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RESEARCH ARTICLE

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The positive impact of introducing modified directed self-learning using pre–small group discussion worksheets as an active learning strategy in undergraduate medical education

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ABSTRACT

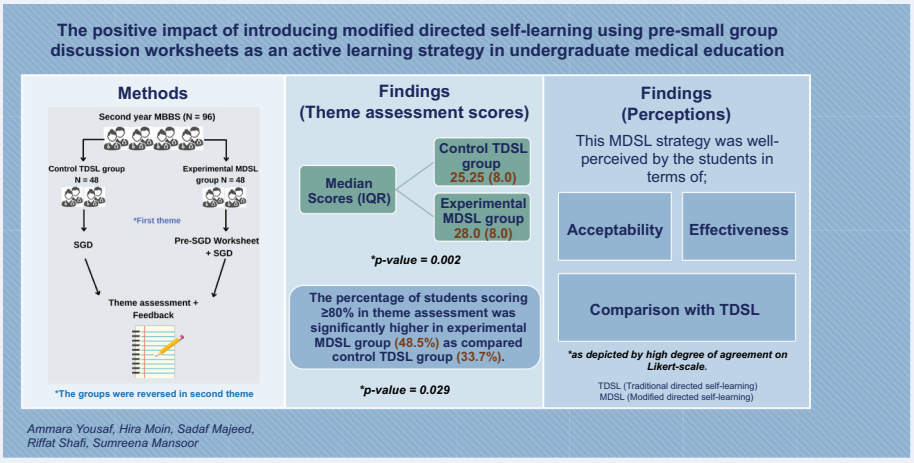
Background: Directed self-learning (DSL) is an active learning approach where the learners are provided with predefined learning objectives and some facilitation through the learning process in the form of guidance and supervision. It can help establish a strong foundation for autonomous and deep learning.

Objective: The aim of this study was to introduce a modified form of DSL to second-year undergraduate medical students using pre–small group discussion (pre-SGD) worksheets. The authors intended to evaluate its effectiveness through theme assessment and investigate students' perceptions using a feedback questionnaire.

Methods: This was an analytical cross-sectional study. Modified DSL (MDSL) was introduced to 96 second-year undergraduate medical students in two themes. Students were divided randomly into two groups. One group was exposed to traditional DSL (TDSL), and the other was introduced to MDSL using pre-SGD worksheets for the first theme. Groups were reversed for the second theme. The activity was followed by a theme assessment, which was scored for research purpose only. The scores of this assessment were compared, and perceptions of the students were gathered using a validated questionnaire. Data were analyzed using IBM's statistical package of social sciences (SPSS) version 22.

Results: The comparison of theme assessment scores revealed statistically significant difference (P = 0.002) in median scores between control TDSL and experimental MDSL groups. The percentage of students scoring ≥80% in theme assessment was significantly higher in the experimental group compared to the control group (P = 0.029). This strategy was well perceived by the students in terms of acceptability and effectiveness as depicted by a high degree of agreement on the Likert-scale.

Conclusion: Modified DSL resulted in significant improvement in academic performance of undergraduate medical students. MDSL was also well perceived as an active learning strategy in terms of acceptability, effectiveness, and comparison with TDSL.



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Introduction

The primary aim of education is to equip learners with desirable knowledge and skills that can enable them to become lifelong learners [1]. To achieve this aim, learning strategies in medical education have gradually evolved from pedagogy to andragogy, i.e., educator-centered to student-centered learning [1,2]. This shift has given the students the opportunity to

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take responsibility for their learning. Student-centered learning or active learning is an approach where the content, resources, strategies, and pace of learning are decided and controlled by the students themselves. The instructor acts as a facilitator and guides the students to acquire the necessary skills that can help them learn independently and from each other [3]. Active learning enhances higher-order cognitive skills of the students and motivates them to become independent and self-regulated learners [4,5]. Several modalities of active learning being currently implemented in the medical arena include self-directed learning, problem-based learning, case-based learning, team-based learning, flipped classroom, and portfolios [6,7].

