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# Docemur Docemus: Peer assisted learning improves the knowledge gain of tutors in the highest quartile of achievement but not those in the lowest quartile.

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## Abstract

**Objectives:** Peer assisted learning (PAL) is a form of collaborative learning where members of a peer group act as teachers for each other. A reciprocal PAL program was designed to investigate whether there were differential gains in knowledge acquisition amongst tutors compared with tutees.

**Design:** Bayesian statistical analysis was used to quantitatively assess the impact of tutor status on performance in a knowledge-based exam. Subgroup analysis according to student achievement and question difficulty was performed.

**Participants and setting:** Final year undergraduate medical students in a 5-year degree program (n=126)

**Results:** The overall probability of getting a correct answer on the knowledge exam was 49.7%. For questions on topics where a student had acted as a tutor this improved to 57.3%. However, students who performed in the upper quartile had a greater percentage gain in the probability of a correct answer in topics that they had taught versus students who performed in the lowest quartile.

**Conclusions:** There was demonstrable overall knowledge-gain associated with acting as a tutor in a PAL program but the greatest gain occurred in students of highest academic ability.

**Highlights:**

- Peer assisted learning is learning that occurs when peers help each other learn and learn by teaching.
- Gains in knowledge from acting as a peer-assisted learning (PAL) tutor have not been examined in detail in the medical education setting.
- Students who perform at the top of their class are more likely to demonstrate improved knowledge in areas which they taught, versus students who are achieving at the lower range of their class.
- Knowledge gains as a result of acting as a PAL tutor are limited in more difficult areas of the curriculum.

**Keywords**: Peer-assisted learning, Reciprocal, Tutor, Surgical education

**Abbreviations:**

PAL: Peer-assisted learning

## Introduction

The pedagogic rationale for involving students in their own teaching is that the technique promotes active learning. In peer-assisted learning (PAL) programs, there is teacher-learner duality[1], whereby the student learns through the process of teaching (Docemur docemus: Even as we teach, we learn). For the individual student, the act of teaching involves simplification, clarification and exemplification and requires both a thorough understanding of the concept being taught as well as the ability effectively to communicate it. Cognitive congruence theory indicates that near-peer teachers have a better understanding of the fund of knowledge, including the shortcomings of knowledge of their colleagues, thereby enabling them to better clarify problems at an appropriate level [2, 3].

Shulman[4] recognized undergraduate PAL programs as an extension of one of the signature pedagogies employed in the clinical setting, namely the apprenticeship model. This refers to the near-peer instruction that is common within clinical teams. A potential benefit of reciprocal peer tutoring programs, where all students at the same level act as tutor regardless of ability, is to facilitate equal opportunity involvement and reducing any potential associated social divisiveness [5, 6]. To date, few studies have assessed the learning benefits that tutors experience within PAL programs or whether tutors benefit from participation[7].

Previous studies report positive reactions to involvement as a PAL tutor with perceived increases in clinical, communication and teaching skills[8, 9]. Early work reported that students who act as both tutors and tutees make greater learning gains than those in fixed tutee roles[10]. The tutor role itself is of importance to students' experience of peer learning. Participant satisfaction, perceptions of good performance and actual performance were directly dependent on becoming a tutor and entering an equitable relationship in a psychological assessment of student perceptions of peer learning arrangements conducted by Rosen et al.[11] In their test of undergraduate general and specific competence, measured performance was contrasted in students who read material only, read with the expectation of having to teach it to a peer and read the

material and taught it to a peer [11]. The tutors learned more than the tutees in this experiment.

Some of the proposed benefits from acting as a tutor include improved performance at assessment and both increased satisfaction and lower stress due to the development of a reciprocal support system [11]. Conversely, concerns have been raised as to whether students are competent to provide large scale lecture-like teaching[12].

In a study by Iwata et al.[13] of 172 volunteer student PAL tutors of a total cohort of 1050 students, the PAL tutors had only a 1-3% increase in their final year examination results. In this study, PAL tutors taught more junior students history taking and clinical examination skills. PAL tutors scored above the class average in their exams indicating that students choosing to become tutors may have greater academic ability.

