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MONOGRAPH

Peer Tutoring in Preclinical Medical Education: A Review of the Literature

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Abstract
Peer-assisted learning (PAL) is an educational method where students teach their peers. PAL has been increasingly integrated into medical education in various formats including near-peer tutoring (NPT), reciprocal-peer tutoring (RPT), and peer-to-peer tutoring. This review adds to current literature by focusing exclusively on outcomes from PAL peer tutoring programs implemented in conjunction with basic science courses in medical education. Although the programs differ in size, duration, course, resource availability, and method of evaluation and thus can be difficult to compare, PAL programs overall demonstrate benefits for both tutors and tutees and merit further investigation into optimal methods of implementation.

Keywords Peer-assisted learning · Near-peer tutoring · Reciprocal-peer tutoring · Peer-to-peer tutoring

Introduction

Peer-assisted learning (PAL) is an educational method where students learn from other students [1]. PAL is used in many medical schools for both preclinical and clinical studies, but the program design, reason for implementation, and method of evaluation often differ. In near-peer tutoring (NPT), the tutor is more advanced in training (often by at least 1 year) compared to the tutee [2]; in reciprocal-peer tutoring (RPT), students within the same year of training and course of study alternate between serving as the tutor and tutee [2]; in peer-to-peer tutoring, stronger students are designated tutors, and those in need of support are designated tutees as they simultaneously take a course [3]. Within each of these categories, some peer tutoring programs are designed for one-on-one sessions, while others implement small groups or larger lecture formats. The goals of these programs often differ; some are implemented to help struggling students in a course [4], and some supplement the limited number of faculty available [5, 6], while others are created to train students how to teach prior to residency [6, 7]. Many methods have been used to qualitatively and quantitatively evaluate PAL programs. Some studies focus on subjective feedback, while others evaluate examination scores to provide quantitative results, and some integrate both methods.

Such differences make it difficult to directly compare outcomes from studies of medical school PAL programs, but prior reviews have shown some similarities in how peer teaching programs can benefit tutors, tutees, and medical educators [2, 6, 8, 9]. This literature review exclusively focuses on PAL peer tutoring programs implemented in conjunction with medical school basic science courses. We aim to provide insight into the implementation, strengths, weaknesses, and evaluative methods of peer tutoring programs used in these preclinical courses and distinguish between subjective and objective outcomes to better elucidate commonalities in qualitative and quantitative results.

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Near-Peer Tutoring (NPT) Programs in Medical School Basic Science Courses

Subjective Outcomes for Tutees

Many studies that evaluated qualitative feedback from tutees' participants in near-peer tutoring (NPT) programs emphasized that students benefitted from social and cognitive congruence

(Table 1). Social congruence promotes a sense of camaraderie and openness through a shared understanding of the difficulties of medical school; cognitive congruence is an ability to explain how to learn and synthesize information at the level of a medical student [10]. Lockspeiser et al. (2008) described a supplementary, voluntary NPT program where second year students led weekly review sessions throughout the year covering anatomy, physiology, pathology, medicine, and pharmacology for small groups of 5–10 first year students. Student tutors were perceived by the tutee group as able to connect over common medical school struggles and explain strategies for understanding complex topics [10]. Similarly, Nelson et al. (2013) found that senior medical students teaching younger students case-based problems in a 6-week basic science course were perceived by tutees to create a welcoming learning environment and provide compassion for the stressors of medical school [11]. Other studies have also found that peer-led learning sessions have been viewed positively by tutees [12–14].

Multiple studies have examined how students evaluated faculty-led basic science small group sessions compared to student-led sessions (Table 1) [13, 15–17]. Hall et al. (2014) evaluated whether a larger difference in training experience between tutors and tutees impacted social and cognitive congruence. They compared feedback regarding enjoyment, approachability, use of time, delivery of teaching, and relevance of content from two neuroanatomy small group review sessions led by either recent medical school graduates or senior medical students. They reported that senior medical students were evaluated significantly higher in all aspects, with the exception of approachability and relevance of content [15]. Tayler et al. (2015) found that near-peer tutors leading groups of 10–17 first and second year medical students in pathology tutorial sessions were rated as more approachable, aware of learning outcomes, and receptive to student input compared to consultant pathologists leading the sessions [17]. Similarly, Nagraj et al. (2019) evaluated a program where senior medical students, who were also studying to receive a master's degree in clinical education, led problem-based learning (PBL) sessions for second year medical students throughout the year. Students rated the peer teachers higher than faculty in demonstrating interest in learning, providing guidance, and encouraging discussion [16].