A modality that is emphasized in the integrated medical curricula from the early years is self-directed learning (SDL). Its primary objective is to produce independent lifelong learners [8]. SDL has been defined by various educators. However, the most widely accepted definition has been provided by Knowles;

'In its broadest meaning, "self-directed learning" describes a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes.' [9]

Implementation of SDL in the early years of medical education is challenging. We assume that the learners already possess the desired level of maturity, motivation, and self-direction required for independent learning. However, this may not always be the case as these aspects depend upon individual characteristics and diverse backgrounds of the learners. Furthermore, it is challenging to assess if the learners are able to use the SDL session effectively to achieve the desired level of comprehension of a topic without any guidance [8]. A few researchers have mentioned that SDL is more suitable for learners who already have the basic knowledge and concepts that they can use as a base to build on further knowledge [9–11]. Another drawback of SDL identified in the literature, particularly in the context of medical education, is that it focuses on promoting the success of the individual learner [12]. However, for medical students it is critical to work within teams to solve problems and offer community services [13].

Kadirvelu et al. suggested that in the early years of medical education, '*directed self-learning*' (DSL) is preferable to SDL. DSL is an approach where the learners are provided with predefined learning objectives and some facilitation through the learning process in the form of guidance and supervision. Students in the foundation years often lack the essential attributes required for effective SDL and may experience frustration if they find a disparity between the existing and expected level of proficiency. In the initial years, guidance for learners on identifying their individual learning needs and styles, setting learning goals, achieving learning outcomes, and selecting appropriate learning strategies can establish a good foundation for autonomous and deep learning. Moreover, it can ensure that the learners are not overwhelmed by large amount of information from different sources [8].

Directed self-learning (DSL) has been adopted by various educators in the early years of undergraduate education. The terms of directed self-regulated learning (DSRL) and directed self-guided learning (DSGL) have also been used for similar approaches by various authors [14,15]. Brydges et al. defined the requirements of DSL as follows;

'Specifically, DSRL requires a knowledgeable educator to design practice conditions using validated learning principles. A trainee then steps into this structured setting and is given limited control of a specific aspect of practice and therefore is metacognitively, behaviorally, and motivationally active in the learning experience'. [15]

Furthermore, it is pivotal to inculcate collaborative learning during the early stages of undergraduate medical education. Collaborative learning is a method whereby students help and support one another in learning by working together in groups. This type of learning is essential to develop medical professionals who have the ability to practice within teams to solve more complex problems and serve the community at large. Collaborative learning and group cohesion have shown to promote SDL behaviors and support SDL readiness [16–19]. Moore et al. explained a collaborative self-directed learning model whereby the learners can practice independently on learning objectives and then work together in groups to reflect and critique their learning [20].

Currently, in the institution this study took place, DSL is practiced in a traditional way where students are provided learning objectives and resources on a particular topic. Students are required to learn the topics on their own, as guided by the given learning objectives. Afterward, the students discuss these topics in small groups (12–13 students each). This small group discussion (SGD) is an active learning process led by the students in the presence of a facilitator. Students are expected to take responsibility for their learning by engaging in a comprehensive discussion and achieving the learning outcomes. The role of the facilitator is to provide necessary guidance, which includes asking questions to assess students' understanding and resolve their misconceptions. The facilitators are required to

ensure the active participation of all group members and listen to and encourage ideas or opinions without being didactic and authoritative [21,22]. By the end of the SGD session, the student's performance is graded by the facilitators in individual student logbooks. This is based on the preparation, participation, collaboration, and professionalism of the students during the session. This grading is incorporated as part of continuous internal assessment. However, it has been observed that in the early years of undergraduate medical education students are not accustomed to various active learning strategies and often struggle to reach desired learning goals. Hence, sometimes the educator has to intervene beyond the defined role of a facilitator. This leads to passivity among students, thereby reducing the effectiveness of the entire active learning process [21,23].

To enhance student engagement, a modified form of DSL using PowerPoint slides as pre-reading assignments was implemented by Abraham et al. among first-year undergraduate medical students in physiology sessions. Students' perceptions regarding the usefulness of this strategy were gathered. However, the study did not report the anticipated positive perceptions of the students in terms of their satisfaction with the effectiveness of the strategy [24]. Moreover, the efficacy of this modified form of DSL on student performance and achievement of learning outcomes was not evaluated.

In order to address this gap in the literature and enable the students to become better self-learners from the early years of medical education, we identified the need to improve the effectiveness of our traditional DSL (TDSL) method and refine it into a better active learning strategy. For this reason, we introduced a modified DSL (MDSL) method using pre-SGD worksheets to the second-year medical students, which incorporated the principles of DSL, flipped classroom (an educational approach in which students independently learn course content as homework before the face-to-face active group discussion session) [25] and collaborative learning simultaneously.

