Teaching by concordance: Individual Versus Team-Based Performance

Short title: Teaching by concordance

Abstract

Clinical competence is multi-dimensional and must be acquired by all medical students. Accordingly, a prospective quasi-experimental study was conducted to evaluate the merging of script concordance testing (SCT) and team-based learning (TBL) as a teaching/learning approach for medical students in clinical settings. The study comprised three phases: Phase 1 (preparatory phase) involved students' preparation and preparation of the SCT. In Phase 2 (implementation phase), the individual and team SCT (iSCT and tSCT, respectively) were applied. In Phase 3 (evaluation phase), the score results were compared, and students' feedback was obtained. The SCT/TBL approach improved the clinical reasoning skills of the students in some vignettes, and the tSCT helped those achieving lower marks improve their performance. The approach supported discussions and helped students correct their mistakes and improve their problem-solving and reasoning skills. The SCT/TBL approach improved students' performance, especially that of those achieving lower marks.

Keywords: Script concordance testing; team-based learning; clinical reasoning; instructional approach

Introduction

Medical educators face major challenges in teaching clinical competence. First, clinical competence is a multi-dimensional, complex construct, representing the ability of a professional to use clinical judgment and reasoning skills, an ability that must be acquired by all medical professionals (Loughlin et al., 2017). Second, the problems encountered during professional practice do not always have straightforward algorithmic solutions but require judgment and insight that cannot be taught or measured by conventional tools (Bernard Charlin et al., 2017). However, most students learn clinical reasoning skills informally in clinical rotations with varying degrees of supervision. In addition, the ever-increasing class size and associated high student-to-faculty ratio in medical education have led to the need for innovative ways to promote student engagement and facilitate learning.

Script concordance testing (SCT) is a reliable and valid pedagogical tool. It can discriminate the levels of practice between medical students, residents, and medical doctors and can effectively evaluate the development of skills in clinical reasoning (B Charlin et al., 1998; Lee et al., 2010). SCT can be administered online in multicentric centers at a national or international level (Karila et al., 2018). It allows testing based on real-life situations that are not adequately measured with current tests through probing multiple judgments in the clinical reasoning process. Scoring reflects the degree of concordance of these judgments with those of a panel of reference experts (Fournier et al., 2008). SCT is based on script theory (B Charlin et al., 2000). Script theory posits higher-level thinking skills originate from cognitive scripts, knowledge, and previous experience (Schank RC & Abelson R, 1977). The test is case based. Cases, described as short vignette, always incorporate uncertainty. A clinical vignette is an abridged report of a patient summarizing any relevant history, physical examination findings, investigations data and treatment. Several options are relevant to solve the diagnostic or management problem posed by the situation. A case, with its related questions, constitutes an

item. Vignette are followed by a series of questions, presented in three parts. The first part ("if you were thinking of") contains a relevant diagnostic or management option. The second part ("and then you were to find") presents a new clinical finding, such as a physical sign, a pre-existing condition, an imaging study, or a laboratory test result. The third part ("this option would become") is a five-point Likert scale that captures examinees' decisions. The task for examinees is to decide what effect the new finding has on the status of the option, in direction (positive, negative, or neutral) and intensity. This effect is captured with a Likert scale because script theory assumes that clinical reasoning is composed of a series of qualitative judgments (Bernard Charlin et al., 2007).

Script concordance tests have been employed in several medical specialties, including urology, otorhinolaryngology, surgery, neurology, pediatrics, and radiology as well as in other health sciences, including dentistry, pharmacy, optometry, veterinary medicine, and nursing. However, no published studies have developed and validated a script concordance test for the field of ophthalmology (Atayee et al., 2018; Faucher et al., 2016; Tedesco-Schneck M, 2018).

