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Using Team-Based Learning to Teach Grade 7 Biology: Student satisfaction and improved performance

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Team-based learning (TBL) is an innovative form of collaborative learning. The purpose of this study was to evaluate TBL's effect on the performance and satisfaction of grade 7 students in biology in a private school in Lebanon, as well as teachers' willingness to implement this new methodology. An exploratory study was performed whereby two biology units were taught to two groups of students using either TBL (60 students) or traditional lecture-based instruction (30 students). Later, a summative test was administered to evaluate students' performance. Students' attitudes were evaluated using a questionnaire and teachers' classroom observations. Finally, science teachers' willingness to try TBL in their classes was assessed using a questionnaire (14 teachers). Results showed that underachievers taught according to TBL did better than underachievers taught with the lecture-based approach. The majority of students enjoyed TBL and found it useful and fun. Finally, science teachers agreed that TBL is a good alternative to the traditional lecture-based method.

Keywords: *Team-based learning; Collaborative learning; Middle school; Biology teaching*

Introduction

Imagine our students coming to class well-prepared, engaging in all the activities, and communicating their ideas in a scientific way! Imagine them leaving class with enough concrete knowledge to use in their daily lives! Can this be a way of teaching biology to meet the needs of the twenty-first century? If yes, this would be the dream come true of every modern educator.

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A 2004 survey of career recruiters published in the *Wall Street Journal* indicated that, after communication skills, teamwork is the second most essential type of skill for business graduates to possess (Alsop 2004). Hence, an important challenge facing school educators nowadays is to create suitable reflective individuals ready to interact within teams to fulfil the increasing demands of the workplace (Parmelee and Pelton-Sweet 2008). This is a significant challenge, especially to Lebanese culture, since most Lebanese tend to celebrate individual achievement and success. In addition, another challenge that is facing educators today, as it faced Dewey, Piaget, Cousinet and others in the past, is to devise methods to motivate students, especially lower achievers, to learn in ways that are appealing to them (Cousinet 1972).

Based on the above, educators may determine that current teaching strategies fall short. Thus, to meet the challenges, changes in the curricula and educational methods are required (Vasan, DeFouw, and Compton 2009). This is in conformity with a 2007 report published by the World Bank which suggests that the Arab educational system – including that in Lebanon – needs urgent reform to create students who are well prepared for the twenty-first century work environment (Boujaoude 2010). Thus, the methodologies and interventions used should be more student-centred to aid in the comprehension of scientific topics, especially the more challenging ones, and aimed at increasing the motivation and performance of students.

Collaborative Learning

Due to the efforts of many educational reformers, teaching has been changing; the old paradigm is being dropped for a new one based on theory and research (Johnson, Johnson, and Holubee 1994). In the new paradigm, learning is something students should do: they should construct, discover, transform and extend their own knowledge, while teachers' efforts should be aimed at developing students' competencies and talents (Johnson, Johnson, and Holubee 1994). Collaborative learning is used to operationalise the new paradigm of teaching, because it provides the context that encourages the development of students' talents (Johnson, Johnson, and Holubee 1994).

Collaborative learning stems from Vygotsky's social constructivist theory, which is related to Piaget's theory but has much more room for an active and/or involved teacher and older and/or more experienced children and parents. For Vygotsky, the culture gives the child the cognitive tools needed for his development, such as cultural history, social context, language and, nowadays, electronic forms of language. Vygotskian classrooms create a context in which students can become engaged in interesting activities that are rooted in real-life situations. The teacher, as well as peers or other members of the community, often guides students to work in groups to facilitate learning. The 'zone of proximal development' is probably Vygotsky's best-known concept. It argues that students can, with help from others who are more advanced, master concepts and ideas that they cannot understand on their own and, thus, perform better in collaborative groups (Slavin 1990).

Theoretical models agree that collaborative learning methods are superior to traditional methods (Slavin 1990), even if they are more complex than any other method of instruction (Johnson, Johnson, and Holubee 1994). They assume that these methods

should be used when the learning objectives are highly significant, retention and mastery are essential, problem-solving is desired, creativity is expected and higher levels of cognitive abilities are needed, even though certain limitations exist due to the 'free-rider effect' and the 'rich get richer' effect (Johnson, Johnson, and Holubee 1994). Since the first research study on collaborative learning in science, in 1897, much research has been conducted to study the effects of applying cooperative learning in science education. It has been found that cooperative learning, compared to competition and individualistic efforts, helps the teacher simultaneously accomplish three important goals: greater efforts to achieve, more positive relationships among students, and greater psychological health (Glasgow, Cheyne, and Yerrick 2010). Results also show that collaborative experiences promote greater social support than do competitive or individualistic experiences. This is important, since social support promotes achievement and productivity, physical health, psychological health and the ability to cope with stress and adversity.