The aim of this study was to introduce MDSL to second-year undergraduate medical students using pre-SGD worksheets and to evaluate its effectiveness through theme assessment and gather students' perceptions using a feedback questionnaire.

Materials and methods

Ethical considerations

The study was carried out after obtaining approval from the institutional review board and ethics committee of Shifa International Hospitals. For recording perceptions of students, written informed consent was obtained from all the participants (response rate: 100%). Permission to conduct the present study was obtained from the module director.

Setting and participants

The study was conducted in May 2022 during the module of Endocrinology and Metabolism (ENM). The total number of students in second year was 100, out of which 96 students participated in the study.

Study design

This was an analytical cross-sectional study aimed to introduce MDSL to the students using pre-SGD worksheets. The effectiveness of this strategy was evaluated using theme assessment, and students' perceptions were gathered by administering a feedback questionnaire. For this study, two themes were selected: physiology of thyroid gland and physiology of adrenal gland.

Study groups

The participants were divided randomly into two equal groups, labelled A and B ($n = 48$ each). In the thyroid theme, group A was the experimental MDSL group, which was exposed to MDSL; B was the control TDSL group, which studied the theme by the traditional DSL method already in practice at the institute. For the adrenal theme, groups were reversed, i.e., A was the control TDSL group and B was the experimental MDSL group.

Groups A and B were further divided into four small groups each, thus, making a total of eight small groups with 12–13 students each. A faculty member was assigned to facilitate each small group. All facilitators were post-graduate subject specialists.

Traditional DSL

In each theme, predefined learning objectives were shared with students 3 days prior to the session. To ensure standardization across the groups, a pre-SGD meeting with the facilitators was conducted a day prior to the SGD session by the faculty member who was assigned to conduct the large group wrap-up session and pre-SGD meeting for the respective topic. During the meeting, facilitators were briefed about the learning objectives, learning resources, and theme assessment.

A small group discussion was carried out by the students and facilitated by their respective facilitators. The duration of this session was 2 hours. Students'

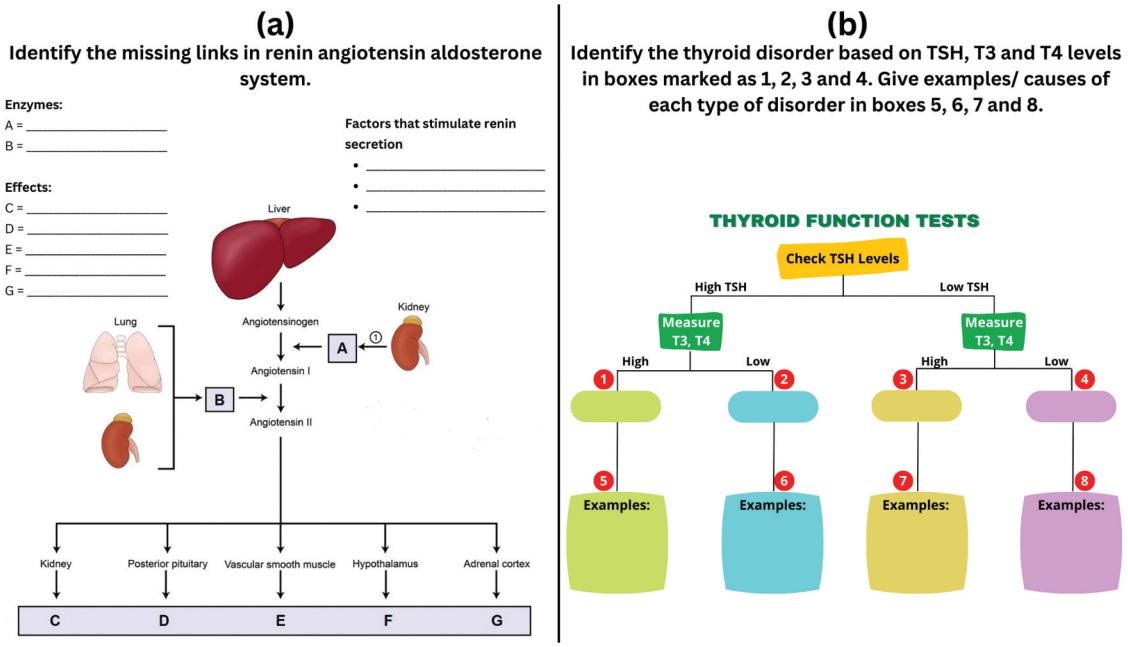


Figure 1. Examples of exercises designed for pre–small group discussion worksheets.