In the Department of Surgery at Trinity College Dublin, a reciprocal PAL program was designed for undergraduate final year medical students whereby all final year students acted as a tutor for their peers. The objectives of the study were to explore the role of the tutor within a peer assisted learning program using Bayesian statistical techniques, to assess whether performance in knowledge-based assessment is improved in topics in which the students acted as tutor versus topics for which they were the tutee and whether this varied according to the ability of the student tutor or according to the difficulty of the material examined.

## Methodology

### Brief description of the Peer learning program:

The PAL program was a mandatory part of the surgical teaching program, conducted over a 12 week period during the second semester of the final medical year. All 126 final year students participated in the program. During this time period, students participated in hospital-based attachment with clinical teams but had no other formal teaching sessions. During each PAL session a pair of students delivered a 10 minute seminar to all of their classmates on an assigned topic. Two one-hour sessions were scheduled per week. Three topics were covered in each session for a total of 66 topics over the course of the 12 weeks. The program was run concurrently on two clinical teaching sites and each student pair delivered two 10 minute seminars during the program. Students were randomly paired and each pair was randomly assigned their teaching topic. Topics were mapped to the surgical curriculum with the aim of ensuring all aspects of the curriculum were covered during the program.

Prior to their presentation the pair was expected to prepare a single page document summarizing the topic covered which was circulated to the class. All summary documents were saved to the teaching server and were made available to all students online. All presentations were reviewed in advance under the supervision of a specialist registrar (the lead investigator), ensuring factual accuracy and that the salient points of each topic were covered. This ensured the factual accuracy of the teaching content and highlighted any important omissions. Ethical approval for the study was obtained from the local institutional review board (IRB) and written informed consent was obtained from all participants.

### Study methods

In order to quantitatively evaluate gains in student knowledge as a result of acting as tutor in PAL program the end of year MCQ examination in surgery was used to assess gain in knowledge.

The MCQ is a component of the assessment for the surgery course for final year medical students. It comprises

50 questions with a single-best answer (A-E) format. Questions were randomly drawn from the department question bank and were mapped to the surgical curriculum to ensure coverage of a breadth of the surgical curriculum. Not all topics were directly examined in the MCQ exam. The MCQ was marked using an automated system located within the University. The MCQ was prepared in isolation from the knowledge of the content of the PAL sessions. The MCQs covered many of the topics included in the PAL program but the MCQ content was not directly drawn from information covered during those sessions.

A Bayesian approach to data analysis was employed, as standard frequentist hypothesis-based testing would require a very large difference between tutor and tutee performance in order to demonstrate statistical significance given the sample size available.[14, 15] Utilizing Bayes' theorem:

$$p(AB) = p(B|A)p(A)/p(B)$$

The probability of a student having a correct answer is designated pA. The probability of the student acting as tutor is designated pB. The results were tabulated as follows, where w,x,y,z are all numbers of times the event occurred:

| | Tutor | Tutee |
|---|---|---|
| Correct answer | W | X |
| Incorrect answer | Y | Z |

The question under study was: what is the probability of student getting a correct answer given that they were the tutor for that topic? This is designated p(B|A), the probability that the student is a tutor given that the answer is correct (=w/w+x); p(A) is the overall probability of the outcome occurring without knowledge whether they are a tutor(=w+x/w+x+y+z) and p(B) is the probability of being a tutor (=w+y/ w+x+y+z)

This allows the comparison between the probability of a student getting a correct answer when they are tutor versus

the overall probability of a correct answer. The probability of a correct answer when they are a tutee will be determined using similar analysis and the proportion of questions where they are tutees. If p(A/B) is greater than the observed probability of a correct answer then the null hypothesis is rejected.

Subgroup analysis was performed to assess whether the effect of tutor status was influenced by overall student performance. This was done to address whether student gains are greater in students who perform better on examinations versus those who perform less well.

Further analysis of the component questions was performed to analyze the data according to the difficulty of the questions, whereby questions with fewer overall correct responses may demonstrate a different degree of “tutor effect” than questions with a higher number of correct responses. Questions were ordered according to their difficulty using the overall percentage of correct answers achieved by the group. The questions were grouped into the most difficult questions (n=13) with the lowest probability of a correct answer and the easiest questions (n=13) with the highest probability of being answered correctly.

## Results

Of the 50 questions examined the overall probability of a correct answer was 49.7%. This increased to 57.3% when the analysis was restricted to questions on topics where students had acted as a tutor. Improved performance from acting as a tutor was seen in 31 (62%) of questions.

