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The Use of SOLO Taxonomy in Medical Education Training for Medical Teachers

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Medical teachers need training in medical education to improve their teaching skills, keep up with modern teaching methods, and promote student-centered learning. Multiple methods exist for training medical teachers in the area of medical education. The SOLO (Structure of the Observed Learning Outcome) taxonomy can be included in training medical teachers. The SOLO taxonomy has five levels, which is used as a framework for assessing depth of understanding and the complexity of a learner's response to a question. Here, the author constructed two questions in the field of medical education and provided examples of answers related to each level of understanding in the SOLO taxonomy. A medical educator can employ the SOLO taxonomy to conduct a qualitative analysis of the level of understanding of medical teachers and can use this understanding to design training activities that promote higher levels of thinking and understanding. Additionally, the SOLO taxonomy can be used to improve the effectiveness of training strategies, as well as to provide targeted feedback to medical teachers.

Keywords: SOLO taxonomy, Medical teacher, Medical education, Faculty development

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Introduction

Medical teachers require training on medical education to enhance their teaching skills and stay up-to-date with modern teaching methods, curriculum design, and student assessment techniques. Such training provides them with an opportunity to learn and improve their teaching skills and to become more effective educators. It also helps to promote student-centered learning, which has been shown to improve student engagement and academic performance.[1] Additionally, training in medical education can help medical teachers to understand the unique challenges faced by students in medical schools, such as high academic demands, stress, and work-life balance, and help them to provide support and guidance to their students.[2] Overall, training in medical education is essential to ensure that medical teachers are well-equipped to provide high-quality education to medical students and to enhance the overall quality of medical education.

Methods of How to Train Medical Teachers in the Field of Medical Education

There are various methods of training medical teachers in the field of medical education. Here are a few examples:[3-5]

1) *Faculty development workshops*: Faculty development workshops have been found to be effective in enhancing teaching skills and improving the quality of medical education. These workshops usually cover topics such as teaching and learning principles, assessment and evaluation, curriculum development, and educational research.

2) *Mentoring*: Mentoring is a one-on-one relationship between an experienced teacher and a less experienced teacher. Mentoring has been found to be effective in enhancing teaching skills, promoting professional development, and improving the quality of medical education.

3) *Peer observation and feedback*: Peer observation and feedback involve teachers observing each other's teaching and providing constructive feedback. This method has been found to be effective in improving teaching skills and promoting reflective practice.

4) *Online courses*: Online courses are becoming increasingly popular as a way to provide training in medical education. These courses cover a wide range of topics related to medical education and are often self-paced and flexible.

The SOLO (Structure of the Observed Learning Outcome) taxonomy can be incorporated into the above methods for training medical teachers. A study found that using the SOLO taxonomy as a framework for training medical teachers resulted in significant improvements in their teaching practices, including their ability to design effective learning activities, assess student understanding, and provide feedback.[6] Another study also found that using the SOLO taxonomy in teacher training programs led to improvements in teaching practices and increased student engagement and motivation.[7]

SOLO Taxonomy

SOLO taxonomy is a framework for assessing the complexity of a learner's response to a question. It was developed by Biggs and Collis (1982) as a way to categorize student responses beyond just right or wrong answers.[8] The SOLO taxonomy has five levels: prestructural, unistructural, multistructural, relational, and extended abstract. Each level builds on the previous one and represents a higher degree of complexity and depth of understanding. Since its development, the SOLO taxonomy has been widely used in education research and instructional design. It has been applied to various fields such as science, engineering, medicine, and nursing to assess student learning outcomes.[9-11] The five levels in the SOLO taxonomy are as follows (Table 1).

