Comparison of Case-Based and Lecture-Based Learning in Dental Education Using the SOLO Taxonomy

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Abstract: The aim of this study was to compare the impact of case-based learning (CBL) and lecture-based learning (LBL) on fourth-year dental students' clinical decision making by using the Structure of Observed Learning Outcome (SOLO) taxonomy. Participants in the study were fourth-year dental students (n=55) in academic year 2012-13 taught in a large-group LBL context and fourth-year dental students (n=54) in academic year 2013-14 taught with the CBL methodology; both took place in the oral diseases course at Yeditepe University Faculty of Dentistry, Istanbul, Turkey. All eligible students participated, for a 100 percent response rate. A real case was presented to the students in both groups to assess their clinical decision making on the topic of oral diseases. Their performance was evaluated with the SOLO taxonomy. Student t-test was used for statistical evaluation, and significance was set at the $p<0.05$ level. A statistically significant difference was found between the mean scores of the relational and extended abstract categories of the CBL and LBL groups ($p<0.05$). Students who were taught with CBL had higher scores at the top two levels of the SOLO taxonomy than students taught with LBL. These findings suggest that an integrated case-based curriculum may be effective in promoting students' deep learning and it holds promise for better integration of clinical cases likely to be encountered during independent practice.

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Case-based learning (CBL) is a teaching and learning methodology that aims to prepare students for clinical practice through the use of real clinical cases. These cases link theory to practice and encourage the use of inquiry-based learning methods. CBL encourages learning through students' application of knowledge to clinical cases, enhancing the relevance of their learning and promoting their understanding of concepts.[1] CBL promotes student learning by focusing attention on a presented scenario and requiring students to develop resolutions, thereby developing their thinking skills and creative abilities. CBL aids in the development of reflective thinking and deeper conceptual understanding[2] and supports a deep learning approach, with active and meaningful learning.[3-6]

Biggs[7] noted that, to maximize learning, all parts of the learning environment—curriculum, assessment, and outcomes—should be in alignment. These principles of constructive alignment can be used when constructing and analyzing a learning environment that encourages students to adopt a deep approach to learning. The Structure of Observed Learning Outcome (SOLO) taxonomy, developed by Biggs and Collis,[8] is a way of evaluating students' responses and performance in assessment and thereby of evaluating the quality of learning. The SOLO taxonomy has a hierarchical structure in which the complexity of knowledge increases in direct proportion to student learning.[9]

The SOLO taxonomy categorizes observed learning outcomes as prestructural, unistructural, multistructural, relational, and extended abstract, based on the complexity of the underlying cognitive skills. At the prestructural level, the answer misses the point. At the unistructural level, the answer shows one string of relevant details. At the multistructural level, the answer contains several strings of details that are unrelated to each other. At the relational level, the answer shows how the different strings of details relate to each other, and the relevant aspects are integrated into a coherent overall structure. The

final level is the extended abstract, in which the answer shows that the construction of knowledge and the coherent whole are generalized to a higher level of abstraction.[8] This deep approach to learning is a prerequisite for reaching higher levels of complexity. If students are to construct knowledge with increasing complexity, the ability to reflect on one's learning is essential. Boulton-Lewis and Lucander et al. suggest that students need to learn more about their own learning, acquiring a meta-perspective, to become independent self-directed learners.[10,11]

We chose the SOLO taxonomy for this study for the following reasons. The claim that the SOLO taxonomy replicates the stages of development of competence in the cognitive domain has been validated by empirical data in higher education.[12] Also, the taxonomy can be used for formulating intended learning outcomes,[13] for specifying teaching objectives to enable attainment of these outcomes,[13-15] and for assessing learning.[12,16-18] Therefore, the SOLO taxonomy is an effective means to analyze the real quality of learning.

Innovative evaluation strategies can have an important effect on learning.[19] Recently, a case-based curriculum was designed for the undergraduate program of Yeditepe University Faculty of Dentistry, Istanbul, Turkey, instead of lecture-based learning (LBL). The new curriculum is designed to enable students to develop clinical skills. CBL was applied in modified form to improve the ways in which dental students approach their learning and studying. In this curricular context, students participate in small groups with real patients in the oral diseases clinic.[7] Also, questions of the CBL type comprise at least 30 percent of both formative and summative assessments in the undergraduate program.

