professional identity formation, teamwork was the major facet of the "COVID-19" model. Teamwork was an added important advantage of the COVID-19 SDL, which created opportunities to interact with peers and teachers and this has shown to be a major advantage in prior studies [2, 14-17]. In the medical curriculum, learning has to be enjoyable and motivating to help better retention and improve professional acumen. The teamwork and presentation in the classroom along with your teammates helped to create these qualities [3, 16, 17]. SDL also helped students improve their time management [3, 5, 18]. Thus, SDL will have several advantages if applied with the appropriate methodology.

Strengths and Limitations

By evaluating content mastery using DINA model, we found that students benefited from expanding their content mastery through the SDL exercises. The content mastery in Covid-19 related content was very high compared to the class averages in internal assessments. Survey responses show that out of the 90% of students who responded to the survey, the majority (> 60%) agreed that the goals of implementation were successful. However, there are additional constructive comments in the narrative section that can be useful in making necessary changes for the upcoming iterations (see sections marked* in Table 2). An example is taking into consideration comments that some of the students did not find the assignment challenging enough, and therefore we may consider carefully balancing the process so that all the students benefit from the exercise. Another limitation was that the authors were not able to assess the topic of "anticoagulants" using DINA model analysis. We intend to rectify this in the upcoming iteration.

Conclusion and Next Steps

Our ultimate goal is to introduce the concept of Master Adaptive Learners (MAL) to our medical students from the very beginning of their education in the medical school. We believe the principles of SDL will allow students to take ownership of their learning and support their professional growth. This, in turn, will help them develop the skills necessary for a successful career in the field of medicine. Some of the proposed future plans include taking the ideas presented in this study and expanding them into other organ systems. It is our goal to develop rubrics that course directors can easily incorporate into organ systems and establish an operational system to help faculty construct clinical vignettes using the PICO (Patient/Population, Intervention, Comparison, Outcomes) model [19].

List of Abbreviations

Self Directed Learning (SDL); Liaison Committee on Medical Education for Accreditation (LCME); Accreditation

Council for Graduate Medical Education (ACGME); Learning Management System (LMS); Deterministic Input, Noisy "and" Gate (DINA); Academic Year (AY); Self-Regulated Learning (SRL); SDL in Medical Education, (SDL-ME); Master Adaptive Learners (MAL); Patient/Population, Intervention, Comparison, Outcomes (PICO).

Ethics approval and concent to participate

The authors declare that all methods were conducted in accordance with relevant guidelines and regulations. All experimental protocols were approved by The University of Toledo College of Medicine and Life Sciences "Institutional Review Board (IRB)" which has determined that this study meets the "exempt" category. Informed consent was obtained from all subjects as per IRB guidelines.

Consent for Publication

Not applicable

Availability of data and Materials

The datasets generated and analyzed are available from the corresponding author on reasonable request.

Competing Interests

The authors report no declarations of interest.

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Authors' Contributions

BM supervised the SDL implementation and was responsible for data analysis and manuscript writing. CDM conceived the study and contributed to manuscript writing. JJL was responsible for the overall supervision of the study, manuscript writing and critical revision.

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References

1. Spiro RJ, Coulson RL, Feltovich PJ, Anderson D: Cognitive flexibility theory: Advanced knowledge acquisition in ill-structured domains. Hillsdale, NJ: Erlbaum (1988).
2. Abraham RR, Torke S, Gonsalves J, Narayanan SN, Kamath MG, Prakash J, et al. Modified directed self-learning sessions in physiology with prereading assignments and Pecha Kucha talks: perceptions of students. *Adv Physiol Educ* 42 (2018): 26-31.
3. Premkumar K, Vinod E, Sathishkumar S, Pulimood AB, Umaefulam V, Prasanna Samuel P, et al. Self-directed learning readiness of Indian medical students: a mixed method study. *BMC Med Educ* 18 (2018): 134.
4. Murad MH, Coto-Yglesias F, Varkey P, Prokop LJ, Murad AL: The effectiveness of self-directed learning in health professions education: a systematic review. *Med Educ* 44 (2010): 1057-1068.
5. Buch A, Rathod H, Naik M. Scope and Challenges of Self-Directed Learning in Undergraduate Medical Education: A Systematic Review. *J Med Edu* 20 (2021).
6. Jeong D, Presseau J, ElChamaa R, Naumann DN, Mascaro C, Luconi F, et al. Barriers and Facilitators to Self-Directed Learning in Continuing Professional Development for Physicians in Canada: A Scoping Review. *Acad Med* 93 (2018): 1245-1254.
7. Ricotta DN, Richards JB, Atkins KM, Hayes MM, McOwen K, Soffler MI, et al. Self-Directed Learning in Medical Education: Training for a Lifetime of Discovery. *Teach Learn Med* 34 (2022): 530-540.
8. Matus AR, Matus LN, Hiltz A, Chen T, Kaur B, Brewster P, et al. Development of an assessment technique for basic science retention using the NBME subject exam data. *BMC Med Educ* 22 (2022): 771.
9. Bangeranye C, Lim YS. How to Use Cognitively Diagnostic Assessments of Student Performance as a Method for Monitoring and Managing the Instructional Quality in Undergraduate Medical Education. *Acad Med* 95 (2020): 145-150.
10. de la Torre J. The Generalized DINA Model Framework. *Psychometrika* 76 (2011): 179-199.
11. Junker BW, Sijtsma K. Cognitive assessment models with few assumptions, and connections with nonparametric item response theory. *Applied Psychological Measurement* 25 (2001): 258-272.
12. Tatsuoka KK. Rule Space - an Approach for Dealing with Misconceptions Based on Item Response Theory. *J Educ Meas* 20 (1983): 345-354.
13. Papanagnou D, Corliss S, Richards JJ, Artino AR, Schwartzstein R. Progression of Self-Directed Learning

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DOI:10.26502/fjhs.151

in Health Professions Education: Clarifying Terms and Processes. *Acad Med* (2023).

14. Peine A, Kabino K, Spreckelsen C: Self-directed learning can outperform direct instruction in the course of a modern German medical curriculum - results of a mixed methods trial. *BMC Med Educ* 16 (2016): 158.
15. Kershaw G, Grivna M, Elbarazi I, AliHassan S, Aziz F, Al Dhaheri AI: Integrating Public Health and Health Promotion Practice in the Medical Curriculum: A Self-Directed Team-Based Project Approach. *Front Public Health* 5 (2017): 193.
16. Patra S, Khan AM, Upadhyay MK, Sharma R, Rajoura OP, Bhasin SK. Module to facilitate self-directed learning among medical undergraduates: Development and implementation. *J Educ Health Promot* 9 (2020): 231.
17. Zheng B, Zhang Y: Self-regulated learning: the effect on medical student learning outcomes in a flipped classroom environment. *BMC Med Educ* 20 (2020): 100.
18. Cleary TJ, Sandars J. Assessing self-regulatory processes during clinical skill performance: a pilot study. *Med Teach* 33 (2011): e368-374.
19. Richardson WS, Wilson MC, Nishikawa J, Hayward RS: The well-built clinical question: a key to evidence-based decisions. *ACP J Club* 123 (1995): A12-13.