Note: *(a) A task from pre–small group discussion worksheet of adrenal theme (used with permission from medbullets, Lineage Medical, LLC): Renin-angiotensin-aldosterone system). (b) A task from pre–small group discussion worksheet of thyroid theme.*

performance was marked in individual student logbooks by the facilitator.

MDSL using pre-SGD worksheets

For the modified DSL, two pre-SGD worksheets were developed by subject specialists (one for each theme) based on specific predefined learning objectives. These worksheets were designed in a format aimed to be visually engrossing and appealing to maximize student interest. The idea behind developing these worksheets was to devise a strategy that can help students comprehend the information rapidly and reinforce concepts efficiently in a creative and enjoyable manner. Additionally, special emphasis was made on developing exercises that can aid students to integrate basic science knowledge with the pathophysiology of disease. Such worksheets can also be a resource to enhance memory recall, retention of knowledge, critical thinking, and problem-solving skills.

Each pre-SGD worksheet comprised flow charts with missing links, diagrams with missing labels, along with pictorials, match the column-type, and problem-based questions. Figure 1 shows few examples of exercises that were designed for pre-SGD worksheets.

In each theme, learning objectives of the topic were shared with the experimental MDSL group 3 days prior to small group discussion. This group was given pre-SGD worksheets and was instructed to attempt them while preparing for their SGD sessions in the absence of a facilitator. To ensure standardization across the groups, a pre-SGD meeting with the facilitators was conducted a day prior to the SGD session in the same way as mentioned for the traditional DSL. Additionally, these facilitators were instructed to ensure the completion of pre-SGD worksheets by the students.

A small group discussion was then carried out by the students and facilitated by their respective facilitators. The groups were given time initially to discuss the topics based on learning objectives. During the same session, the facilitators ensured that the students completed and discussed pre-SGD worksheets as well. The duration of this session was the same as that of the TDSL session (2 hours). Students' performance was marked in the logbook by the facilitator.

Theme assessment and feedback

At the end of SGD, a theme assessment was conducted in small groups that included both control and experimental groups. Theme assessment was designed and validated by subject specialists. Both the thyroid and adrenal theme assessments comprised multiple choice, true–false, extended matching, and short answer questions. All of the questions were in accordance with the table of specifications of the particular theme. However, these questions were different from the exercises in pre-SGD worksheets. This assessment was graded by the small group facilitators. Meanwhile, the students were given a break for 30 minutes after which they were to gather in

their respective small groups for feedback, to be provided by their respective facilitators. In these feedback sessions, the facilitators addressed misconceptions and deficiencies identified during the grading process.

The assessment was scored only for this study, and group scores were compared in two ways. Firstly, a comparison of median theme assessment scores was done between the control and experimental groups. Secondly, the percentage of students with theme assessment scores of ≥60% and ≥80% was also compared between the two groups. Scores were neither shared with the students nor did they contribute towards their internal assessment scores. These assessments were intended to enhance students' learning by providing them with feedback and helping them fill gaps in their knowledge.

The whole activity was followed by a large group wrap-up session for all participants ($N = 96$) by a post-graduate subject specialist, who was also one of the facilitators of the SGD sessions. This large group interactive session was scheduled a day following the small group activity.

Feedback questionnaire

A questionnaire was developed and validated by the faculty after an extensive literature review. Cronbach's alpha was determined to measure the internal consistency of the questionnaire items. Hard copies of this questionnaire were distributed among the students after the theme assessment. The questionnaire comprised 15 questions on a Likert-type scale with one open-ended question to evaluate the attitude and perceptions of participants towards MDSL. Items 1–4 of the questionnaire were regarding acceptance, 5–10 regarding effectiveness and 11–12 regarding the feasibility of MDSL. Items 13–15 evaluated students' perception about the comparison between MDSL and TDSL. A five-point Likert-scale (where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree) was used to evaluate student perceptions.

Methodology of MDSL is summarized in Figure 2.