Applying the SOLO Taxonomy in Health Education

Here are a few examples of applying the SOLO taxonomy in medicine:

1) Assessing learner performance

A study used the SOLO taxonomy to assess the performance of medical students in a problem-based

learning course. The authors found that the SOLO taxonomy was useful for evaluating student performance and identifying areas for improvement in the course.[12]

2) Evaluating clinical reasoning

In a study, the SOLO taxonomy was used to evaluate the clinical reasoning abilities of dental students. The authors found that the SOLO taxonomy provided a useful framework for evaluating clinical reasoning and identifying areas for improvement in dental education.[13]

3) Assessing problem-solving skills

A study used the SOLO taxonomy to evaluate the problem-solving skills of veterinary medicine students in a clinical reasoning course. The authors found that the SOLO taxonomy was a useful tool for assessing problem-solving skills and identifying areas for improvement in the course.[14]

Applying the SOLO Taxonomy for Self-Assessment

The SOLO taxonomy can be used for self-assessment in learning. Learners can use the SOLO levels as a guide to assess their own understanding and progress towards achieving learning objectives. They can reflect on their own learning and evaluate the depth of their understanding by asking themselves questions such as "What level of understanding have I achieved?", "What are the strengths and weaknesses of my understanding at this level?", "What do I need to do to improve my understanding to the next level?" By doing this, learners can identify gaps in their knowledge and understanding and develop strategies to improve their learning.

Table 1. Levels of SOLO Taxonomy

Level 1: Prestructural
• Learners have no understanding of the topic being learned. • They may not have any relevant knowledge or experience that would enable them to answer a question or complete a task related to the topic.
Level 2: Unistructural
• Learners have some basic knowledge or understanding of the topic. • They may be able to recall a fact or identify a single element related to the topic, but their understanding is limited to one aspect of the topic.
Level 3: Multistructural
• Learners have a broader understanding of the topic. • They may be able to recognize multiple aspects of the topic and can organize them into a simple structure or framework. • However, they may not be able to make connections between the different aspects or explain how they are related.
Level 4: Relational
• Learners have a more sophisticated understanding of the topic. • They can make connections between the different aspects of the topic and can explain how they are related. • They can organize the information into a complex structure or framework that demonstrates a deep understanding of the topic.
Level 5: Extended Abstract
• Learners have the ability to apply their understanding of the topic in new and novel ways. • They can synthesize information and create new connections that go beyond the original content. • They can analyze, evaluate, and create new ideas related to the topic.

Self-assessment using the SOLO taxonomy can be particularly useful in promoting metacognition, as it encourages students to reflect on their own learning process, take ownership of their learning, and develop a deeper understanding of the subject matter. It has been found to be effective in improving students' performance and self-awareness in various educational settings.[15, 16]

Training Medical Teachers in Medical Education Using the SOLO Taxonomy

In the training of medical teachers, participants are presented with a question related to any field in medical education and are instructed to provide their answers in writing. The levels of understanding, namely level 1: prestructural, level 2: unistructural, level 3: multistructural, level 4: relational, and level 5: extended abstract, can be defined as "poo", "acceptable", "average", "very good", and "outstanding", respectively, along with detailed definitions. Once the participants have completed the task, an example of answers for each level of understanding can be provided through different channels such as a QR code and a paper sheet for self-evaluation. The medical educator can employ the SOLO taxonomy to conduct a qualitative analysis of the level of understanding of participants. Objectives and outcomes of the training can be specified based on the specific goals of the training program such as online self-assessment for continuous medical education (CME) of medical teachers, or evaluation of a medical teacher's knowledge for certification purposes.

In this review, the author constructed two questions in the field of medical education and provided examples of answers related to each level of understanding in the SOLO taxonomy (Tables 2 and 3).

Table 2. Example Responses to the Question "Why is Student Assessment Important to Medical Teachers?"