Team-based learning (TBL) is a form of cooperative learning that allows learners to achieve higher levels of learning (i.e., application, analysis, evaluation, and creativity). It is a structured form of small-group learning that emphasizes student preparation out of class and the application of knowledge in class (Haque & Majumder, 2017). Team-based learning (TBL) provides an active, structured form of small group learning, that can be applied to large classes. Student accountability is achieved through the specific steps of TBL, including pre-class preparation, readiness assurance testing, problem-solving activities, and immediate feedback. Globally, a growing number of healthcare faculties have adopted TBL in a variety of combinations, across diverse settings and content areas (Burgess et al., 2020). TBL has been reported to improve student performance and increase student engagement and satisfaction. The same research also recommended TBL should be considered as a method of instruction in medical education (Chung et al., 2009). Another study demonstrated that TBL can be an

effective active learning approach, especially among low academic performers (Koles et al., 2005). TBL also builds collaborative teamwork skills during group sessions (Hrynchak & Batty, 2012).

Accordingly, it seems that TBL and SCT are compatible in that they are both student-centered and based on constructivist learning theory and both support active learning by helping students to develop their mental scripts, which helps students develop clinical reasoning skills. Moreover, this approach could have general application to healthcare professional education, SCT was used to assess ethics (Pau et al., 2019).

The purpose of this study is to evaluate the merging of the script concordance test method with the TBL approach as a teaching/learning strategy for medical students during their clinical clerkship. The study asks three research questions:

1. What are the students' perceptions of the merging of the script concordance test approach with the TBL approach as a teaching/learning strategy in a clinical setting?
2. Is there a difference between the students' scores in the individual SCT (iSCT) and the team SCT (tSCT)?
3. Does the use of the script concordance test differentiate the clinical reasoning skills of medical students and experts?

Material & Methods

Study setting

This quasi-experimental study was conducted at the Faculty of Medicine, XXX University.

Study Participants

Reference panel

The reference panel consisted of 10 subject matter experts to ensure score reliability and develop the key score. The experts all had at least six years in practice and were selected

according to their familiarity with the students and the curriculum. They were asked to complete the SCT individually. The experts were approached by the researcher in their workplace.

Students

Fifty-five fifth-year medical students who attended the ophthalmology clerkship during the first term in the academic year 2019–2020 were enrolled in the study. The clerkship is clinical rounds where students learn clinical sciences. Each round lasts for 5-8 weeks according to the speciality.

They were randomly divided into small teams of five students each. The purpose of the study was communicated to the students. All participants participated in the study voluntarily. They had the right to refuse or withdraw from the study at any point without any consequences.

Study intervention

The study comprised three phases: the preparatory, the implementation, and the evaluation phases.

Preparatory phase:

During this stage, the students were prepared for the in-class TBL session, and the script concordance test was developed.

Students' preparation

An announcement about the SCT was made 5 days before the test day. The students were encouraged to review the course objectives and material during this period to be ready for the SCT/TBL session. Students were also informed that the SCT would review the whole course through a new question format.

Script concordance test

a. Structure and format: An ophthalmology version of the SCT was developed based on the core objectives of the fifth-year curriculum in the Faculty of Medicine. The relevance, appropriateness, and quality of the items developed for the SCT were ensured through written

and verbal consultations with both ophthalmologists and medical education experts. The final test had 17 items and 57 questions. The vignettes measured students' ability to diagnose common clinical presentations, to identify appropriate laboratory tests for confirmation of diagnoses, choose appropriate treatment or management options, and measure students' understanding of biomedical ethics The test was administered in the English language.

b. Validation: A group of subject matter experts, different from the reference panel, reviewed the SCT for both face and content validity by completing an evaluation form that asked about the vignette, the questions, and the panel reference. Questions were selected according to their relevance to the curriculum, their fairness for the level of the candidate, and their appropriateness and clarity of language.

c. Scoring: For each question, one point was assigned to the answer chosen most often by the members of the reference panel (the modal response). Partial scores were given for other answers, depending on the number of members on the reference panel who chose these answers. An answer not chosen by any reference panel member was given a score of zero.