Most cooperative learning instruction has shown positive effects on the achievement of middle school students, but sometimes the effects have been insignificant (Burron, James, and Ambrosio 1993; Chang and Lederman 1994). Students in cooperative conditions have been shown to score significantly higher on post-tests when compared to students in competitive and individualistic conditions (Humphreys, Johnson, and Johnson 1982; Okebukola and Ogunniyi 1984). Moreover, Chang and Mao (1999a, 1999b) showed that cooperative learning enhanced students' learning in higher cognitive domains and promoted students' achievement and attitudes toward earth science. Johnson and Johnson (1989) reviewed and identified more than 550 experimental and 100 correlation research studies. Theoretical and demonstrative research proved the effectiveness of cooperative learning over other types, since it promoted an intrinsic motivation to remember and use the information. Similarly, Slavin (1990) reviewed 60 studies that contrasted achievement effects of cooperative learning and traditional methods in elementary and secondary schools. Results showed that 72% of the studies reviewed favoured cooperative learning in terms of achievement, self-esteem and intergroup relations due to the motivational and cognitive theories employed. Moreover, a recent article by Slavin et al. (2013) presents a systematic review of literature on the achievement of students in science using various teaching approaches. This study concludes that teaching methods that focus on enhancing teachers' classroom instruction throughout the year, such as cooperative learning methods, have significant potential to improve science learning in elementary science teaching.

Team-based Learning

Team-based learning (TBL) is an innovative form of collaborative learning (Koles et al. 2010) that was first applied in the early 1990s by Larry Michaelsen in the business school at the University of Oklahoma (Parmelee 2010). In this method, students are first required to pre-read material at home. After this, teachers test students on their comprehension of this basic information individually using an individual readiness assurance test (IRAT), and then collaboratively using a group readiness assurance test (GRAT) (Table 1). Finally, and most importantly, students spend most of the class time in teams, applying

Table 1. Definitions of certain terms used in TBL

Terms	What do they stand for?	What they actually mean?
RAP	Readiness assurance process	The process to assure teachers that students understood the basic knowledge and are ready to enter the next phase. It includes IRAT and GRAT
IRAT	Individual readiness assurance test	Teachers test students on their comprehension of basic information individually
GRAT	Group readiness assurance test	Teachers test students on their comprehension of basic information collaboratively

the information using real-world application activities (Sweet and Michaelsen 2012). TBL was developed and refined through a trial-and-error process that spanned more than 20 years. This process was guided by theory and empirical research on small-group dynamics and the direct observations and classroom experiences of Michaelsen and the early users of TBL (Haidet, Schneider, and Onady 2008). TBL enhances communication skills, interpersonal skills, teamwork skills and giving and receiving feedback. Moreover, students develop an appreciation of the value of teams in solving difficult, complex and real-world problems. Designing a TBL course requires teachers to think backwards: the instruction is planned in accordance with what teachers want students to be able to do when they finish the course (Michaelsen and Sweet 2014). The four basic principles of TBL should be respected in order to eliminate some of the limitations of traditional collaborative learning and transform groups of students into powerful learning teams (Michaelsen and Sweet 2002).

- First, teams should be properly formed and managed by the teacher. The latter should create teams with heterogeneous skills, knowledge, abilities and attitudes (Smart and Csapo 2003). The teams should contain 5–7 members and be permanent throughout the sessions. Michaelson suggests 40 h of working in the same team is optimal to obtain highly functional results (Thomas and Bowen 2011). Eventually, the team will perform better than its smartest team member; in this way, even the best student will be motivated to engage even more. This principle does not necessarily apply during traditional collaborative learning.
- The second principle is students' accountability as individuals and as a team. In this method, students are accountable not only to their teacher, but also to their team members (Parmelee and Pelton-Sweet 2008). This is done through a grading system that takes into account all the TBL phases, as well as a peer evaluation system that rewards each student according to how much he or she contributes to the learning of his or her team (Smart and Csapo 2003). During TBL, self-criticism and effortful thinking are required, because students are accountable to their teacher–student audience: an audience which is well informed and interested in accuracy, and whose views on the issue are unknown. This accountability creates social anxiety, which can focus attention and improve learning and high-quality critical thinking (Parmelee and Pelton-Sweet 2008; Sweet and Michaelsen 2012). Peer evaluation ensures accountability, especially because

it teaches students to evaluate others honestly (Vasan, DeFouw, and Compton 2009). It guarantees that no student will act as a 'free-rider' in order to receive the same grade as all the other team members, a major drawback in traditional collaborative learning (Nieder et al. 2005).

- The third principle is the timely, frequent and discriminatory feedback provided by the teacher during the readiness and application phases. The content of this feedback is determined by the students' choices and actions, so teachers could provide either positive reinforcement or corrective instruction (Michaelsen and Sweet 2014). In this way, the teacher can instantly modify students' misconceptions, so that students can quickly apply the modified concept in the application phase (Clark et al. 2008). This is because TBL focuses not simply on the answer, but rather on the process. According to W. Edwards Deming and other advocates of total quality management, it is more important to focus on the process than on the outcome of learning, since by improving the process, the quality and quantity of learning will eventually improve (Johnson, Johnson, and Holubee 1994). During traditional collaborative learning, this principle is not respected. As a result, the quality of explanations provided by students to their group members is questionable. Feedback is essential to content learning retention, and has a tremendous impact on group development (Michaelsen and Sweet 2014).
- The fourth key principle to succeed in TBL is the quality of the application activities given to students. These have to be significant problems, capture students' interests and require complex critical thinking, yet yield a specific answer. Students cannot divide the work between them and it cannot be done by one person alone (Clark et al. 2008). These conditions ensure that students can work together on one project and come up with a single solution. In addition, the same application activity should be given to all teams, and the answers to the questions should be simultaneously reported. These activities produce long-term gains in students' ability to recall and use course concepts. If this principle is not respected, students would put minimum effort to get to a satisfactory grade (Michaelsen and Sweet 2002).