Level	Category	Response Level	Response Example
1	Poor	Pre-structural	"Student assessment is important to medical teachers because it helps them evaluate students' knowledge and understanding of the subject matter."
2	Acceptable	Unistructural	"Student assessment is important to medical teachers because it helps them to evaluate the students' understanding of the subject matter and identify areas that need improvement. By assessing students regularly, teachers can tailor their teaching methods to meet the needs of individual students and provide them with appropriate feedback. Additionally, student assessment plays a crucial role in determining whether a student has met the necessary standards to progress to the next level of study or to become a qualified healthcare professional."
3	Average	Multistructural	"Student assessment is crucial for medical teachers to evaluate their teaching methods, identify gaps in knowledge and skills, and provide feedback to students. It helps teachers determine whether the students have achieved the expected learning outcomes and to adjust their teaching strategies accordingly. In addition, student assessment is important for measuring the effectiveness of the curriculum and to maintain academic standards. It also encourages students to be more engaged and accountable for their learning and to strive for improvement."
4	Very good	Relational	"Student assessment is important to medical teachers as it helps to evaluate the effectiveness of their teaching methods and curriculum. By using a variety of assessment tools, such as written exams, practical assessments, and clinical evaluations, teachers can identify areas where students may be struggling and

Table 2. Example Responses to the Question "Why is Student Assessment Important to Medical Teachers?" (Continued)

Level	Category	Response Level	Response Example
			adjust their teaching accordingly. Additionally, student assessment provides feedback to both students and teachers, allowing them to identify strengths and weaknesses in their performance and work towards improvement. Assessment also helps to ensure that students are meeting the necessary learning objectives and developing the skills needed for their future careers in medicine. Ultimately, effective student assessment plays a critical role in ensuring the success of medical students and the quality of healthcare delivery."
5	Outstanding	Extended abstract	"Medical teachers must continually evaluate students to ensure that they are developing the necessary competencies and knowledge to become effective healthcare providers. Student assessment is important because it provides feedback to both the student and the teacher on areas that need improvement, strengths that should be further developed, and potential gaps in the curriculum. Assessments can also help to identify areas where modifications to teaching methods and materials may be necessary. In addition, student assessments are essential for ensuring that the overall quality of the medical education program is maintained and meets accreditation requirements. Effective student assessment methods can also contribute to the improvement of patient care by ensuring that medical students are adequately trained and prepared to provide high-quality care."

Table 3. Example Responses to the Question "Why is the Programmatic Assessment Important for Medical Schools?"

Level	Category	Response Level	Response Example
1	Poor	Pre-structural	"Programmatic assessment helps to improve the quality of medical education."
2	Acceptable	Unistructural	"The programmatic assessment is important for medical schools because it enables ongoing evaluation and feedback to improve the learning process and ensure students achieve the expected outcomes."
3	Average	Multistructural	"Programmatic assessment is important for medical schools because it allows for a comprehensive evaluation of students' learning throughout their entire medical education. This type of assessment can help identify strengths and weaknesses in the curriculum and teaching methods, which can be used to improve the quality of education. Additionally, programmatic assessment promotes longitudinal assessment, which can lead to a more holistic understanding of a student's progress and competency. Overall, programmatic assessment can improve the validity, reliability, and fairness of student assessment in medical education."
4	Very good	Relational	"The programmatic assessment is important for medical schools because it allows for a more comprehensive evaluation of a student's progress and competence. It provides ongoing feedback and allows for early identification of

Table 3. Example Responses to the Question "Why is the Programmatic Assessment Important for Medical Schools?" (Continued)

Level	Category	Response Level	Response Example
			areas where the student may need additional support or guidance. Additionally, programmatic assessment helps to ensure that students are achieving the desired learning outcomes and that the curriculum is meeting the needs of both the students and the profession. Finally, it allows for the continuous improvement of the educational program and its assessment methods, as data and feedback can be analyzed and used to make changes and improvements over time."
5	Outstanding	Extended abstract	"One example of a programmatic assessment plan that ensures continuous improvement of medical education in a medical school setting is to establish a competency-based curriculum that identifies and measures the knowledge, skills, and attitudes necessary for the practice of medicine. This curriculum can be supported by a variety of assessment methods, including written and oral examinations, clinical performance evaluations, and portfolios. The data collected from these assessments can be used to identify areas of strength and weakness in the curriculum and inform improvements and modifications. Additionally, the assessment plan should include regular faculty development sessions to ensure that faculty are trained and supported in the use of the assessment methods and that they have the necessary skills to provide feedback and guide students towards achieving their learning objectives. Finally, the plan should involve ongoing review and evaluation by stakeholders, including students, faculty, and administrators, to ensure that the program remains responsive to changing needs and contexts."