Statistical analysis

Data were analyzed using IBM's Statistical Package of Social Sciences (SPSS) version 22. Descriptive statistics were used to analyze quantitative items in the questionnaire and theme assessment scores. Comparison of assessment scores between groups

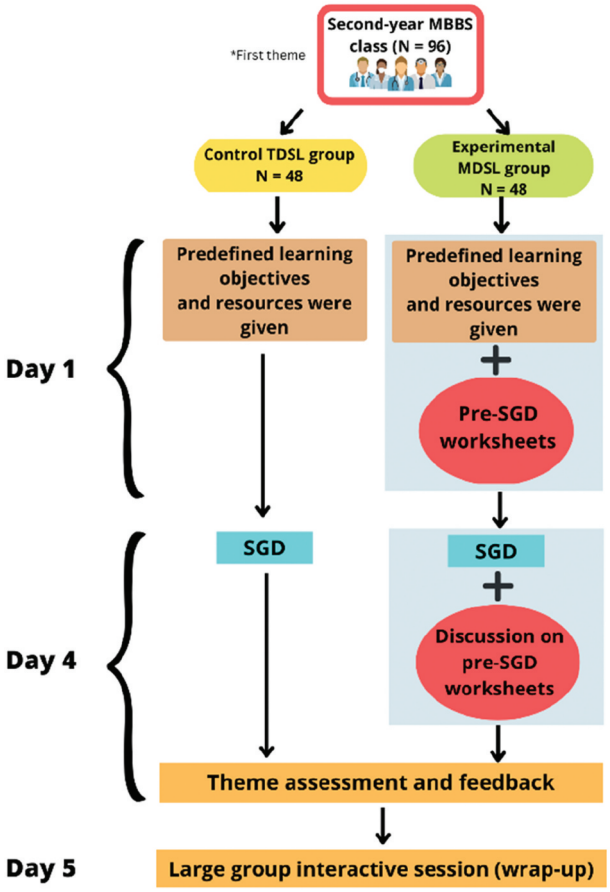


Figure 2. Flow chart of the methodology of modified directed self-learning in a cohort of second-year undergraduate medical students.

Note: *The groups were reversed for the second theme.*

(TDSL = traditional directed self-learning, MDSL = modified directed self-learning, and SGD = small group discussion)

was done using the Mann–Whitney U test. $P < 0.05$ was considered significant.

Results

Scores

For the analysis of theme assessment scores, normality of data was assessed by applying Kolmogorov–Smirnov and Shapiro–Wilk tests. The results showed that data were not normally distributed in the control TDSL group (Kolmogorov–Smirnov $P = 0.028$ and Shapiro–Wilk $P = 0.015$) as well as in the experimental MDSL group (Kolmogorov–Smirnov $P = 0.019$ and Shapiro–Wilk $P < 0.001$).

Since the data were not normally distributed, the comparison of median theme assessment scores between the groups was done by applying a non-

Table 1. Comparison of median theme assessment scores between the control TDSL and experimental MDSL groups.

Groups	Median	Interquartile range	*P*
Control TDSL group (*N*=96)	25.25	8.0	**0.002***
Experimental MDSL group (*N*=96)	28.0	8.0	

Data expressed as median with interquartile range. Analysis done using Mann–Whitney U test.
*$P<0.05$ considered significant *N* = total number of students, TDSL = traditional directed self-learning, MDSL = modified directed self-learning.

parametric Mann–Whitney U test. The median theme assessment score of the experimental MDSL group was significantly higher compared to the control group ($P = 0.002$) as shown in Table 1.

The percentage of students with theme assessment scores of ≥60% and ≥80% was also compared between control and experimental groups. Normality of the data was determined by applying Kolmogorov–Smirnov and Shapiro–Wilk tests. The data were not normally distributed in both the groups ($P < 0.001$). As a result, comparison was done using the non-parametric Mann–Whitney U test. The percentage of students scoring ≥80% in theme assessment was significantly higher in the experimental MDSL group compared to the control TDSL group ($P = 0.029$). The percentage of students scoring ≥60% in theme assessment was higher in the experimental MDSL group compared to the control TDSL group, though this was not significant ($P = 0.065$) as shown in Table 2.

Table 2. Comparison of the percentage of students with theme assessment scores of ≥60% and ≥80% between control TDSL and experimental MDSL groups.

Variables	Number of students (Percentage) Control TDSL group (*N*=96)	Experimental MDSL group (*N*=96)	*P*
Students with ≥ 60% score in theme assessment	73 (72.3%)	83 (82.2%)	0.065
Students with ≥ 80% score in theme assessment	34 (33.7%)	49 (48.5%)	**0.029***

Analysis done using the Mann–Whitney U test. *$P<0.05$ considered significant.
N = total number of students, TDSL = traditional directed self-learning, and MDSL = modified directed self-learning.

