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WEB PAPER

Both preparing to teach and teaching positively impact learning outcomes for peer teachers

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Abstract

Background: We sought to evaluate the independent effects of preparing to teach and teaching on peer teacher learning outcomes.

Aim: To evaluate the independent contributions of both preparing to teach and teaching to the learning of peer teachers in medical education.

Method: In total, 17 third-year medical students prepared to teach second-year students Advanced Cardiac Life Support algorithms and electrocardiogram (ECG) interpretation. Immediately prior to teaching they were randomly allocated to not teach, to teach algorithms, or to teach ECG. Peer teachers were tested on both topics prior to preparation, immediately after teaching and 60 days later.

Results: Compared to baseline, peer teachers' mean examination scores (±SD) demonstrated the greatest gains for content areas they prepared for and then taught (43.0% (13.9) *vs.* 66.3% (8.8), $p<0.001$, $d=2.1$), with gains persisting to 60 days (45.1% (13.9) *vs.* 61.8% (13.9), $p<0.01$, $d=1.3$). For content they prepared to teach but did not teach, less dramatic gains were evident (43.6% (8.3) *vs.* 54.7% (9.4), $p<0.001$, $d=1.3$), but did persist for 60 days (42.6% (8.1) *vs.* 53.2% (14.5), $p<0.05$, $d=1.3$). Increase in test scores attributable to the act of teaching were greater than those for preparation (23.3% (10.9) *vs.* 8% (9.6), $p<0.001$, $d=1.6$), but the difference was not significant 60 days later (16.7% (14.4) *vs.* 10.2% (16.9), $p=0.4$).

Conclusion: Our results suggest preparing to teach and actively teaching may have independent positive effects on peer teacher learning outcomes.

Background

The use of peer teaching – or "students-teaching-students" – continues to gain momentum within medical schools for many different reasons including increased resource efficiency, improved dynamics of the learning experience and preparing students for their future roles as educators (ten Cate & Durning 2007a). But perhaps one of the most relevant positive outcomes of the peer teaching process is the improved learning of the peer teachers themselves (Cloward 1967; Morgan & Toy 1970; Weiss & Needlman 1998; Tang et al. 2004; Roscoe & Chi 2007; Wong et al. 2007; Graham et al. 2008; Peets et al. 2009).

While numerous hypotheses exist, it remains unclear which particular aspects of the peer teaching process are responsible for these knowledge gains (Weiss & Needlman 1998; Tang et al. 2004; Buckley & Zamora 2007; Wong et al. 2007; Graham et al. 2008; Peets et al. 2009). However, the results of investigations that have explored the relative contributions of (1) preparing to teach and (2) subsequently teaching on important learning outcomes within other domains may help enlighten this issue.

First, Bargh and Schul (1980) asked college students to study a text passage with the intention of either being tested on the content, or teaching the content. Students who prepared to teach did not actually teach; instead both groups completed a recall/recognition test. Those who prepared to teach performed significantly better on the test, leading the authors to conclude that preparing to teach enhances learning beyond simply studying the material. Building on this, Annis (1983) performed a similar experiment but allocated students to three groups: reading with the intention of recalling, reading to teach but not actually teaching, and reading to teach and then teaching. Performance on the retention test was progressively higher for these three groups, suggesting that the process of teaching itself also enhances learning.

Unfortunately, we cannot simply extrapolate these findings to medical education. Subjects in these experiments faced

Practice points

- Peer teaching in undergraduate medical education has previously been shown to have both cognitive and non-cognitive benefits for peer teachers.
- The separate contributions of preparing to teach and actively teaching small group sessions have independent positive effects on knowledge gains for peer teachers.
- To optimize the learning experience for both peer teachers and their students, future studies should explore ways to improve how peer teachers' prepare to teach and subsequently how they teach.

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a very different task to that of our medical school peer teachers. Rather than spending between 5 and 15 min memorizing a text with the intention of sharing this with one other student, medical educators spend considerably longer preparing to facilitate the learning of a group of students, reviewing materials, organizing their knowledge and planning their educational strategy. In addition, classroom teaching sessions for medical students will be longer (hours rather than minutes) and will go far beyond reciting text, to include such tasks as application and synthesis of new information, the development of problem solving skills and interacting within a group setting.