Students were then divided into quartiles based on their performance in the MCQ examination (Figure 1). Students who were in the highest quartile of performance had a probability of obtaining a correct answer on questions about topics where they were a tutor 69.7% of the time versus 57.8% of the time for questions on topics where they were a tutee. In 32/50 (64%) questions the probability of getting a correct answer was greater as a tutor than as a tutee. There was a 10.7% overall greater probability of a correct answer in tutored topics amongst the students with best performance in the test.

Conversely, students in the lowest quartile of performance had a probability of a correct answer on questions about topics where they were a tutor just 36.7% of the time versus 38.4% of the time for questions on topics where they were a tutee. In fact in only 48.7% of questions was there any benefit observed in terms of being a tutor translating into a 1.7% overall negative outcome from being a tutor.

There were 66 randomly assigned tutor pairs in total. Based on the overall MCQ score, the number of pairs that fell within concordant or discordant quartiles was calculated and were as follows: High-high 5, Mid-mid18 and Low-low 3. The discordant pairs were: High-low 7, High-mid 14, Mid-low 19. For the lowest quartile students, when paired with another lowest quartile student (n=3 pairs) the probability of getting a correct answer in questions where they acted as tutor was 25%. For lowest quartile students paired with a highest quartile student (n=7 pairs) the probability was 35.7%.

Questions were then ordered according to their difficulty. The questions were then grouped into the most difficult questions (n=13) with the lowest probability of a correct

answer (range: 7-33%) and the easiest questions (n=13) with the highest probability of being answered correctly (range: 66-88%). Of the 13 most difficult questions, only 54% of the questions had a greater probability of being answered correctly more frequently by tutors versus the 13 easiest questions where 77% of them were more likely to be answered correctly by tutors versus tutees (Figure 2). There was a 7.2% increased probability of correct answers in the tutor group where “difficult” questions were concerned versus 16.6% increased probability of correct answers in the tutor group where “easy” questions were examined.

## Discussion

The act of learning something new with the ultimate aim of teaching seems to improve knowledge organization and recall. However, a number of important aspects of the tutor role within peer learning programs have not been explored in detail, including the validity of using co-peers of all abilities as tutors and whether students of all abilities make similar gains in academic performance.

Benware and Deci [10] demonstrated that students randomly assigned to learn a topic with the intended purpose of teaching, performed better in a subsequent test of conceptual understanding compared to those who learned for the purpose of passing the test. Both groups performed equally well in a test of rote learning. Tutors were also more motivated and perceived their experience as more active and interesting.

This study, therefore, involved the use of tutors at the same educational level as tutees. This is an under-explored area in the literature. In fact, in a systematic review [16] of the ability of peer tutoring programs to improve or maintain the academic performance of health care professional students, reciprocal and collaborative peer learning studies were excluded due to the authors' concerns that poorly performing students may not have been able to fulfil the teaching role for students who were performing adequately. This review, therefore, only looked at the performance of programs where tutors were of more advanced knowledge than their tutees ('near peer tutors'). Of the 10 studies included in the review which compared the academic performance of students who received peer tutoring to those who received no additional tutoring, eight found improved performance, one found mixed results and one found performance to be lower in the tutored group. In a further 10 studies comparing peer tutoring to faculty tutoring groups, five studies showed no difference between groups, four showed mixed results and one found peer-tutored students to do better. The authors concluded that although further evaluation was necessary, reported evaluations, on balance, indicated that academic performance in tutored students was at least equivalent in

peer learning programs. Gains by the tutors in these programs were not specifically analyzed.

The use of Bayesian statistical analysis controls for the difficulty of the individual questions on the outcome as it takes the pre-test probability into account. Therefore, for questions for which more of the students have the correct answer, the pre-test probability of having a correct answer will be greater, allowing the effect of tutoring to be more precisely analyzed. Frequentist statistics were not appropriate for evaluation of the data given the study design since only a limited number of students could act as tutor for each topic, therefore, no matter how large the observed differences in performance they could never reach statistical significance due to the imbalance in the size of the groups to be compared. Interpretation of Bayesian statistics requires an assessment of the differences in probabilities under different conditions and a decision on whether the difference observed are of practical significance. It determines whether the probability of the observed events given certain conditions (e.g. whether the student is a tutor) is similar to the prior probability of the data (e.g. the outcomes of the results of students who were not tutors)[17]. If the difference in~~s~~ probabilities is large enough to be of practical importance then this represents a probable true difference in outcome. Bayesian statistics do not exclude that some part (or all) of the difference in probability may be due to chance alone.