After Larry Michaelsen, TBL was implemented by Dean Parmelee in a medical school in 2001(Koles et al. 2010). Since then, TBL has proven effective in medical pharmacology, physiology and anatomy courses, as well as in dentistry, pharmacy and veterinary schools at more than 50 universities in the US (Dunaway 2005; Parmelee 2010; Seidel and Richards 2001; Vasan and DeFouw 2005). In addition to the medical field, TBL has been used successfully in a variety of other educational settings including marketing, accounting and business (Mennenga and Smyer 2010). Besides the US, countries such as Japan, Korea, Singapore and Turkey have also introduced TBL (Parmelee 2010). TBL use has been very limited in Arab countries; to our knowledge, only two universities have adopted it: the University of Sharjah Medical School (Abdelkhalek et al. 2010) and the American University of Beirut Faculty of Medicine (Zgheib, Simaan, and Sabra 2010). TBL has been shown to improve students' satisfaction (Abdelkhalek et al. 2010; Conway, Johnson, and Ripley 2010; Dunaway 2005; Levine et al. 2004; Nieder et al. 2005; Parmelee and De Stephen 2009; Smart and Csapo 2003; Sunay and Awalt 2011; Vasan, DeFouw, and Compton

2009; Wiener, Plass, and Marz 2009; Zgheib, Simaan, and Sabra 2010; Zgheib, Simaan, and Sabra 2011), with high learner-to-learner engagement and higher learner-to-instructor engagement. In addition, students showed higher comprehension and retention of information (Haidet, O'Malley, and Richards 2002; Hunt et al. 2003; Kelly et al. 2005; McInerney and Fink 2003; Seidel and Richards 2001; Sunay and Awalt 2011; Zgheib, Simaan, and Sabra 2011). As for student performance, most students' scores on their unit examination after TBL instruction were not different from their grades in tests taken after traditional instruction (Conway, Johnson, and Ripley 2010; Dunaway 2005; Nieder et al. 2005; Sunay and Awalt 2011; Zgheib, Simaan, and Sabra 2011), yet few studies showed improved student performance with TBL instruction when compared to traditional instruction (Clark et al. 2008; Koles et al. 2010; Letassy et al. 2008; McInerney and Fink 2003; Nieder et al. 2005; Pileggi and O'Neill 2008; Smart and Csapo 2003; Thomas and Bowen 2011; Vasan and DeFouw 2005; Wiener, Plass, and Marz 2009; Zgheib, Simaan, and Sabra 2010). Others showed that even though the mean rates on exams following the TBL method were not significantly different than those of previous years, the spread and the failing rates were lower with TBL (Nieder et al. 2005) and there were no students with non-passing grades; thus suggesting a potential benefit for low-performing students without affecting mid- or high-ranked students (Conway, Johnson, and Ripley 2010; Glasgow, Cheyne, and Yerrick 2010). This is likely to be because of the increased social support or peer tutoring (Michaelsen and Sweet 2014). The most encouraging results were the statistically significant increases in the National Board of Medical Examiners (NBME) subject test scores for students taught with TBL (Clark et al. 2008; Levine et al. 2004). In addition, faculty experienced TBL as a very rewarding experience that was dynamic, enjoyable and instructional (Conway, Johnson, and Ripley 2010; Dunaway 2005; Nieder et al. 2005; Pileggi and O'Neill 2008; Touchet and Coon 2005). Due to these positive outcomes, the Liaison Committee on Medical Education (LCME), recognised by the US Department of Education to accredit medical education programmes leading to the MD degree, has stressed changes in the medical school curriculum to include the implementation of new teaching styles such as TBL (Janssen et al. 2008). In addition, several elements of TBL instruction were supported by the 2007 standards set forth by the Accreditation Council for Pharmacy Education (ACPE) (Conway, Johnson, and Ripley 2010).

Although TBL has the potential to be used in any classroom (Mennenga and Smyer 2010 and has many features that could make it applicable at the school level, an extensive review of the literature has shown that no research in this area has been published. This was our motivation for conducting this study and applying the TBL methodology, as previously shown to be successful, to a new environment that might benefit from it.

Purpose of the Study

This research aimed at finding out whether TBL leads to improvement in grade 7 students' academic achievement in biology, and if it is associated with increased student satisfaction and motivation. It also aimed to evaluate teachers' willingness to implement this new methodology of teaching. The study design was guided by three questions:

(1) How does TBL affect the performance of Grade 7 students in biology?
(2) What are students' attitudes towards TBL?
(3) What is the school's science teachers' level of willingness to apply TBL after attending a workshop about it?