Implementation phase:

The students were asked to complete the SCT individually within a one-hour time frame. The individual script concordance test (iSCT) reflected the individual readiness assurance test in this session. Following the administration of the iSCT, the student teams were given an additional hour to answer the same set of questions. The team script concordance test (tSCT) represents the team readiness assurance test. Teams were encouraged to engage in discussion to reach a consensus on each question. Following the student teams' completion of the iSCT, the instructor and the students discussed the questions, including analyzing each patient scenario and applying critical thinking to reach a suitable diagnosis and determine clinical features and management plans. The instructor probed students' rationales for answers. Then the instructor announced the most appropriate answer according to the experts. Our TBL

approach was based on Michaelsen's (Michaelsen et al., 2002) description of team-based learning.

Evaluation phase:

Students' scores on the iSCT and tSCT were analyzed and compared. The low achiever students (students who scored less than 20 on the iSCT and achieved a mean score of 0.2-0.3) were identified, and their responses were compared to the responses of their team members. Students' perceptions of their test-taking experience were gathered through an anonymous questionnaire that comprised 28 five-point Likert-type scale items from 1 = strongly disagree to 5 = strongly agree. The items were distributed over three thematic sections: SCT, SCT/TBL, and teamwork.

Results

The SCT consisted of 17 vignettes; 14 of these had three questions, one had four questions, one had five questions, and one had six questions for a total of 57 test items. Cronbach alpha analysis for the 57-item test showed excellent reliability (0.879). Kolmogorov–Smirnov analysis revealed that the results of the SCT were normally distributed as shown in **Figure 1**. Levene's test showed that the variance between the groups was equal ($p = 0.323$, 0.006, 0.192, respectively).

There was a statistically significant difference ($p < 0.05$) between the whole test mean scores of both the students' iSCT and tSCT and the experts' scores. However, there were no statistically significant differences between the individual students' and the student teams' mean test scores ($p > 0.05$). Our results revealed a statistically significant difference ($p < 0.001$) between the mean scores of those achieving lower marks students and the team's mean scores (tSCT).

Most of the clinical vignettes showed a significant difference ($p < 0.05$) between the mean scores of the students and that of the experts except for the third and fifth clinical vignettes. However, non-significant differences existed between the mean scores of the student

teams (tSCT) and the experts on nine vignettes when (see Supplementary file). The scores of those achieving lower marks students showed non-significant differences ($p > 0.05$) in eight vignettes when compared with the scores of their teams (see Supplementary file).

Table 1 presents the results of the questionnaire regarding the students' perceptions of the SCT, the STC/TBL approach, and working in teams, which generally indicate their satisfaction.

Discussion

The main observation of the current study is that the SCT/TBL approach can be appropriate for teaching and training site assessment of clinical practice. TBL and SCT showed a mutually beneficial relationship, in which each method helped the students to benefit from the other's advantages and added new advantages. Using the SCT provided a valid and authentic way of assessing and teaching clinical reasoning. Incorporating the TBL approach gave the SCT an interactive component and fostered active learning, student engagement, teamwork, and collaborative learning.

In the current study, a significant difference existed between the students' and experts' whole test scores and their scores on most of the vignettes. This is because the SCT can differentiate between the different levels of experience. However, when the test was completed in teams, the scores for 9 out of the 17 vignettes showed non-significant differences with the experts' scores on these vignettes. This points to an improvement in students' scores when they worked in teams, although these improvements were statistically non-significant. Thus, the use of this approach as a teaching tool may help to narrow the gap between the clinical reasoning of students and that of experts. The statistical insignificance may be since the students were experiencing the SCT for the first time and were still not familiar with it.