In terms of the performance of students, these data support the hypothesis that students who perform best in knowledge tests are more likely to gain most from acting as a tutor. Students who were in the highest quartile of performance had a probability of obtaining a correct answer in the tutee topics 57.8% of the time and in the tutor topics of 69.7% of the time - a 10.7% overall greater probability of a correct answer in tutored topics amongst the students with best performance in the test. Conversely, students who achieved in the lowest quartile, did not have a higher probability of a correct answer in topics that they had tutored versus topics in which they were taught by other students. Based on a small number of students, there appeared to be an effect of outcomes for the lowest

performing quartile students when paired with students of different abilities. Lowest quartile students paired with a highest quartile student had a greater probability of a correct answer in questions when they acted as tutor (35.7%) versus the lowest quartile students paired with another lowest quartile student (25%).

In a previous study by Iwata et al. of the impact of PAL tutoring on performance in final year examination, the small improvement in overall scores amongst tutors (of 1-3%) was not statistically significant when prior academic performance was controlled for[13]. PAL tutors in the highest quartile of performance throughout medical school in this study, scored better in the clinical component of their final exam than students who had not participated in PAL tutoring. Overall the study suggested that academically strong students have a tendency to volunteer to become peer tutors. In the present study, all students participated but only the highest performing students demonstrated any gain in knowledge supporting the hypothesis that academically strong students seem to benefit most from teaching.

In comparison to the previous study by Iwata et al.[13] which demonstrated little impact of peer tutoring on examination results and where PAL tutors taught more junior students basic clinical skills, in the present study, peer tutors were involved in teaching knowledge aspects of the curriculum which were directly relevant to their own current learning aims. This may explain the larger improvements in performance noted by academically strong tutors in this study – the material they had taught was actually examined during the assessment, allowing them to exploit the enhanced fund of knowledge gained from preparing to tutor.

With respect to the difficulty of the knowledge examined, when questions were examined according to the difficulty of the question, (rated as questions most likely versus least likely to be answered correctly), the effect of being a tutor was greatest for the easiest questions. That is, in questions with the highest~~lowest~~ probability of being answered correctly, students who were tutors were 16.6% more likely to answer these questions correctly versus the tutees.

However, for the most difficult questions, tutors were only 7.2% more likely to answer questions correctly than those whom they taught.

This study has number of potential biases and limitations. Limitations of the study include that the interaction of the student pairs and the amount of time spent preparing material for the seminar was not assessed. Data on whether students had a particular interest or career preference for surgery were not prospectively recorded and this is a confounding factor. Any tutor related gains may just be a result of spending a greater amount of time studying the topic and this was not measured. There may be an effect of study participation (Hawthorne effect) which is not controlled for in the study design[18]. There is also a limited ability to control for learning that takes place outside of the PAL program, whereby students must organize and direct their own learning within the pre-existing curricular structure. Thus gains may be attributed to the PAL program but were not due to the PAL program. Similarly pre-intervention measurement of knowledge was not captured. However, this study is in a "real-life" setting. The program should orientate the learners to the surgical curriculum and help them direct their learning appropriately. Therefore, credit for any improvements in surgical knowledge may be largely credited to the PAL program, particularly as the tutored students act as a control for each question and therefore, if this topic was covered in greater detail in other parts of the teaching program, there should be no greater probability of a correct answer in the tutors for this topic versus the tutees, unless there is a benefit from being a tutor.

The form of assessment of knowledge acquisition for the study is through the use of a multiple choice question exam paper, formatted as a course-related assessment. This does not measure deep learning nor the use of deep learning techniques. It must be acknowledged that MCQ tests are more often a test of knowledge (recognition/recall) rather than higher order learning such as understanding and manipulation/application (when compared to extended matching questions, essays or viva voce examinations as assessment tools). For the purposes of this study, the PAL

program is based on the transmission of factual information and therefore, examination in the form of MCQ is not wholly inappropriate. Furthermore, the MCQs themselves are based on clinical scenarios and therefore, require more complex data interpretation skills than standard fact-based MCQs. The broader validity of MCQ assessment is a matter of much conjecture, but MCQs remain a pillar of assessment in most medical schools[19].