This is an exploratory study that provides previously non-existent knowledge about TBL at the school level and adds to the limited literature published on TBL in the Middle East. This study could be considered a feasibility study that paves the way for additional research to generalise the effects of TBL to the teaching of biology in the school environment.

Methods

Research Design

This study involved two randomly assigned groups of grade 7 students: a comparison group that was taught in the traditional, lecture-based instruction, and an experimental group that was exposed to the intervention (TBL). The theory of method in this study follows the TBL fundamental principles and conditions of application (Michaelsen and Sweet 2002). TBL was applied in two units of the eight-unit biology course over a period of about three weeks in November 2012. The choice of the two units and their timing was made to provide the instructor with baseline data on students' performance in previous tests. This allowed, when applicable, assessment of the effect of TBL on students' performance, as well as the formation of homogenous TBL teams with heterogeneous skills.

Participants

Participants were 12–13-year-old Lebanese grade 7 biology students from a trilingual private school in Lebanon with around 2500 students of mixed gender and belonging to low, medium and high socioeconomic classes. This school is not necessarily representative of the Lebanese population and its choice was a matter of convenience since the researcher, also the author (CJ), is a teacher and biology coordinator in the school. This facilitated the implementation of the study. CJ holds a master's degree in teaching science and has had extensive previous TBL training through workshop attendance. Grade 7 biology instruction is in English, and is shared by two instructors who are responsible for three sections each.

The three grade 7 sections' achievement on biology tests taught by the instructor involved in this study (CJ) was approximately the same (7A: 14.48/20; 7B: 14.09/20; 7C: 14.33/20); therefore one entire class of 30 students (7A) was randomly assigned as the comparison group, and two entire classes of 30 students each (7B and 7C) were assigned to be the experimental group. The comparison group consisted of 11 girls and 19 boys, while the experimental group included 21 girls and 39 boys. Participants in each team were allocated by the teacher according to their academic achievement on the

biology test, which assessed content not taught by TBL (pre-test), and according to their sex and their level of activity, in order to create heterogeneous teams of students.

Procedure

The study procedures were approved by the school's administration, and letters were sent to parents describing the intervention and the mandatory pre-class readings and preparation. Students in grade 7 were taught biology four times per week. Both groups studied two units – birds and mammals – and worked on the same objectives, but in a different context: TBL vs. the traditional lecture-based approach. The study period for the experimental group included eight 50 min sessions: six TBL sessions and two wrap-up sessions. The teacher/researcher wrote the lesson plans for both the experimental and comparison groups to ensure the authenticity of the intervention, and was responsible for teaching both groups. In addition, the course content and time frame were constant across the two groups.

For the experimental group, prior to the study, the students were briefed about the TBL procedure and grading system. Students were then asked to read assigned material on their own at home, following a reading guide given by the teacher which included the objectives. This pre-reading transformed the discussions in class; they became more engaging and thoughtful for both the teacher and the learner (Vasan, DeFouw, and Compton 2009).

During the six TBL sessions in class, students were first individually tested (IRAT 10 min), then the same test was repeated as students sat with their teams (GRAT 5 min). This repeated test ensured the accountability of students as individuals and as a team (Clark et al. 2008). The test questions were of the objective type.

(1) Both the pre-class readings and the tests carried out formed the readiness assurance process (RAP) to check if students were ready to enter the next phase (Table 1). Next, during the application phase, for 25 min, students applied the knowledge to real-world complex issues. This was their chance to connect information they had learned (theory) with real-life situations (practice) by solving an application activity as teams. When the application phase's allocated time was up, the teacher invited teams to share their answers simultaneously during the whole-class discussion (10 min). For example, the teacher or a student read a question such as: 'What container kept water hottest after 10 min?', with choice a container 1, choice b container 2, choice c container 3 and choice d container 4. A student from each group raised a letter card inscribed a, b, c or d representing the correct answer according to previous within-team discussion, such that all groups raised the letter card representing the correct answer simultaneously. The teacher then asked for justification of the chosen answer from the different teams. These discussions helped the teacher fill in gaps and deficiencies by acting as a facilitator and as a content expert (Thompson et al. 2007). While students were engaged in solving their application activities, the teacher circulated among them to observe their level of engagement, to clarify information, to provide immediate feedback and to determine their level of performance as individuals and as a team. During the two wrap-up sessions, the teacher focused on the

10–15% of concepts that were the most problematic. At the conclusion of the study, students were asked to fill out an already established and very well studied peer evaluation form (Michaelsen form) that insured student–student accountability (Cestone, Levine, and Lane 2008; Levine 2008). Students were also asked to fill out a student satisfaction questionnaire to comment on their experience with TBL.

The comparison group undertook eight 50 min sessions following the traditional lecture-based approach. Chapters were explained using the traditional method of instruction. Accordingly, the students were provided with clear and detailed explanations and instructions, while the teacher's main role was to transfer scientific knowledge to students.