Aims

Our objective in this study was to evaluate the independent contributions of both preparing to teach and teaching to the learning of peer teachers in medical education.

Method

Study design and subjects

This was a prospective, randomized intervention study. Our subjects were 17 third-year medical students who volunteered to teach second-year students on Advanced Cardiac Life Support (ACLS). We had planned to study 18 third-year students but one withdrew prior to the start of the study. The Conjoint Health Research Ethics Board at the University of Calgary approved our study and we obtained written informed consent from both the peer teachers and the second-year students they were teaching prior to the start of the study.

The University of Calgary is a 3-year medical school, with the first 2 years consisting of system-based courses that utilize didactic, small group, clinical, and laboratory-based learning experiences and with the last year being a traditional clinical clerkship. Prior to clerkship all second-year medical students took a mandatory, 4-h teaching session on ACLS that was designed by the authors. The course was delivered in two 120 min parts: (1) the American Heart Association (AHA) 2006 algorithms and (2) rapid electrocardiogram (ECG) interpretation. For this course, we randomly allocated all 150 second-year medical students into 24 groups of 6 or 7 students, and then randomized the small groups to either faculty or peer teachers.

About 3 days prior to the scheduled teaching session, we gave our peer teachers 4 h of ACLS review, including an overview of the course materials and suggestions on how to run each session. Afterwards, we gave them the teaching material for both the AHA algorithm and rapid ECG interpretation sessions to take with them. We asked them to prepare to teach both sessions and told them that they would be informed immediately prior to the teaching session which area, if any, they would be teaching. On the scheduled teaching day, we then randomly allocated peer teachers to not teach, to teach two sessions on AHA algorithms, or to teach two sessions on rapid ECG interpretation. Figure 1 shows an outline of our study design.

Evaluation of knowledge of peer teachers and learners

The peer teachers' knowledge of ACLS was evaluated using three 50-item multiple-choice question (MCQ) evaluations. One pre-test was administered just before the ACLS review session to evaluate baseline knowledge. The second MCQ evaluation, to assess knowledge acquisition, was written as an immediate post-test, either after the teaching sessions or, for peer teachers who did not teach, after being informed that they would not be teaching. The third MCQ evaluation, to assess knowledge retention, was administered 60 days after the scheduled teaching sessions as a delayed post-test. All study participants, including the non-teaching group were invited to participate. An examination blueprint was used to match test questions to the course objectives and to ensure that the content and format of the three examinations were the same – 25 items on AHA algorithms and 25 items on rapid ECG interpretation, with each item a "one-best-answer" question. In order to make the three MCQ examinations different, but equivalent in difficulty, prior to initiation of the study, we piloted all questions on four residents and repaired or deleted poor quality items. The remaining questions were then divided into a range of difficulty (high, medium, and low) based on how many of the residents got each question correct. Then, using the examination blueprint to ensure appropriate content, an equal number of questions with high-, medium-, and low-difficulty were assigned to each test.

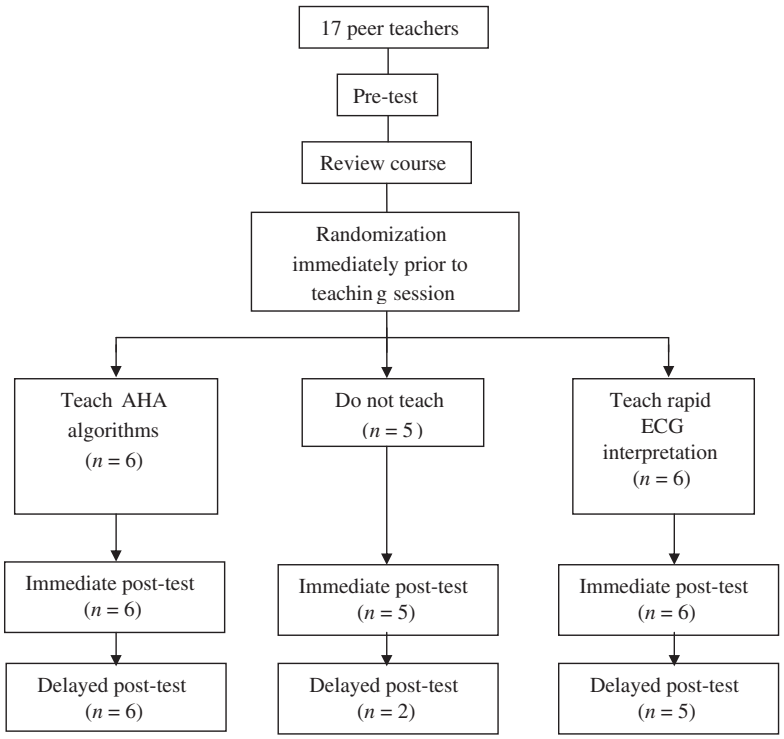
We used a similar procedure to evaluate knowledge of the second-year students before and after the ACLS teaching session, this time using two 20-item MCQ evaluations. We used Cronbach's α to assess reliability of each of our evaluations.