To assess the quality of the education students receive, different strategies need to be compared. Therefore, it is essential to measure the outcome of the CBL methodology that has been recently implemented. The aim of this study was to compare CBL with LBL in terms of its impact on fourth-year dental students' clinical decision making on oral diseases by using the SOLO taxonomy.

Materials and Methods

The study received formal review and approval by the Institutional Review Board of the Yeditepe University Faculty of Dentistry (019/2012). Fourth-year undergraduate dental students (n=55) from academic year 2012-13 were taught with LBL, and fourth-year undergraduate dental students (n=54) from academic year 2013-14 were taught with CBL.

The students in the LBL group were taught in a conference manner in the classroom, using lectures addressing various oral disease topics. This course was designed to teach the etiology, pathophysiology, clinical signs, diagnosis, differential diagnosis, and treatment of disease conditions that affect the oral mucosa. For the CBL group, all students were divided into groups of eight students each. Most of the course time was devoted to discussion of clinical cases in oral diseases, based on identification of patient problems, development of differential diagnosis, the definitive diagnosis, and management. No formal lectures were planned for this portion of the course. A short introduction to each problem presented the patient's history, physical examination findings, and laboratory test results and asked the students to develop a list of clinical findings, a list of differential diagnoses for each problem, an initial diagnosis based on intersecting differential diagnoses, and a list of additional diagnostic tests or treatments. After this, the case was summarized, and the instructor posed additional questions as necessary to ensure complete coverage of the problem and the pathophysiology and other learning objectives underlying the case.

Students from the two groups took the same examination at the end of the course. Their performance on this examination was evaluated with SOLO taxonomy. The difficulty level of each question was determined based on the SOLO taxonomy's five categories, from less to more complex: prestructural (A), unistructural (B), multistructural (C), relational (D), and extended abstract (E) (Figure 1). The students' scores on the exam did not have any impact on their overall performance in the course because it was conducted with an experimental design. Before the exam, the lecturer in charge provided information to both groups about how the responses would be scored at each level.

A real case was presented to the students in both groups to assess their clinical decision making on the topic of oral diseases. Pictures of the case were viewed in a darkened classroom as a slide show (Figure 2). Students were given the history, physical examination findings, blood test, and histopathological results of biopsy of the case and were asked to answer the questions according to SOLO. The case concerned a forty-nine-year-old female patient referred to our clinic with the chief complaint of a pain/burning sensation of the buccal