The TBL/SCT exposes students to authentic, uncertain, real-life clinical cases and allows them to evaluate hypotheses, select and discuss one hypothesis, modify wrong concepts, and

identify correct ones. These steps are encouraged by the post-test discussion led by the instructor, who addresses any misconceptions, answers students' questions, and provides immediate, corrective feedback. Moreover, the team SCT provides the opportunity for peer teaching (Parmelee et al., 2012), during which students can share their reasoning, hypotheses, and explanations. All these steps help students develop their own script that, in turn, will guide them to use expert reasoning and foster pattern recognition. The students indicated that both the team discussion and the class discussion following the test helped them correct their mistakes, and both were useful learning activities. Hence, the TBL/SCT approach helped individualize students' learning despite the large class size and can be considered an appropriate approach to teaching clinical reasoning in the context of teaching large classes.

Our results showed significant differences between the individual scores of those achieving lower marks and the scores of the student teams. This indicates that the SCT/TBL approach helped those achieving lower marks to get more involved in the learning process and improve their clinical reasoning skills. However, it is important to bear in mind that the students were familiar with the test. The students have completed the same test individually then in teams. This may have augmented their performance as a team. However, the value is incorporated in building knowledge. This approach provides a holistic perspective to build clinical reasoning in large group through construction of knowledge through multiple sources and steps. Nonetheless, further investigation using two equivalent forms of the test may be warranted.

The interactions that result from the TBL approach provide the SCT with the interactive and dynamic context that is needed to teach clinical reasoning (Schuwirth et al., 2020). The SCT/TBL approach develops students' clinical reasoning through interactions with peers and the instructor. As suggested by (Torre et al., 2020), any approach to teaching and assessing clinical reasoning should raise awareness among educators, enhance their understanding, and promote the implementation of the social–cognitive aspects of clinical reasoning. The

TBL/SCT approach enhances students' capacity to evaluate hypotheses and judge a situation according to new information (Humbert et al., 2011).

According to the students' feedback in our study, the SCT/TBL approach helped them solve patients' clinical problems, think critically, and develop clinical judgment skills. The students benefited from the advantages of both the SCT and TBL as the SCT can effectively assess students' knowledge while focusing on the critical thinking process rather than on the outcome (B Charlin et al., 2000), and the TBL enhances effective active learning approaches, especially among low academic performers (Koles et al., 2005). Additionally, combining SCT and TBL can prepare students for future professional practice. It was found that physicians' tolerance of uncertainty influences their clinical practice, and physicians who are less tolerant of uncertainty are more likely to order excessive diagnostic testing and additional empiric treatment (Cooke & Lemay, 2017).

The current study found that students preferred SCT as a teaching method but not as a summative assessment tool, and this is congruent with the study assumptions. This can be attributed to the nature of the test, which is challenging but at the same time confusing as it is a first-time experience for undergraduate students. However, we believe that practice of clinical reasoning in the educational process will have an impact on their way of thinking and their acceptance of and performance in the SCT. The Likert scale may be sophisticated for their level, and it may be better to use a three-anchor scale for undergraduate students. Fournier (Fournier et al., 2008) stated that if SCT is used as a learning stimulus, it appears that using a three-anchor scale is more effective for the induction of relevant discussion. Another possible explanation is the students' training and familiarity with the test format. (Roberti et al., 2016) suggested that the difficulties in constructing the SCT test and scoring key might make its application unfeasible in units with limited resources (Lineberry et al., 2019; Roberti et al., 2016). Also, (Lineberry et al., 2019) reported that SCT can be used as a guide for the assessment of learning.

Although the research design of our study does not lack rigor, the study has some limitations. One notable limitation is that the study sample may affect the findings. Another limitation is that the preparation of the students for the test and the unfamiliarity of the students and panel with the SCT format may have affected their responses. However, the current study was a prospective study introducing a new approach to assessing clinical reasoning among undergraduate students. Further investigation is needed to investigate the effect of this approach in deeper manner. Finally, the use of the same test as iSCT and tSCT may have augment the team performance as an instrument bias. We aim to identify the effect on clinical reasoning by using pre-post-test research model. Further qualitative approaches will be adopted to explore the transfer of learning from students and experts' point of view.