In conclusion, using Bayesian statistical techniques, knowledge gain associated with tutoring was quantitatively assessed and demonstrated a gain in knowledge from acting as a tutor which was greatest in those students who performed in the highest quartile of achievement. Students in the lowest quartile did not gain knowledge in a test from acting as tutor. The gain from acting as a tutor was greatest from easier material examined than more difficult topics. These findings are important as they quantify the beneficial impact of PAL programs and for the first time, the tutor effect according to tutor ability and difficulty of the material being examined.

This study has implications for the role of peer tutoring in the medical undergraduate curriculum. This study suggests that students who perform at the top of their class may be better suited to acting as tutors and this may have implications where peer tutor places are limited. Students who are achieving at the lower range of their class may not gain from acting as a tutor. Whether specific interventions to more closely mentor these students during their teaching practice or allocating less difficult aspects of the curriculum to these students helps improve their knowledge acquisition remains a question for further study.

## References


1. Dandavino M, Snell L, Wiseman J. Why medical students should learn how to teach. *Medical Teacher* 2007; 29(6):558-565.
2. Lockspeiser TM, O'Sullivan P, Teherani A, et al. Understanding the experience of being taught by peers: the value of social and cognitive congruence. *Adv Health Sci Educ Theory Pract* 2008; 13(3):361-72.
3. Schmidt HG, Moust JH. What makes a tutor effective? A structural-equations modeling approach to learning in problem-based curricula. *Academic Medicine* 1995; 70(8):708-14.
4. Shulman L. Signature pedagogies in the professions. *Daedalus* 2005; Summer:52-59.
5. Topping KJ. Trends in peer learning. *Educational psychology* 2005; 25(6):631-645.
6. Fantuzzo JW, Dimeff LA, Fox SL. Reciprocal Peer Tutoring: A Multimodal Assessment of Effectiveness With College Students. *Teaching of Psychology* 1989; 16(3):133-135.
7. Ten Cate O, Durning S. Dimensions and psychology of peer teaching in medical education. *Medical teacher* 2007; 29(6):546-552.
8. Weyrich P, Schrauth M, Kraus B, et al. Undergraduate technical skills training guided by student tutors–analysis of tutors' attitudes, tutees' acceptance and learning progress in an innovative teaching model. *BMC medical education* 2008; 8(1):18.
9. Buckley S, Zamora J. Effects of participation in a cross year peer tutoring programme in clinical examination skills on volunteer tutors' skills and attitudes towards teachers and teaching. *BMC medical education* 2007; 7(1):20.
10. Benware CA, Deci EL. Quality of Learning with an Active versus Passive Motivational Set. *American Educational Research Journal* 1984; 21(4):755-765.
11. Rosen S, Powell ER, Schubot DB. Peer-tutoring outcomes as influenced by the equity and type of role assignment. *Journal of Educational Psychology* 1977; 69(3):244-252.
12. Glynn LG, MacFarlane A, Kelly M, et al. Helping each other to learn - A process evaluation of peer assisted learning. *BMC Medical Education* 2006; 6.
13. Iwata K, Furmedge DS, Sturrock A, et al. Do peer-tutors perform better in examinations? An analysis of medical school final examination results. *Medical education* 2014; 48(7):698-704.
14. Athanasiou T, Debas H, Darzi A. Key topics in surgical research and methodology: Springer, 2010.
15. Gurrin LC, Kurinczuk JJ, Burton PR. Bayesian statistics in medical research: an intuitive alternative to conventional data analysis. *Journal of Evaluation in Clinical Practice* 2000; 6(2):193-204.
16. Santee J, Garavalia L. Peer tutoring programs in health professions schools. *American journal of pharmaceutical education* 2006; 70(3).
17. Ni Z, Phillips LD, Hanna GB. The Use of Bayesian Networks in Decision-Making. Key Topics in Surgical Research and Methodology: Springer; 2010:pp. 351-359.
18. Cook DL. The Hawthorne effect in educational research. *The Phi Delta Kappan* 1962; 44(3):116-122.
19. Epstein RM. Assessment in Medical Education. *New England Journal of Medicine* 2007; 356(4):387-396.