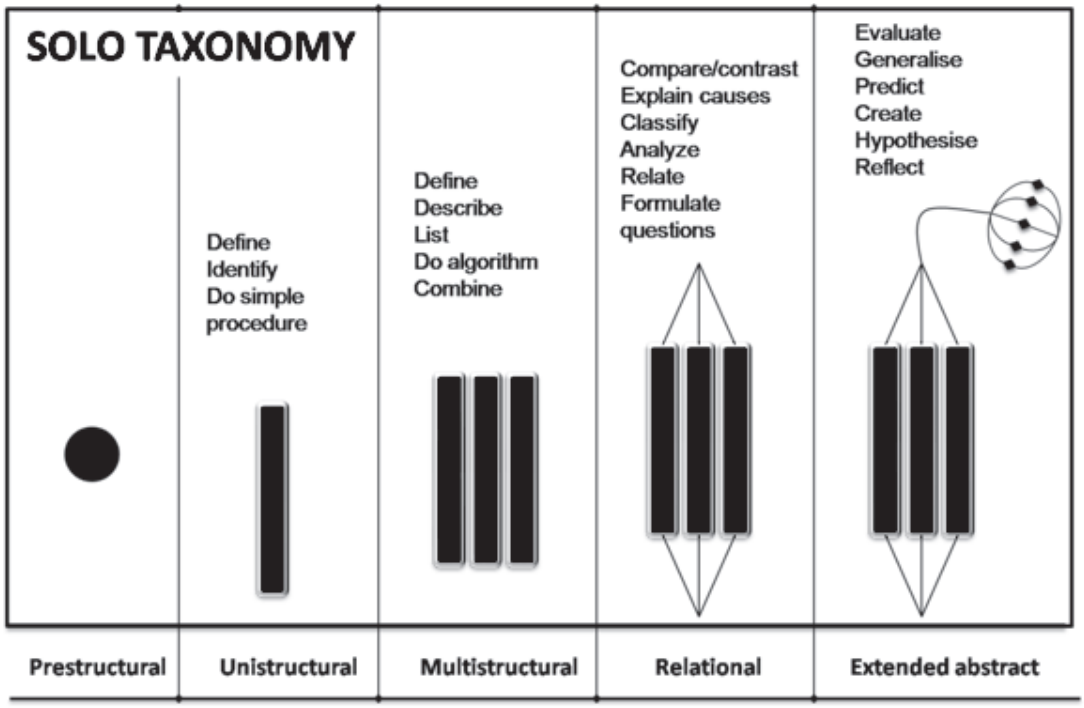

Figure 1. Subgroups of the SOLO taxonomy

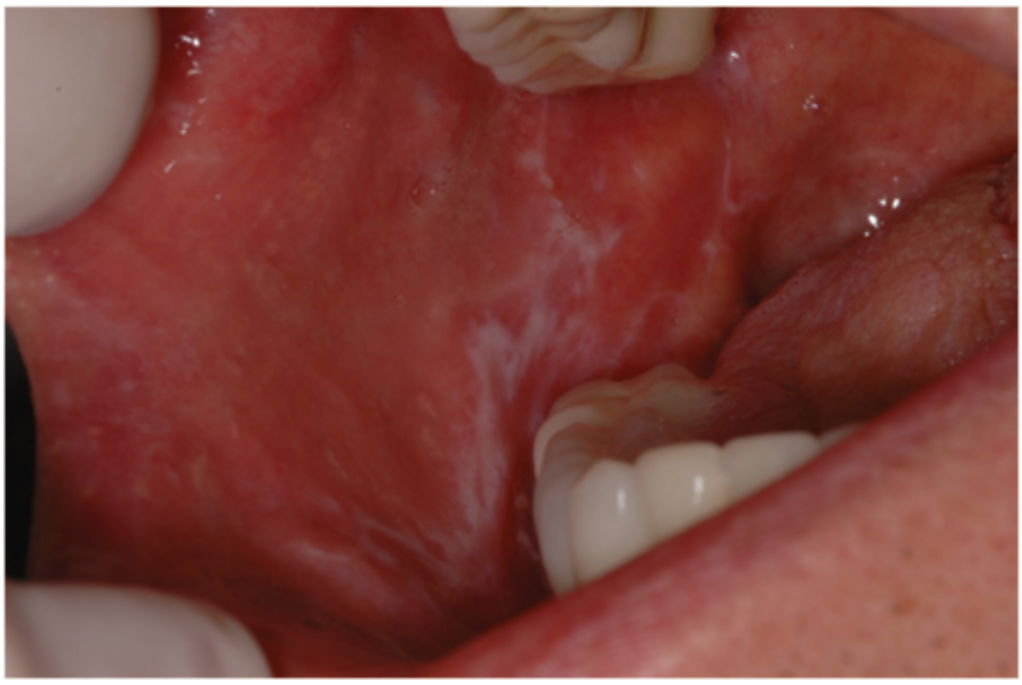

Figure 2. Clinical view of the case

mucosa, especially while eating nuts and eggplant. She had Type II diabetes and was taking Gliclazide 30 mg per a day (Diamicron 30 mg tablet, Servier). She had previously presented to other dentists with the same complaint. Her pain score (VAS) was 7. She had been administered Amoxicillin clavulanic acid 2000 mg per day (Klamoks BID 1000 mg tablet, Bilim), Acyclovir 600 mg per day (Asiviral 200 mg tablet, Terra), and Dexpanthenol cream twice a day (Bepanthene 5 percent, Bayer) to relieve her symptoms. However, this medication was not beneficial. She had been using a multi B vitamin plus C vitamin tablet per day (Becozyme C forte tablet, Bayer) for six months, and there was no alleviation in pain symptoms. In the intraoral examination, a unilateral white lesion surrounded by an erythematous area on the right buccal mucosa was observed, so a biopsy specimen was taken from this region. The report of the biopsy showed hyperkeratosis and paraceratosis. Subepithelial edema and band-shaped lymphocyte infiltration were also observed. Additionally, Civatte bodies were detected. Table 1 shows the laboratory test results. Although the students were allowed access to all blood test results for the patient, they were asked to make comments only on those specifically related to her condition.