Instruments

For the first research question – how does TBL affect the performance of Grade 7 students in biology? – a final biology summative test (post-test) was administered after the intervention. Another test, administered prior to the intervention, was considered as the baseline grade and used for comparison purposes (pre-test). Questions of both tests, RATS and application activities, were reviewed by the other grade 7 biology instructor, the biology coordinator, and the head of the biology department of the school. These tests were designed to assess students' knowledge, comprehension, application, analysis and problem-solving with regard to the material taught according to the skills and competencies required by the Lebanese curriculum. Moreover, scores on IRATs, GRATs, application activities and peer evaluations were collected for analysis. The TBL daily grade was calculated as follows: IRAT: 30%, GRAT: 15%, application activities: 40%; peer evaluation: 15%.

As for the second research question – what are students' attitudes towards TBL? – a questionnaire was administered to the experimental group (N=60) to assess students' attitudes towards TBL using 10 questions with a four-item Likert-type scale. The questionnaire was checked for content validity by colleagues and included space for personal comments and feedback to perform qualitative analysis. An observation grid was filled by four middle school science teachers and coordinators in addition to the school principal. They observed students' behaviours and interactions during different TBL sessions according to a predetermined schedule. The observation grid included questions such as the students' engagement in class, their willingness to help other team members and their desire to learn. The observers were briefed and trained in using the observation grid. These two tools were designed by the researcher and fine-tuned after collecting feedback from colleagues. They were used to assess students' level of engagement and attitude towards TBL, from both the student and teacher perspectives.

For the third research question – what is the school's science teachers' willingness to apply TBL after attending a workshop about it? – a questionnaire that included a list of 17 questions using a four-item Likert-type scale, with space for comments, was administered to 14 science teachers, coordinators and heads of school departments following their participation in a workshop about TBL prepared and delivered by the researcher (CJ). The workshop was two hours long and its goal was to make the teachers acquire enough

knowledge, skill and enthusiasm to apply TBL in their classes. This questionnaire was administered to assess the school's science teachers' willingness to adopt TBL as a new strategy of instruction and not their attitudes towards it, as they would have had only superficial contact with TBL.

Data Analysis

Data were entered into and analysed using the SPSS software version 19 (USA). For the first research question, the experimental and comparison groups' grades on the final summative test (post-test) were compared using the t-test for comparison of means of independent samples. Both groups' final summative grades were compared to performance on the baseline summative test (pre-test) using the t-test for paired samples. In addition, students' IRAT scores in the different TBL sessions were compared to each other, and were compared to GRAT scores within the same session. Finally, the post-test grades of the experimental group were correlated with the daily TBL work grades – that is, IRATs, GRATs, application activities and peer evaluation. In addition, the final summative grades of underachievers (defined as students with pre-test scores < 11/20) and achievers (defined as students with pre-test scores ≥ 11/20) in both groups were compared to grades of the baseline summative pre-test using the t-test for paired samples. To evaluate the students' attitude towards TBL – the second research question – responses to the Likert scale of the 10 questions were calculated (min score=1, max score=4) and the Cronbach's alpha was calculated as an estimate of instrument reliability. Moreover, content analysis of the students' comments was carried out. To evaluate students' attitude towards TBL as observed by teachers, responses were calculated as described above and content analysis of the teachers' comments was performed. Finally, to view the teachers' willingness to try TBL – the third research question – responses to the teachers' implementation questionnaire were also calculated. Cronbach's alpha was not calculated for these two instruments because of the small sample size.

Results

How Does TBL affect Grade 7 Students' Performance in Biology?

Students in the comparison group had lower scores on the final test (13.88/20; standard deviation (SD) of 2.78) than on the baseline test (14.48/20; SD of 2.58). However, students in the experimental group had higher scores in the final test (14.29/20; SD of 3.25) than in the baseline test (14.21/20; SD of 3.27). In addition, the experimental group had a higher mean final score (14.29/20; SD of 3.25) than the comparison group (13.88/20; SD of 2.78). Nevertheless, none of these values were statistically significantly different ($P = 0.181$, 0.802 and 0.554 respectively) (Table 2).

The students were divided into two categories: 'underachievers', defined as students with pre-test scores < 11/20, and 'achievers', defined as students with pre-test scores ≥ 11/20. Interestingly, the mean of the final test of underachievers in the experimental group was significantly higher than that of the baseline test (9.94/20 vs. 8.28/20;

Table 2. Comparison of performance on baseline and final tests between the two groups

Group	Baseline grad /20	Final grade/20	Significance level (t-test)
Control (Mean ± SD)	14.48 ± 2.58	13.88 ± 2.78	0.181
Experimental (Mean ± SD)	14.21 ± 3.27	14.29 ± 3.25	0.802
Significance level (t-test)	0.693	0.554	

$P = 0.025$). Although the mean of the final test for achievers was lower than that of the baseline test (14.96/20 vs. 15.13/20), but this was not statistically significant ($P = 0.601$). The number of underachievers in the comparison group was just three, so the statistical analysis in this case is not applicable. Moreover, similar to the experimental group, the mean of the final test for achievers in the comparison group was lower than that of the baseline test (14.19 /20 vs. 14.97/20), but this result was also not statistically significant ($P = 0.114$; Table 3).