Conclusion

The use of the SCT/TBL approach improved the clinical reasoning skills of those achieving lower marks through the tSCT. The tSCT helped the students to correct their mistakes, generate discussion, and engage in teamwork. The SCT/TBL approach can be used as an instructional approach to teach and formatively assess clinical reasoning as it may facilitate problem-solving and enhance clinical judgment for undergraduate medical students.

Declaration

Ethics approval and consent to participate and publish

All the students participated voluntarily in the study, and the purpose of the study was communicated to them. They had the right to refuse to participate in or withdraw from the study at any point without any consequences. Informed consent to participate and publish was obtained from all the participants included in the study. Approval from the Research Ethics Committee, Faculty of Medicine at XXX University was obtained before any data was

collected. The study was performed following the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments and incomparable ethical standards.

Availability of data and materials

The datasets generated during and/or analyzed during the current study are available in abouzeid, enjy, 2021, "Team-Based Script Concordance Test", https://doi.org/10.7910/DVN/8PGSK8, Harvard Dataverse. https://dataverse.harvard.edu/dataverse/SCT

Code availability

Not applicable

Conflict of interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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Table:

Table 1. Students' perceptions of the STC structure, the STC/TBL approach, and the benefits of teamwork

	Agreement (%)	Neutrality (%)	Disagreement (%)
STC test structure and format:			
Clear test instruction	75	13	11.1
Appropriate test duration	87	7.4	9.3
Vignettes reflect real-life situations	75.9	20.4	3.7
Learning enhancement	73.2	13	13.8
Challenging test format	68.6	18.4	13
Instructional method	68.9	7.4	24.2
Assessment tool	33.3	16.7	50
The STC/TBL approach helped the students in:			
Critical thinking	75.9	18.5	5.6
Problem solving	75.9	14.8	9.3
Clinical judgement	64.8	29.6	5.6
Understanding course material	57.4	29.6	13
Focusing on core information	50	38.9	11.1
Independent thinking	79.6	11.1	9.3
Correction of mistakes made on the iSCT through discussions during the tSCT	77.7	11.1	11.2
STC/TBL students' judgment:			
Differences in answers between iSCT and tSCT	46.3	37	16.7
Preference of SCT/TBL over the traditional lecture format	73.8	11.4	14.8
Useful learning activity	68.4	27.8	3.8
Benefits of teamwork:			
STC/TBL is a perfect way to practice what was learned	79.5	16.70	3.80
The teams worked well together	83.3	14.8	1.9
Attention during TBL sessions	83.3	14.8	1.9
Development of information-synthesizing skills	75.9	18.5	5.60
Respect for the points of view of teammates	83.3	11.10	5.60