How to Rate the Responses to a Question With Regard to the SOLO Taxonomy?

To rate a response using the SOLO taxonomy, medical educators should consider the complexity of the response and the level of understanding demonstrated by the learner. The following steps can be followed:

1) *Identify the learning outcomes*: This involves identifying the expected level of knowledge, understanding, or skills that the learner should have attained from the instruction.

2) *Determine the rubric*: Use a rubric or scoring guide that outlines the criteria for each level of the SOLO taxonomy.

3) *Evaluate the response*: Evaluate the response and determine which level of the SOLO taxonomy it falls into based on the rubric. Consider the depth of knowledge demonstrated and the extent to which the learner has shown an understanding of the subject matter.

4) *Provide feedback*: Based on the evaluation, provide feedback to the learner on areas of strength and areas that need improvement. This feedback can help the learner improve their understanding and demonstrate higher levels of the SOLO taxonomy in future responses.

5) *Repeat the process*: Use the same rubric and evaluation process consistently to ensure fairness and accuracy in grading.

Overall, the SOLO taxonomy provides a framework for assessing the quality of learner responses and their level of understanding in a particular topic.

Advantages of the SOLO Taxonomy

The SOLO taxonomy has been widely used in educational research and assessment. The following are some of its advantages:

1) *Clarity and ease of use*: SOLO is a simple and straightforward taxonomy that can be easily understood and used by teachers and students.[17]

2) *Assessment for learning*: SOLO provides a clear framework for assessing students' learning outcomes, which can be used to improve their future performance.[18]

3) *Flexibility*: SOLO can be applied to a wide range of subject areas and learning contexts, making it a versatile tool for educational research and assessment.[19]

4) *Encourages higher-order thinking*: SOLO encourages students to move beyond simple recall of information and to engage in higher-order thinking processes, such as analysis, synthesis, and evaluation.[20]

5) *Reliable and valid*: Studies have shown that SOLO is a reliable and valid tool for assessing students' learning outcomes.[21, 22]

Published data on the beneficial outcomes of using the SOLO taxonomy in medical teacher development is limited. Indirect data suggests that its utilization enables medical educators to design learning experiences that are tailored to each medical teacher's current level of understanding, and facilitate their progression towards higher levels of knowledge. Previous study has showed that this intervention results in enhancements in self-evaluation,[15] which may help improve the quality of training for medical teachers and promote a deep approach to their CME in the medical education field. The shared understanding of learning levels provided by the SOLO taxonomy may help promote peer learning and collaboration, as medical teachers can effectively communicate and support each other's progress.

Limitations of the SOLO Taxonomy

One limitation of the SOLO taxonomy is that it may oversimplify the cognitive process, reducing it to a linear progression from simple to complex thinking.[23] Another limitation is that the SOLO taxonomy may not be universally applicable to all subject areas, as it was originally developed for use in evaluating learning outcomes in science education.[24] Additionally, there may be a lack of consensus among educators on the appropriate level of abstraction for each learning outcome, leading to inconsistencies in assessment.[25]

To mitigate the limitations of the SOLO taxonomy, educators may consider alternative approaches. These include integrating it with other learning taxonomies such as Bloom's taxonomy or Webb's Depth of Knowledge, breaking down the existing levels into more specific sub-levels, introducing additional levels to address specific types of learning, and providing clearer descriptors for each level of the SOLO taxonomy to ensure consistent interpretation and application.

Current Status of the SOLO Taxonomy

The SOLO taxonomy is still widely used in various fields, including education and medicine, for assessing and evaluating learning outcomes. However, some scholars have also pointed out the need for further refinement and development of the taxonomy to make it more applicable and effective in modern learning environments.[26, 27] Some studies have also explored the use of the SOLO taxonomy in combination with other assessment tools, such as rubrics and feedback, to enhance its effectiveness.[28, 29] Overall, the SOLO taxonomy remains a valuable framework for assessing and promoting deep learning and understanding.