As expected, performance on the six IRATs generally improved over time: 3.3/5, 3.9/5, 3.9/5, 4.1/5, 4.3/5 and 3.8/5; in addition, the GRAT scores were consistently higher than the relevant IRATs: 4.7/5, 4.8/5, 4.7/5, 4.8/5, 5/5 and 5/5. Moreover, there was a significantly high correlation between the daily TBL grades and the final post-test grade (Pearson correlation = 0.695; $P < 0.01$).

What are the Students' Attitudes towards TBL?

From the students' perspective. According to Table 4, results show that the majority of students concur to a high and a very high degree on the positive effect of TBL. This tool was highly reliable as Cronbach's alpha was 0.871. There were 21 negative and 40 positive comments from the 60 students of the experimental group, from which we could infer that most students enjoyed TBL and preferred it over the classical, lecture-based method of instruction.

More specifically, 13 students believed that TBL could improve their grades because it encouraged them to study at home on a daily basis and 15 said that TBL helped them communicate better with their friends, as working in teams is beneficial to learning and

Table 3. Comparison of performance on baseline and final tests between underachievers and achievers of the two groups*

Category	Baseline grade /20 (Mean ± SD)	Final grade /20 (Mean ± SD)	Significance level (*t*-test)
Experimental group: Underachievers ($N = 8$)	8.28 ± 2.17	9.94 ± 3.28	**0.025**
Experimental group: Achievers (N = 52)	15.13 ± 2.32	14.96 ± 2.71	0.601
Control group: Achievers (N = 27)	14.97±2.21	14.19±2.68	0.114

*Statistical analysis is not applicable for the control group underachievers as N=3.

Table 4. Students' attitude towards TBL (*N*=60)

Questions	Not at all *N* (%)	To an average degree *N* (%)	To a high degree *N* (%)	To a very high degree *N* (%)
The sessions were well organised	0 (0)	15 (25)	30 (50)	15 (25)
TBL challenged me to give my best	4 (7)	6 (10)	23 (38)	27 (45)
TBL increased my level of engagement in class	3 (5)	9 (15)	20 (33)	28 (47)
TBL helped improve my communication skills	5 (8)	9 (15)	21 (35)	25 (42)
TBL had a positive impact on my study habits	3 (5)	8 (13)	18 (30)	31 (52)
I benefited from the team discussions	5 (8)	12 (20)	26 (44)	17 (28)
I benefited from the whole class discussions	1 (2)	10 (17)	28 (46)	21 (35)
I would like future chapters to be formatted as TBL	3 (5)	4 (7)	7 (12)	46 (76)
I like TBL more than the classical method of teaching	3 (5)	5 (8)	11 (18)	41 (69)
I learned more from TBL than from the classical method of teaching	5 (8)	12 (20)	22 (37)	21 (35)

understanding new things while having fun at the same time. One student, in summary, said: 'TBL is the best way to increase knowledge, friendship and communication. It helped us study daily and understand the details.' Seven students said it was more fun and amusing than the classical method of instruction and six others said they would like more TBL in biology and indeed in all other subjects. One said: 'I encourage the school to continue TBL. It is very helpful. It allows us to communicate with each other and to study daily. TBL is a challenge for us to earn better grades.' Other comments described the TBL activities as 'nice and challenging' and 'very well organised'.

Even though most 'didn't find anything negative with TBL', a few students offered negative comments: 12 believed that TBL would be more beneficial if all the team members worked seriously and came to class prepared, but two of these admitted however that 'after a few TBL sessions, the team spirit became better: we knew how to divide the work between ourselves'. Two other students wrote that their team members ignored their answers, even though sometimes they were right. Yet another believed that sometimes students argued and fought over the answers. One felt it was unfair for students who were not prepared to earn the same grade as the others.

Only three students said they preferred the classical method. One said: 'Studying with the teacher and taking notes then asking questions before doing the quizzes is better'. Three other students said they wanted notes written on their copybooks so that they could be better prepared for the tests.

From the Teachers' Perspective. Results from the teachers' observation grid showed the majority of teachers agreed that students seemed happy with the TBL experience, as they were fully engaged in both inter- and intra- team discussions. Students were on-task, were willing to help other team members and showed a desire to learn.

Among the positive comments, one teacher noted that students were interested and active because they understood each other; another noted that students were cooperating with the teacher and with their friends, and sensed that students were coming to class prepared and 'knew' what the teacher was talking about. A third teacher believed that reluctant students were now more involved in the activity, and that the underachievers seemed to benefit from the group work and understood the lesson better.

In terms of negative comments, one teacher felt that there must be a team leader. Another noted that some talkative students took opportunities to distract others and discuss issues not related to the lesson. Moreover, he believed that some students depended on their friends for an understanding the lesson during group work, without putting in any effort. A third teacher perceived that TBL might be time-consuming as it requires extra preparation on the part of the teacher.