The medical and dental history of the case, a clinical intraoral view, the medications the patient used, some laboratory test results, and the report of the biopsy were presented to the students as photos on an exam sheet. An answer sheet, arranged according to the SOLO categories, was given to each student (Table 2). Students were given fifty minutes to complete the test. At the end of the slide show, a quick review was allowed for the slides they wanted to see again. One marking protocol was used for each student's response. An answer key was prepared for each question. The scores for all SOLO categories (A:5, B:15, C:20, D:25, E:35) were calculated, and each score was converted into values out of a hundred to facilitate statistical analysis and enable comparison. All responses were evaluated by the same lecturer. The data were analyzed using the Statistical Package for Social Sciences (SPSS) 15 software for Windows. Quantitative data were evaluated using t-tests in order to compare the two groups. Significance was set at $p<0.05$.

Results

All eligible students participated, for a 100 percent response rate. Table 3 shows the mean values of SOLO categories according to teaching methods. A statistically significant difference was found between the means of the D and E categories of the CBL and LBL groups ($p<0.05$). Students who were taught with CBL methodology had the highest

Table 1. Laboratory test results for patient: students were requested to comment only on results related to case

Test	Value	Unit	Reference Range
Fasting Blood Sugar (FBS)	85	mg/dl	65-110
Total Cholesterol (TC)	245*	mg/dl	123-200
Triglyceride (TG)	55	mg/dl	50-170
High-Density Lipoprotein (HDL)	107	mg/dl	>65.0 (high risk)
		mg/dl	45.0-65.0 (standard risk)
		mg/dl	<45.0 (low risk)
Low-Density Lipoprotein (LDL)	127	mg/dl	<150.0
Aspartate Transaminase (AST)	20	U/l	0-46.0
Alanin Aminotransaminaz (ALT)	14	U/l	0-46.0
Iron (Fe)	93	µg/dl	37.0-145.0
Iron Binding Capacity	356	µg/dl	250.0-420.0
Triiodothyronine (T3) TOTAL	1.5	nmol/L	1.20-2.80 (adult)
Thyroxine (T4) TOTAL	129.0	nmol/L	60.0-160.0 (adult)
Thyroid Stimulating Hormone (TSH) 3	4.05*	µIU/ml	0.4-4.0 (adult)
Generation	221	pg/ml	200-970
Vitamin B12	6.89	ng/ml	3.0-17.0
Folic Acid	NEGATIVE		NEGATIVE (<1.0)
HBsAg	NEGATIVE		NEGATIVE (<1.0)
Anti HCV			

*Value higher than the reference range.

Table 2. SOLO categories and questions used for oral lichen planus

SOLO Category	Structured Questions
Prestructural (A)	Describe the clinical appearance of the lesion.
Unistructural (B)	What is your pre-diagnosis? Explain.
Multistructural (C)	Write the etiology of the lesion. Which laboratory tests do you want? (Select the proper ones from the list.) What are your selection reasons?
Relational (D)	Write your opinion about the results of the tests you selected. What is your decision according to the biopsy report and precise diagnosis? Please outline your treatment plan.
Extended abstract (E)	Write a synthesis about the relationship among systemic diseases. Evaluate the medication the patient used related to your diagnosis. Predict the prognosis, and evaluate a consultation necessity.