Statistical analyses

To assess the effect of preparing to teach on knowledge acquisition, paired *t*-tests were used to compare each peer teacher's score on the immediate post-test to his or her score on the pre-test in the content area(s) of AHA algorithms and/or rapid ECG interpretation that they *did not* teach. Therefore, the students who did not teach at all had their data included in the preparation-only subset for both content areas. To evaluate the effect of preparing to teach on knowledge retention, the same analysis was repeated, this time comparing delayed post-test scores to pre-test scores. A similar analysis was performed to assess the effect of preparing to teach and then teaching on knowledge – this time focusing on the scores from the content that the peer teachers taught. The change in knowledge from baseline in content areas taught *vs.* not taught (i.e. preparing and teaching *vs.* preparation only) was compared using a two-sample *t*-test, which was subsequently used as a surrogate for the additional impact that the act of teaching had on knowledge gains.

As a quality control measure, a two-sample *t*-test was used to compare the knowledge of students taught by faculty *versus* Peer teachers, both before and after the ACLS teaching session. Cronbach's α was used to assess reliability of each evaluation.

Our sample sizes were limited by the number of sessions to be taught and the class size for the peer teacher and second-year student groups, respectively; therefore, a formal sample



ACLS: Advanced Cardiac Life Support
AHA: American Heart Association
ECG: Electrocardiogram

Figure 1. Outline of our study design and participant flow.

Table 1. Peer teacher performance on three ACLS knowledge examinations.

Group	Pre-test (%)	Immediate post-test (%)		Delayed post-test (%)	
		Algorithm	ECG	Algorithm	ECG
Non-teachers	39.6 ($n=5$)	57.6 ($n=5$)	58.4 ($n=5$)	44.0 ($n=2$)	44.0 ($n=2$)
Algorithm teachers	42.3 ($n=6$)	66.0 ($n=6$)	54.0 ($n=6$)	59.3 ($n=6$)	50.0 ($n=6$)
ECG teachers	46.0 ($n=6$)	52.7 ($n=6$)	66.7 ($n=6$)	60.8 ($n=5$)	64.8 ($n=5$)

Note: The immediate and delayed post-test results are subdivided into the AHA algorithm and rapid ECG interpretation components of the exam.

size calculation was not performed. Statistical analyses were made using PASW Statistics Version 17.0 (SPSS Inc).

Results

Five of our peer teachers prepared to teach, but did not teach. Six of our peer teachers taught AHA algorithms and six taught rapid ECG interpretation. Each completed the pre-test (reliability 0.76), which demonstrated no difference in scores between the three groups (mean (SD) scores 39.6% (11.8) *versus* 42.3% (7.9) *versus* 46.0% (6.1), respectively, $p=0.49$). Each peer teacher completed the immediate post-test (reliability 0.81), and 13 completed the delayed post-test (reliability 0.68). The exam scores of the three peer teacher groups: non-teachers, AHA algorithm, and rapid ECG interpretation are shown in Table 1. These exam scores were subsequently combined into the categories *content area prepared and taught versus content area prepared* for further analysis as described in the methods section.