Comparison of the SOLO Taxonomy With Other Learning Taxonomies

The SOLO taxonomy, Bloom's taxonomy, and Webb's depth of knowledge are all frameworks used in education to classify levels of learning and cognitive complexity. While there are similarities among these frameworks in terms of assessing cognitive complexity

and promoting higher-order thinking, they differ in their approach, structure, and scope. Medical educators can choose the framework that best aligns with their training goals and objectives. Additionally, the frameworks can complement each other, with the SOLO Taxonomy and Bloom's Taxonomy providing a broader understanding of learning outcomes, while Webb's depth of knowledge focusing on the complexity of tasks.[27]

Perspective of Medical Teacher Training Using the SOLO Taxonomy

The SOLO taxonomy can be a useful tool in the training of medical teachers as it provides a framework for understanding the levels of learning and can guide the design of effective training and assessment strategies. By using the SOLO taxonomy, medical educators can develop a better understanding of how medical teachers learn and can use this understanding to design training activities that promote higher levels of thinking and understanding.

Additionally, the SOLO taxonomy can be used to evaluate and improve the effectiveness of training strategies, as well as to provide targeted feedback to medical teachers. As such, the use of the SOLO taxonomy in the training of medical teachers has the potential to improve the quality of medical education and enhance the learning outcomes of students.

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การนำอนุกรมวิธาน SOLO ไปใช้ในการฝึกอบรมอาจารย์แพทย์ในด้านแพทยศาสตรศึกษา

เพิ่มพันธุ์ ธรรมสโรช

สถาบันการแพทย์จักรีนฤบดินทร์ คณะแพทยศาสตร์โรงพยาบาลรามาธิบดี มหาวิทยาลัยมหิดล สมุทรปราการ ประเทศไทย

อาจารย์แพทย์จำเป็นต้องได้รับการฝึกอบรมด้านการแพทย์เพื่อพัฒนาทักษะการสอน วิธีการสอนที่ทันสมัย และส่งเสริมการเรียนรู้ที่เน้นผู้เรียนเป็นสำคัญ มีหลายวิธีในการฝึกอบรมอาจารย์แพทย์ในด้านแพทยศาสตรศึกษา อนุกรมวิธาน SOLO (Structure of the Observed Learning Outcome) สามารถนำมาใช้ในการฝึกอบรมอาจารย์แพทย์ โดยอนุกรมวิธาน SOLO มี 5 ระดับ เพื่อใช้สำหรับประเมินความเข้าใจเชิงลึกและความซับซ้อนของการตอบคำถามของผู้เรียน ในบทความนี้ผู้เขียนสร้างคำถาม 2 ข้อ ที่เกี่ยวกับแพทยศาสตรศึกษาและให้ตัวอย่างคำตอบที่สัมพันธ์กับระดับความเข้าใจแต่ละระดับในอนุกรมวิธาน SOLO นักการศึกษาทางการแพทย์สามารถใช้อนุกรมวิธาน SOLO เพื่อดำเนินการวิเคราะห์เชิงคุณภาพของระดับความเข้าใจของอาจารย์แพทย์ และสามารถใช้ความเข้าใจนี้ออกแบบกิจกรรมการฝึกอบรมที่ส่งเสริมระดับความคิดและความเข้าใจที่สูงขึ้น นอกจากนี้ยังสามารถใช้อนุกรมวิธาน SOLO เพื่อนำมาปรับปรุงประสิทธิภาพการฝึกอบรม รวมทั้งให้ข้อเสนอแนะที่ตรงเป้าแก่อาจารย์แพทย์

คำสำคัญ: อนุกรมวิธาน SOLO อาจารย์แพทย์ แพทยศาสตรศึกษา การพัฒนาคณาจารย์

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