These results show that MDSL was effective in improving the academic performance of the students.

Perceptions

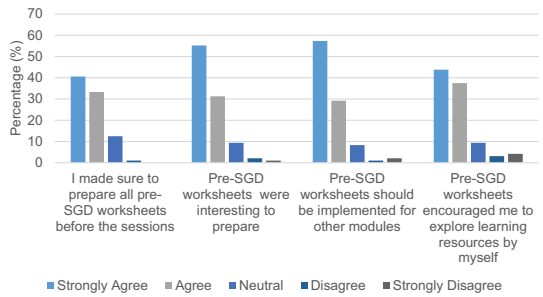
There were 96 responses to the feedback questionnaire. The respondents comprised 55.3% females and 44.6% males. The average age of the participants was 19.75 ± 0.54. Cronbach's alpha value of the questionnaire was 0.843, which was considered satisfactory. Internal consistency of each scale was calculated. Cronbach's alpha values of the scales of acceptance, feasibility, effectiveness, and comparison with TDSL were 0.8, 0.6, 0.8, and 0.7, respectively.

Students' responses to the questionnaire items were analyzed using descriptive statistics (Table 3).

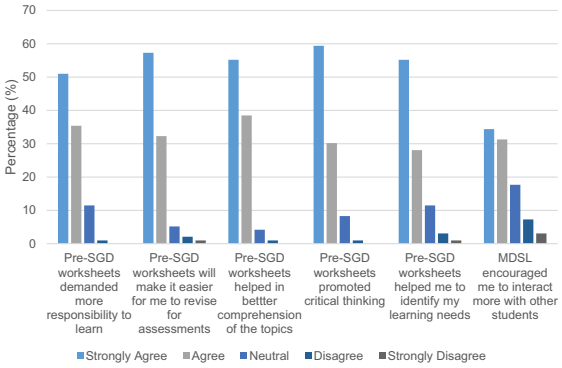
Table 3. Descriptive statistics of students' responses to the questionnaire items.

Questionnaire Items	*N*	Mean	SD
Acceptance			
1. I made sure to prepare all pre-SGD worksheets before the sessions	84	4.3	0.76
2. Pre-SGD worksheets were interesting to prepare	95	4.39	0.83
3. Pre-SGD worksheets should be implemented for other modules	94	4.41	0.86
4. Pre-SGD worksheets encouraged me to explore learning resources by myself	94	4.16	1.02
Effectiveness			
5. Pre-SGD worksheets demanded more responsibility to learn	95	4.37	0.77
6.Pre-SGD worksheets will make it easier for me to revise for assessments/exams	96	4.46	0.78
7. Pre-SGD worksheets helped in better comprehension of the respective topics	95	4.49	0.63
8. Pre-SGD worksheets promoted critical thinking	95	4.48	0.74
9. Pre-SGD worksheets helped me identify my learning needs.	95	4.35	0.88
10. MDSL encouraged me to interact more with other students	90	3.92	1.08
Feasibility			
11. Pre-SGD worksheets were too laborious to prepare	94	2.93	1.13
12.Pre-SGD worksheets were time-consuming and left less time for textbook reading	95	3.08	1.25
Comparison of MDSL with TDSL			
13. MDSL is more interesting than TDSL	95	4.38	0.8
14. I prefer MDSL discussion over TDSL	95	4.05	1.15
15. MDSL demanded more student engagement compared to TDSL	93	4.16	0.89

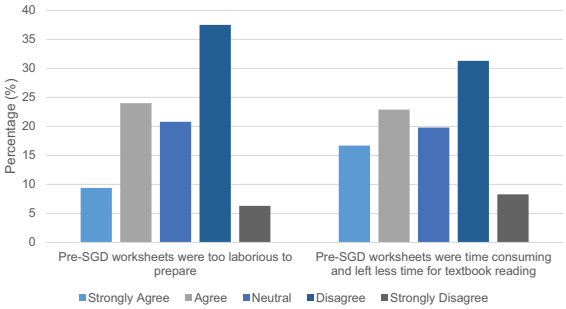
Data expressed as mean ± SD, *N* = number of respondents, SD = standard deviation.
A five-point Likert scale was used (where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree).