On the immediate post-test, we found the largest gains in knowledge occurred in the content areas that the peer teachers prepared for and then taught (66.3% (8.8) *versus* 43.0% (13.9), $p<0.001$, $d=2.1$). This gain persisted to the delayed post-test (61.8% (13.9) *versus* 45.1% (13.9), $p<0.01$, $d=1.3$). There was also a significant increase from baseline in the knowledge of peer teachers in the content area that they prepared to teach, but did not teach (54.7% (9.4) *versus* 43.6% (8.3), $p<0.001$, $d=1.3$). This gain in knowledge was also evident on the delayed post-test 60 days after the scheduled teaching session (53.2% (14.5) *versus* 42.6% (8.1), $p<0.05$, $d=1.3$).

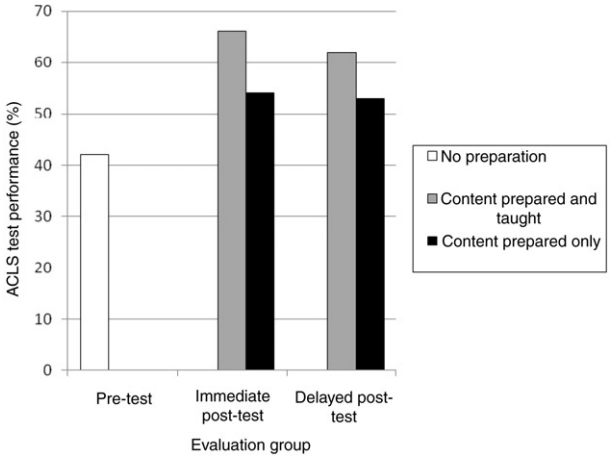


Figure 2. The effect of preparing to teach and teaching on peer teachers' test scores.

The absolute increase in knowledge attributed solely to teaching the sessions was higher than that attributed solely to the preparation for teaching (23.3% (10.9) *versus* 8% (9.6), $p<0.001$, $d=1.6$), although the difference was no longer significant 60 days later (16.7% (14.4) *versus* 10.2% (16.9), $p=0.4$). The effects of preparing to teach with and without teaching on peer teachers' knowledge acquisition and retention are summarized in Figure 2.

There was no difference in baseline knowledge of second-year students who were taught by faculty or peer learners (51.3% (13.1) and 51.8% (13.2), respectively, $p=0.8$), and post-test scores were also similar for both groups of students (55.5% (11.6) *versus* 56.5% (10.1), respectively, $p=0.6$).

Discussion

The results of this study are congruent with those of previous studies demonstrating short-term learning gains for peer teachers in medical education. However, our results additionally suggest that these gains persist, and are due to both preparations for teaching and the act of teaching itself. So, what are the mechanisms by which preparing to teach and teaching lead to long-term learning gains?

The most obvious reason for the benefits of teaching preparation is that more time spent studying leads to a more durable memory trace (Hayes-Roth 1977). Yet, in the experiments of Bargh and Schul (1980), and of Annis (1983), the same preparation time resulted in different learning outcomes – so, time alone is an inadequate explanation. It is more likely, therefore, that improved learning is due to the type, rather than amount of preparation. Preparing to teach is more stressful than preparing to learn, and although the relationship between arousal and learning is non-linear, the extra arousal in preparing to teach may have led to better storage in memory (Roozendaal et al. 1996). Our peer teachers are more likely to have engaged in training activities known to be associated with improved recall and performance, such as being more aware of their own learning processes – metacognition (Prins et al. 2006), spending more time organizing their knowledge (Mandler 1972), increasing the breadth and depth of their reading (Chamorro-Premuzic & Furnham 2008), and verbal rehearsal (Dawson 1980).

Cognizant of previous study in this area, we were not surprised to find that teaching preparation improved learning outcomes of peer teachers, and that these were sustained. But we did not expect to find that teaching itself led to additional learning gains that were similar in magnitude to that associated with preparation. It seems improbable that this was the direct result of new information provided by second-year students. Presumably, therefore, the act of teaching somehow improved storage and/or retrieval of existing knowledge.