Table 3. Mean values of SOLO categories according to teaching methods

SOLO Category	LBL (n=55) Mean±SD	CBL (n=54) Mean±SD	p-value
Prestructural (A)	92.00±13.90	96.27±15.45	0.137
Unistructural (B)	71.00±21.89	73.71±19.33	0.503
Multistructural (C)	66.82±32.63	73.92±27.15	0.228
Relational (D)	65.53±32.18	78.67±20.90	0.014*
Extended abstract (E)	51.25±32.28	64.04±25.74	0.026*

*Significant at $p<0.05$ (Student t test)
LBL=lecture-based learning; CBL=case-based learning

scores at the final two levels of the SOLO taxonomy compared to students taught with the LBL methodology. While the prestructural (A) category had the highest mean values with scores of 92.00±13.90 (LBL) and 96.27±15.45 (CBL), the extended abstract (E) had the lowest scores of 51.25±32.28 (LBL) and 64.04±25.74 (CBL).

Discussion

Evaluation of the quality of education provided in dental schools requires assessment of existing curricula. In the dental school where the study was conducted, one of the learning outcomes of the oral pathology and medicine course is "Recognizing the etiology and pathological processes of oral diseases in order to facilitate their prevention, diagnosis, and management." Evaluating learning outcomes and retention of information is an important part of education and directly affects the ability of the graduating dentist.[8] With regard to oral diseases, there are standards expected of a dental student on graduation. The competencies required of the graduating European dentist also state that a dentist must have knowledge of the etiology and pathological processes of oral diseases in order to facilitate their prevention, diagnosis, and management.[20]

The SOLO taxonomy is based on evaluation of learning outcomes. Lucander et al.[11] reported that it was a useful tool for developing and assessing deep learning in dentistry. In our study, the use of the SOLO taxonomy to analyze students' learning regarding oral diseases showed that the D and E categories of the CBL group were higher than in the LBL group. Chan et al.[5] reported that CBL improved communication through group discussion. This suggests that a case-based approach, which is learner-centered and involves intense interaction among participants, may be more effective in preparing students for deep learning than a lecture-based approach.

In our study, although the deep learning level (extended abstract) scores were sufficient, high scores were not obtained in either group. While this might be different from expected, it emphasizes that the question presented in this category was challeng-

ing. Although the score of the extended abstract was relatively low compared to other categories, it was still at an acceptable level (51.25 and 64.04). It should also be noted that this was the first time in the students' education that they were subjected to such an assessment methodology, so their inexperience with it may have had an impact on the results. Repetitions of this type of assessment at regular intervals may help to improve the overall success rate in the last two categories. The evaluation criteria should include deep learning for dental students to become deeper learners.[11]

The advantages of the case-based method are promotion of self-directed learning, clinical reasoning, clinical problem-solving, and decision making by providing repeated experiences in class and by enabling students to focus on the complexity of clinical care.[21] CBL facilitates the development of reflective thinking and deeper understanding, helps learners to focus on a case, and encourages a structured approach to problem-solving.[2,22] The clinical intraoral view of the patient in this case did not represent the characteristic lesions of oral lichen planus. The appearance of this lesion looked rather like leukoplakia patches, whereas the characteristic view of lichen planus lesion is generally bilateral and Wickham's striae can be detected easily. This case was selected to encourage the students' critical thinking abilities. The medication the patient used, the laboratory test results, and report of the biopsy were presented to the students visually with photos to improve their judgment abilities.

Case-based studies may be more helpful for students than lectures, and group learning activities should be considered a means of delivery of information. Students enjoy CBL and think that it helps them learn better.[1] Deeper learning is essential for the retention of information. More effort should be spent to support a deep approach to learning in dental schools with traditional educational strategies, and changes should be made in the style of the curriculum. Strategies must be developed to integrate this approach into the curriculum. In our dental school, the educational committee meets once a week to improve the curriculum and to ensure its compatibility with universal standards. Based on the results of this study, introducing CBL strategies may have helped students retain what they learned.

Some limitations of the study design should be noted. The study group consisted of a small number of students, all of whom were enrolled in a single dental school, so its results may not be applicable elsewhere. Although the students had some common characteristics, there may have been some variations in their educational background, which may have influenced their approach to the methodologies used. Furthermore, slight differences between the groups tested in 2012-13 and 2013-14 might have introduced some variations, such as initial knowledge level, although the course content was not altered.

Conclusion

This study suggests that the integrated case-based curriculum may have been effective in promoting deep learning among students, and it holds promise for better integration of clinical cases likely to be encountered during independent practice. However, this study was limited to only one topic and one group of individuals and needs to be supported by future research.

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