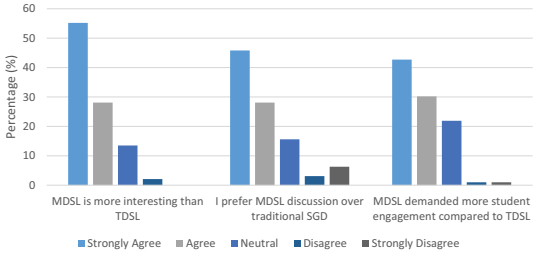
(a): Students' responses to questionnaire items regarding acceptance of MDSL



(b): Students' responses to questionnaire items regarding effectiveness of MDSL



(c): Students' responses to questionnaire items regarding feasibility of MDSL



(d): Students' responses to questionnaire items regarding comparison of MDSL with TDSL

Figure 3. Frequency analysis of responses with percentage of responses to questionnaire items. (a) Students' responses to questionnaire items regarding acceptance of MDSL. (b) Students' responses to questionnaire items regarding effectiveness of MDSL. (c) Students' responses to questionnaire items regarding feasibility of MDSL. (d) Students' responses to questionnaire items regarding comparison of MDSL with TDSL.

Note: *A five-point Likert scale was used (where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree).*

Table 4. Students' responses to the open-ended questionnaire item.

POSITIVE PERCEPTIONS
• *'This learning strategy has been really helpful. It is requested that this be implemented in future modules too'*
• *'This method of learning has made this module the mode conducive to learning compared to previous ones'*
• *'This was actually very fun. It was really nice trying to apply what I've learned immediately to solve questions. Helped me understand the topic a lot better'*
• *'This is a very nice introduction to learning concepts better'*
• *'I look forward to having more pre-SGD worksheets'*
• *'I loved it, made it so easier to understand'*
• *'Continue in all SGDs'*
• *'Really like the effort put into making those worksheets and were really colorful. It was fun and helpful'*
• *'It was good overall. Giving in hardcopy to every student'*
• *'Loved the worksheets'*
• *'It's good and was very helpful. really appreciate the effort made for it'*
• *'I really liked this method because it encouraged me to study in advance for SGDs and helped improve my concepts'*
• *'Satisfied'*
• *'Nice pictures in worksheet'*
• *'It should be implemented in all other modules'*
• *'This was a great learning experience'*
• *'Worksheets were overall very helpful and should be provided for other modules'*
• *'It's a great idea to initiate question based learning among medical students. It's great if it's implemented in the institute'*
• *'Pre-SGD worksheets are beneficial. it should be implemented in future'*
• *'Highly beneficial especially for revisions. Must not be compulsory'*
• *'Hope this method gets implemented in other modules'*
NEGATIVE PERCEPTIONS
• *'It gets too stressful to prepare'*
• *'SGD worksheet is a good initiative but should be assigned after SGD, so that once we prepare topic and lead the SGD we can assess ourselves. This will be a practice for us otherwise worksheet along with Guyton whole chapter in such short time will be something.'*

The mean score of the items assessing acceptance, effectiveness of MDSL, and its comparison with TDSL was >4, except for one item meant to assess the degree of interaction among group members, which showed a mean score of 3.92. Mean scores of items regarding feasibility of MDSL depicted neutral responses. The high degree of agreement on the Likert scale shows that MDSL was overall positively perceived by the students.

Percentages of responses to individual items in the questionnaire to assess acceptance, effectiveness, feasibility of MDSL, and comparison of MDSL with TDSL are presented in Figure 3(a–d).

The students were asked to share comments on the activity. The responses of students to this open-ended question are presented in Table 4.

Discussion

In this study, an MDSL was introduced to second-year undergraduate medical students as an active learning strategy. The purpose of employing this method was to enhance the critical-thinking and problem-solving skills of the learners, which is the crux of student-centered learning. Several types of data were collected to investigate the effect of this strategy on theme assessment scores of the learners. The perceptions of students on acceptance, effectiveness, and feasibility of this method and its comparison with TDSL were also analyzed. To our knowledge, this is a pioneer study exploring the impact of the MDSL method through pre-SGD worksheets on the academic performance of undergraduate medical students.