On the immediate post-test, the content that the peer teachers taught should have been easier to retrieve from long-term memory as they had an additional 4 h of processing by working memory, and were endowed with the cognitive advantages of priming and recency (Bjork 1974; Ratcliff & McKoon 1988). But this does not explain the trend toward improved performance 60 days later. Interacting with learners can improve memory in both the short- and long-terms by several mechanisms. Vocalizing, either to oneself or to others, has been shown to improve learning, and drawing diagrams probably has a similar effect (Durling & Shick 1976; Gobert & Clement 1999). Learners can teach indirectly through questioning – enabling teachers to see new relationships between different elements – in addition to providing both verbal and non-verbal reinforcements by demonstrating their understanding, or otherwise, of concepts (Bargh & Schul 1980). By asking questions or for clarification, learners also may create a test-like atmosphere for the teacher, which has also been shown to reinforce knowledge retention (Carrier & Pashler 1992; Roediger & Karpicke 2006).

Peer teaching has also been demonstrated to provide additional rewards beyond content-specific knowledge gains, such as improved self-esteem, increased empathy, and preparation for future role as faculty teachers (Topping 1996; ten Cate & Durning 2007a, b). The involvement of peer teachers in medical education helps fulfill competencies advocated by organizations such as the Royal College of Physicians and Surgeons of Canada (RCPSC 2005), the Accreditation Council for Graduate Medical Education (ACGME 2007), and the Academy of Medical Royal Colleges (AoMRC 2009). These competencies which include collaboration, communication, scholarly activity including teaching and professionalism are quickly becoming mandatory considerations in undergraduate and postgraduate programs. Importantly, like other studies in the literature that have used peer teachers for ACLS and basic life support training, we found that these benefits seem to be achievable while still providing a quality educational experience for the learner (Perkins et al. 2002; Hughes et al. 2010).

This study has some important limitations. First, as mentioned earlier, the peer teachers had an additional 4 h of exposure to the material they were teaching with no equivalent exposure to the remaining material. As discussed previously there are plausible cognitive explanations, beyond simple time of exposure, to account for our results. Second, we did not have a control group with students simply studying the ACLS material. The gains we found cannot be directly compared to what may have occurred had the students merely studied for the same period of time. However, existing

literature has already suggested both preparing to teach and teaching provide superior knowledge gains compared to studying (Bargh & Schul 1980; Annis 1983). Third, we had a relatively small sample of peer teachers and a significant loss to follow-up for the delayed post-test. Three of the four subjects who failed to attend for the delayed post-test were from the non-teaching group, which reduced our power to demonstrate a difference in knowledge retention associated with teaching. This is clearly an important issue because short-term improvement in learning that quickly dissipates is a poorer justification for peer teaching. Fourth, our subjects were highly motivated volunteers who knew they were participating in a study – so, the effect of preparation and teaching on learning outcomes may have been inflated. Finally, the ACLS content taught in our study is algorithmic and rule-based. We are not able to assume similar peer teacher learning benefits or quality of students' experience compared to a faculty teaching for more complex skills or subjects, such as diagnostic reasoning (Rasmussen & Jensen 1974).

Future studies should attempt to better define which aspects of knowledge, skills, and attitudes can be improved through peer teaching. There may be multiple cognitive processes involved in peer teacher knowledge gains in both preparing to teach as well as teaching itself, so their exact nature and relative contribution to the learning process need to be further delineated. In addition, the merits of "Faculty Development" for peer teachers should be investigated; for example, educating them on how to prepare for teaching sessions or how to be a more effective teacher in the classroom could lead to improved knowledge gains for not only the peer teachers, but their learners too. Determining if residents, fellows or faculty who teach their peers experience similar gains to those demonstrated in our study may help guide how peer teaching is used in post-graduate medical education and continuing professional development. Ideally, efforts should also be made to undertake multi-institutional studies in order to increase the external validity of the results.

Conclusions

Our results suggest that both preparing to teach and teaching itself have independent positive effects on knowledge gains for peer teachers. Further studies are now needed to explore the separate contributions that preparation and teaching have toward cognitive gains and how best to optimize each of these processes in order to maximize the benefits for both the peer teachers and the learners.

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Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the article.

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