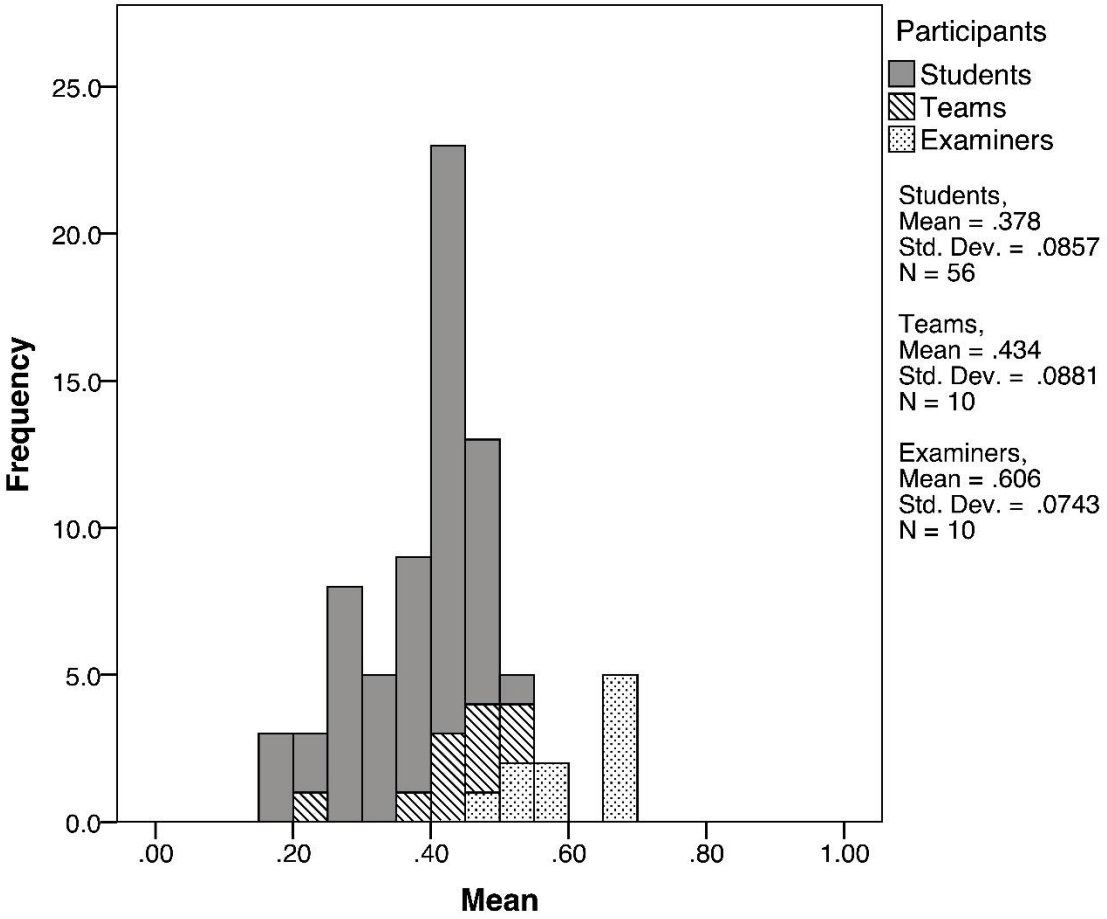

Figure 1. The distribution of the test scores among the three groups

Tables

Table 1. Comparison of students' and experts' mean scores on the script concordance test vignettes.

	Mean (SD)			P value		
Test vignette	Students	Teams	Examiners	Students vs. Teams	Students vs. Examiners	Teams vs. Examiners
1	0.40 (0.19)	0.42 (0.18)	0.62 (0.07)	0.646**	0.000*	0.002*
2	0.27 (0.15)	0.26 (0.13)	0.42 (0.10)	0.774**	0.004*	0.008*
3	0.37 (0.10)	0.41 (0.07)	0.39 (0.10)	0.417**	0.205**	0.557**
4	0.45 (0.23)	0.53 (0.25)	0.75 (0.11)	0.267**	0.000*	0.023*
5	0.36 (0.12)	0.33 (0.10)	0.42 (0.13)	0.313**	0.228**	0.100**
6	0.30 (0.16)	0.32 (0.13)	0.49 (0.15)	0.516**	0.002*	0.022*
7	0.45 (0.28)	0.56 (0.18)	0.71 (0.17)	0.279**	0.006*	0.056**
8	0.55 (0.28)	0.78 (0.28)	0.86 (0.08)	0.007*	0.000*	0.829**
9	0.50 (0.26)	0.57 (0.25)	0.79 (0.02)	0.495**	0.000*	0.005*
10	0.37 (0.22)	0.34 (0.20)	0.71 (0.08)	0.698**	0.000*	0.001*
11	0.29 (0.15)	0.31 (0.16)	0.67 (0.13)	0.667**	0.000*	0.000*
12	0.36 (0.18)	0.40 (0.20)	0.65 (0.17)	0.485**	0.000*	0.005*
13	0.32 (0.16)	0.40 (0.18)	0.44 (0.13)	0.251**	0.039*	0.470**
14	0.34 (0.37)	0.41 (0.17)	0.55 (0.11)	0.176**	0.000*	0.063**
15	0.46 (0.16)	0.52 (0.40)	0.79 (0.14)	0.597**	0.016*	0.186**
16	0.32 (0.19)	0.38 (0.16)	0.50 (0.03)	0.198**	0.010*	0.204**
17	0.43 (0.23)	0.56 (0.20)	0.62 (0.17)	0.054**	0.010*	0.678**
The whole test mean score	0.37 (0.08)	0.43 (0.09)	0.61 (0.07)	0.063**	0.000*	0.001*