Table 5. Teachers' willingness to implement TBL (*N*=14)

	Strongly disagree *N* (%)	Disagree *N* (%)	Agree *N* (%)	Strongly agree *N* (%)
If I use TBL, students tend to veer off task	1 (8)	10 (77)	2 (15)	(0)
If I use TBL, my classroom would be too noisy	1 (7)	7 (50)	5 (36)	1 (7)
If I use TBL, many students expect other group members to do the work	0 (0)	1 (7)	12 (86)	1 (7)
I have enough teaching experience to implement TBL successfully	0 (0)	0 (0)	12 (86)	2 (14)
The amount of TBL training I have received has prepared me enough to implement it successfully	2 (15)	1 (8)	9 (69)	1 (8)
I prefer using familiar teaching methods over trying new approaches	4 (29)	10 (71)	0 (0)	0 (0)
TBL is appropriate for the grade level I teach	1 (7)	2 (14)	7 (50)	4 (29)
Peer interaction helps students obtain a deeper understanding of the material	1 (7)	1 (7)	6 (43)	6 (43)
TBL enhances the learning of low-ability students	0 (0)	2 (14)	9 (65)	3 (21)
TBL enhances the learning of high-ability students	0 (0)	6 (46)	7 (54)	0 (0)
Using TBL fosters positive student attitudes towards the subject taught	0 (0)	2 (14)	10 (72)	2 (14)
Engaging in TBL enhances students' social skills	0 (0)	0 (0)	7 (50)	7 (50)
It is possible to evaluate students fairly when using TBL	1 (7)	5 (36)	7 (50)	1 (7)
TBL is an efficient classroom strategy	0 (0)	1 (7)	11 (79)	2 (14)
Implementing TBL takes too much preparation time	0 (0)	1 (7)	5 (36)	8 (57)
Implementing TBL takes too much class time	0 (0)	5 (35)	5 (36)	4 (29)
I plan to integrate TBL into my future classroom routine	0 (0)	3 (23)	6 (46)	4 (31)

What is the School's Science Teachers' Willingness to Apply TBL after Attending a Workshop About It?

Table 5 shows that the majority of teachers believed that TBL was an efficient classroom strategy and were willing to adopt it.

Discussion

Our results showed that TBL did not significantly improve students' performance on the summative test, along the same lines as results of previous studies by Conway, Johnson, and Ripley (2010), Dunaway (2005), Nieder et al. (2005), Sunay and Awalt (2011) and Zgheib, Simaan, and Sabra (2011). These were in contrast, however, to others that showed that TBL helps students achieve better academic grades (Clark et al. 2008; Koles et al. 2010; Letassy et al. 2008; Levine et al. 2004; McInerney and Fink 2003; Pileggi and O'Neill 2008; Searle et al. 2003; Thomas and Bowen 2011; Vasan and DeFouw 2005; Wiener, Plass, and Marz 2009). Several reasons might explain the non-significant positive effect of TBL on the students' grades. To start with, the question of whether students undergoing TBL can academically outperform students involved in traditional education is very difficult to measure, especially as the types of tests used in schools mainly assess the outcome, with very little emphasis on the process. Thus, the tests used may not capture the additional dimensions that TBL has to offer (Case and Swanson 2002). Next, in other reported studies, most instructors adopted TBL over a whole course and not just for two units; moreover, the students who received TBL instruction in this study had rarely, if ever, been exposed to collaborative learning prior to this study. Hence one can speculate that, with extended exposure to TBL, students may acquire the necessary skills of working in teams well enough to achieve higher grades (Pelley and McMahon 2008).

Despite that, the underachievers in the class benefited more than the high achievers. More specifically, they had significantly higher scores on their final post-TBL test than on their pre-TBL test. This finding is consistent with previous results (Conway, Johnson, and Ripley 2010; Glasgow, Cheyne, and Yerrick 2010), and several reasons might have led to it. For instance, since TBL involves group activities that include inter- and intra-team discussions, this method of instruction may be beneficial to low achievers who generally do not memorise well, and must understand concepts in order to figure out what they have to learn. In addition, the numerous team activities undertaken may provide those students with metacognitive instruction. Moreover, TBL's first step is a RAP, which might have encouraged students to study on a daily basis. Finally, interactions with other team members may have allowed the low achievers to envision how others learn and thus develop a better sense of how they themselves learn (Michaelsen and Sweet 2014).

The results of this study also showed, as expected with successful TBL, improved IRAT scores over time, since – as with any other skill – practice is important to become comfortable with TBL. Moreover, the GRAT scores were always higher than the IRAT scores for each session, due to the fact that team members were able to compare their ideas in a problem-solving dialogue; in this way TBL teams develop a synergy that increases the likelihood of a correct decision (Nieder et al. 2005; Pelley and McMahon

2008; Smart and Csapo 2003; Zgheib, Simaan, and Sabra 2011). Results also show a significantly high correlation between the daily TBL grade and the final grade, meaning that students who do well in the TBL tests and activities are likely to also do well in their final test. Consequently, using TBL could help students prepare for their final tests (Cestone, Levine, and Lane 2008).