In the present study, the difference in scores of theme assessments between the control TDSL and experimental MDSL groups was evaluated. The median scores of the MDSL group were greater than that of the TDSL group, and the difference was statistically significant. Similarly, the percentage of students scoring ≥80% marks was significantly higher in the MDSL group. One of the possible reasons for this difference could be the well-structured pre-SGD worksheets that helped students in better comprehension of the topics, which reflected in their theme assessment scores. Similar findings were reported by Brydges et al. They assessed the usefulness of directed self-regulated learning (DSRL) versus instructor-regulated learning (IRL) for teaching lumbar puncture (LP) technique to internal medicine residents. They found that both groups demonstrated improved performance immediately after training (estimated by the difference in the pre-test and immediate post-test scores). However, the IRL group's skills deteriorated after 3 months, while the DSRL group's performance stayed the same (determined by 3-month retention test), signifying a probable long-term benefit of DSRL [15]. Other authors have also reported the effectiveness of active learning strategies in improving the performance of students. Metz et al. reported that the unit exam scores were significantly higher for a cohort of dental physiology students who were exposed to lectures where active learning approaches were incorporated, as compared to students exposed to traditional lectures [26].

In addition to the positive impact of the MDSL method on the assessment scores, it was also well perceived by the students. The students reported a high level of satisfaction in terms of acceptance and effectiveness of the method. This could be due to well-designed pre-SGD worksheets that were not only visually appealing but also had a variety of exercises to promote critical-thinking and pique students' interest in the given topic. This resulted in a higher level of active involvement of the students compared to TDSL as well as addressed the learning needs of a diverse group of learners. Different studies have reported the perceptions of students on the usefulness of active learning strategies with varying results. Metz et al. reported that the lectures that incorporated active learning strategies were perceived positively by the students of a dental physiology course opposed to the traditional lectures [26]. Similarly, in a study conducted by Huda et al., undergraduate nursing students reported a positive perception of active learning approaches compared to conventional learning approaches [27]. Abraham et al. have reported contradictory results. They introduced modified DSL as an active learning strategy to first-year undergraduate medical students in physiology sessions and recorded the students' perceptions of the same. However, the findings of the study did not reveal the anticipated positive perceptions of the students in terms of their satisfaction with the effectiveness of the MDSL strategy [24].

In this study, feasibility of the MDSL strategy was the only aspect that generated relatively passive or mixed responses from the students. 33.4% of the students agreed or strongly agreed that the activity was laborious and an additional 20.8% gave a neutral response. Similarly, 39.6% of the students agreed or strongly agreed that the activity was time-consuming and an additional 19.8% were neutral about this question. An attributed reason for this may be first-time use of the strategy and 3 days of preparation time. During this, the students had additional academic commitments. Giving extra time for completing the activity might have improved the perceptions on feasibility. Abraham et al. also attributed the passive response of their students regarding the MDSL to the additional amount of time required by the students for the preparation [24]. Active learning strategies not only demand extra effort and time by students but also mandate a greater degree

of responsibility on students' part. This may be a contributing factor as to why some studies have reported less enthusiastic responses from the students about these strategies [28,29].

In the present study, the students perceived MDSL as an effective strategy that enabled them to interact more with one another, which is one of the key features of collaborative learning. Kemp et al. implemented a collaborative self-directed learning (CSDL) model in a course offered to undergraduate medical students and evaluated the reflections of students to assess its usefulness. The students reported an overall admiration for the collaborative nature of the course [13]. White et al. have reported contradictory results. They revealed that neither many students favored collaborative learning nor they appreciated the idea of students supporting one another's learning. The authors stated that the majority of the students liked individual learning and got distracted while studying in groups. They attributed this finding to the students not being developmentally prepared for collaborative learning [29].

Limitations and future suggestions

There were a few limitations of this study, which confine its generalizability. Firstly, the sample size may not be representative of all undergraduate medical students. Secondly, we only performed an immediate theme assessment and did not assess the impact of the MDSL strategy on the long-term retention of knowledge. Thirdly, more time for the preparation of MDSL worksheets could have been more beneficial. We suggest that future studies should be carried out on a larger sample. The effectiveness of MDSL on long-term knowledge retention also needs to be assessed. We further recommend investigating other ways to modify the MDSL strategy that might be useful in promoting active learning among students.

Conclusion

Modified DSL resulted in significant improvement in the academic performance of undergraduate medical students. It was well perceived as an active learning strategy in terms of acceptability, effectiveness, and comparison with TDSL.

Supplementary information

Supplementary material will be available upon request from the corresponding author.

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