SD = standard deviation

*Mann–Whitney U test, P value statistically significant (< 0.05)

**Mann–Whitney U test, P value statistically non-significant (> 0.05)

Table 2. A comparison of the mean scores of those achieving lower marks students and those of the student teams on the script concordance test vignettes.

	Mean (SD)		
Test vignette	Those achieving lower marks	Teams	P value
1	0.37 (0.20)	0.42 (0.18)	0.450**
2	0.16 (0.13)	0.26 (0.13)	0.056**
3	0.32 (0.12)	0.41 (0.07)	0.053**
4	0.29 (0.18)	0.53 (0.25)	0.015*
5	0.31 (0.15)	0.33 (0.10)	0.754**
6	0.19 (0.12)	0.32 (0.13)	0.018*
7	0.29 (0.22)	0.56 (0.18)	0.004*
8	0.29 (0.30)	0.78 (0.28)	0.001*
9	0.31 (0.27)	0.57 (0.25)	0.021*
10	0.34 (0.22)	0.34 (0.20)	0.981**
11	0.23 (0.13)	0.31 (0.16)	0.372**
12	0.27 (0.17)	0.40 (0.20)	0.095**
13	0.26 (0.14)	0.40 (0.18)	0.054**
14	0.20 (0.13)	0.41 (0.17)	0.004*
15	0.26 (0.34)	0.52 (0.40)	0.064*
16	0.23 (0.17)	0.38 (0.16)	0.009*
17	0.32 (0.26)	0.56 (0.20)	0.015*
The whole test mean score	0.37 (0.08)	0.43 (0.09)	0.063**

SD = standard deviation

*Mann–Whitney U test, P value statistically significant (< 0.05)
**Mann–Whitney U test, P value statistically non-significant (> 0.05)

Table 3. Students' perceptions of the STC structure, the STC/TBL approach, and the benefits of teamwork

	Agreement (%)	Neutrality (%)	Disagreement (%)
STC test structure and format:			
Clear test instruction	75	13	11.1
Appropriate test duration	87	7.4	9.3
Vignettes reflect real-life situations	75.9	20.4	3.7
Learning enhancement	73.2	13	13.8
Challenging test format	68.6	18.4	13
Instructional method	68.9	7.4	24.2
Assessment tool	33.3	16.7	50
The STC/TBL approach helped the students in:			
Critical thinking	75.9	18.5	5.6
Problem solving	75.9	14.8	9.3
Clinical judgement	64.8	29.6	5.6
Understanding course material	57.4	29.6	13
Focusing on core information	50	38.9	11.1
Independent thinking	79.6	11.1	9.3
Correction of mistakes made on the iSCT through discussions during the tSCT	77.7	11.1	11.2
STC/TBL students' judgment:			
Differences in answers between iSCT and tSCT	46.3	37	16.7
Preference of SCT/TBL over the traditional lecture format	73.8	11.4	14.8
Useful learning activity	68.4	27.8	3.8
Benefits of teamwork:			
STC/TBL is a perfect way to practice what was learned	79.5	16.70	3.80
The teams worked well together	83.3	14.8	1.9
Attention during TBL sessions	83.3	14.8	1.9
Development of information-synthesizing skills	75.9	18.5	5.60
Respect for the points of view of teammates	83.3	11.10	5.60