The results also showed that students were more engaged in TBL than in the traditional lecture-based course; this included the underachievers, who exhibited a high degree of enthusiasm and participation conducive to a better learning environment. For instance, the majority of students agreed they had enjoyed TBL as a new instructional strategy and recognised its benefits. It is important to note that students probably believed TBL was more effective because they saw that their results in the IRAT and GRAT improving over time; moreover, they were forced to change their studying habits, were active learners during class and, as a potential consequence, may have understood the material more. Nevertheless, a Hawthorne effect, whereby students may have felt change in behaviour due to the attention they received during the experimentation, should also be considered.

Teachers viewed students as happy, engaged, showing a desire to learn and willing to help their friends. This increase in motivation and communication could mostly be attributed to the peer relationships that students experience during TBL (Abdelkhalek et al. 2010; Clark et al. 2008; Conway, Johnson, and Ripley 2010; Dunaway 2005; Seidel and Richards 2001; Sunay and Awalt 2011; Touchet and Coon 2005; Vasan and DeFouw 2005; Vasan, DeFouw, and Compton 2009; Wiener, Plass, and Marz 2009; Zgheib, Simaan, and Sabra 2011). The results of this study are similar to others reporting that students believe TBL is more effective than traditional instruction (Levine et al. 2004). In addition, similarly to previous studies, students recognised that TBL encouraged them to study on a daily basis (Dunaway 2005; Nieder et al. 2005). This might be explained by the fact that students in grade 7 take a full load of 14 courses in parallel. This congestion has forced most of them to adopt a studying style that is passive, test-focused and 'crammed' rather than smooth and continuous. They rely on their short-term memory for study, which does not encourage deep understanding of the material. In adopting TBL, most students were forced to change their studying habits and study daily due to the presence of the RAP. Another benefit of TBL that we experienced during the sessions was that students functioned as trained scientists. They critically analysed and interpreted the course material and related it to the application activities given to them. They made deductions concerning this information, and used creativity in formulating solutions. Moreover, in TBL, students were forced to read the book – a necessity to comprehend the lesson globally, yet rarely practised by students nowadays! Finally, students felt that TBL challenged them to give their best. This might be due to the increase in responsibility that students felt during TBL.

Only a few students had lower perceptions of TBL as an active methodology. This could be due to their belief that traditional lectures are more beneficial, even if the same or better performance was achieved by TBL. These students may be mostly of the bookish, teacher-dependent type. They may only trust the teacher's notes and have less confidence in themselves or peers. Increased out-of-class preparation may also be an issue (Searle et al. 2003). Finally, some students were bothered by members of their team who came to class unprepared or discussed unrelated topics during the sessions. However,

over time, these behaviours might be reduced as the group of students slowly evolves into a highly functional team. This fact was admitted by some students.

Results also show that the majority of teachers believe TBL is an efficient classroom strategy and are willing to adopt it even though they believe it would necessitate excessive preparation time. These are similar to previously reported findings (Conway, Johnson, and Ripley 2010; Nieder et al. 2005; Searle et al. 2003). A point worth mentioning here is that the majority of teachers think many students will expect others to do their work, and consequently many do not believe they will be able to evaluate students fairly in TBL. However, TBL entails a grading system that takes into account all the TBL phases, as well as a peer evaluation system that rewards each student according to how much he or she contributes to the team's learning. This ensures that each student will eventually receive the grade he/she deserves (Smart and Csapo 2003).

Study Limitations

As this is an experimental study, some confounding variables could affect the results, such as minor differences in the academic achievement between the experimental and comparison groups. In addition, the facilitator of the two groups is the researcher (CJ) herself. Nevertheless, the method of TBL instruction requires the teacher to be a facilitator and guide to the learning process, rather than a dispenser of information; thus, if a bias exists at this level it would be in favour of the comparison group since the researcher has more than 13 years of experience in the traditional approach. Nevertheless, it is possible that the researcher may have put more effort into teaching the TBL groups because she was committed to the approach. A point worth mentioning here is that the study was done in one school only, with three classes in particular, on two biology units in grade 7, and for a period of about three weeks. As a result, it may not be possible to generalise the results. Moreover, the sample size was small, which prevented an analytical approach whereby the results could have been more statistically meaningful. Thus, the ability to generalise the results of this study to the population from which the sample was drawn is limited. Finally, not all instruments used were previously validated.

Conclusions

To the best of our knowledge, this is the first report on TBL done at the school level. This study is important because teachers need to devise new teaching methodologies that will be efficient and fun at the same time. In our opinion, the results obtained could be justification for a serious consideration of the introduction of TBL in the biology and sciences curricula. It could help students with demonstrable academic difficulties and support students in developing effective study habits because, as proposed by Roger Cousinet, during TBL sessions teachers stop 'teaching biology': instead, they present students with the means of knowledge acquisition (Cousinet 1972).

A similar study should be carried out over a longer period of time with a larger sample and more biology units, involving several private and public schools and many teachers. Any such large-scale study could measure the effects of TBL more accurately. It could

also more objectively evaluate students' performance and attitude and the willingness of teachers to adopt this new method of instruction. Another question for further research would involve testing the learning benefits of TBL when it is used in different subjects. Our work has received much encouragement and support from the school because students have learned in a way that has combined, according to Roger Cousinet, the pleasant and the useful. Both the students and those involved on the research side share the opinion that TBL was a valuable and illuminating educational experience.

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