Bulte et al. (2007) surveyed tutees participating in NPT programs at two institutions, one where final year students were required to lead a single 2-hour tutorial session for first or second year students, and the other where clinical year students had the option to teach first and second year students in multiple small group laboratory sessions throughout the year. Surveys sent to participating tutees asked about strengths and weaknesses of the student-led sessions and whether participants believed they learned more from student- or faculty-led sessions. At both institutions, tutees perceived that NPTs took more time to explain concepts and were better at discussing study strategies compared to faculty. However, half of surveyed tutees preferred faculty, while only 1/5 preferred peer tutors, potentially because reported weaknesses included lack of student knowledge compared to experienced clinicians [18]. Similarly, Carroll (1996) found that in a 6-week tutorial program focused primarily on biochemistry, tutees felt student tutors were less able to answer questions compared to faculty. However, a separate study reported student feedback from a 1-week student-led tutorial program designed as an introduction to cell biology: the tutors were accessible, adequately prepared to teach, and had a good understanding of course content [19]. This suggests that NPT may be best implemented for shorter periods of time so that student tutors can more easily master a smaller amount of content while balancing the demands of their own coursework.

Cianciolo et al. (2016) compared video recordings of nine small group PBL sessions for second year students led by near-peers, clinical faculty, or basic science faculty throughout three different system-based units. A second year student, fourth year student, and behavioral scientist individually assessed the recordings and noted observations such as who participated in group discussion, the nature and content of discussion, and body language. They found no differences in the nature of tutee's social interaction based on the type of tutor. They therefore proposed the value of professional congruence, shared among any type of teacher (student or faculty member) who contributes to students' professional development [20]. The idea of professional congruence is supported by Durán et al.'s study (2012), which found that tutees participating in clinical case-based sessions, laboratory sessions, and image-based sessions in an anatomy course rated student and faculty tutors similarly in overall satisfaction, communication, and ability to motivate students [5].

Objective Outcomes for Tutees

Many studies report that NPT participation improves tutees' examination scores, post-tutorial quiz scores, and course grades (Table 1). Gallan et al. (2016) found that students participating in small group, case-based NPT sessions in biochemistry demonstrated an increased percentage of correctly answered clinically oriented examination questions compared to students from the previous year's non-NPT class which took the same examination, although statistical significance was not reported [21]. Similarly, Jackson et al. (2012) found an 8% increase in the average student physiology course examination score after implementation of a supplementary and voluntary small group NPT program, although they also did not report if this increase was statistically significant [22]. A study of a 1-year-long, near-peer-led review course for USMLE Step 1 covering multiple choice questions and high yield content found that the 84 self-selected students who participated in 50% or more of sessions scored significantly

Table 1 Summary of near-peer tutoring (NPT), reciprocal-peer tutoring, and peer-to-peer tutoring studies in medical school basic science courses

Study	Program design	Course	Intervention	Number of participants	Subjective evidence?	Objective evidence?
Alcamo et al. (2010)	NPT	USMLE Step 1 Prep	Weekly small groups	198 tutees	Y	Y
Alvarez et al. (2019)	NPT	Anatomy	Weekly sessions for a semester	24 tutors	Y	N
Amorosa et al. (2011)	NPT	Basic sciences	Mixed	92 enrolled tutors	Y	N
Batchelder et al. (2010)	NPT	Basic sciences	System-based reviews	310 tutees, 48 control	Y	Y
Bulte et al. (2007)	NPT	Basic sciences	Review and lab sessions	77 tutees	Y	N
Carroll (1996)	NPT	Basic sciences	Mixed	300 tutees	Y	N
Cianciolo et al. (2016)	NPT	Basic sciences	PBL sessions	9 small groups	Y	N
Duran et al. (2012)	NPT	Anatomy	Mixed	700 tutees	Y	N
Erie et al. (2013)	NPT	Anatomy	Mixed	25 tutors	Y	N
Evans et al. (2009)	NPT	Anatomy	Lab sessions	12 tutors	Y	N
Gallan et al. (2016)	NPT	Biochemistry	Case review session	137 tutees	Y	Y
Gottlieb et al. (2017)	NPT	Pathophysiology	Case-based alongside faculty	114 tutees, 13 tutors	Y	N
Hall et al. (2014)	NPT	Neuroanatomy	Small groups	99 tutees	Y	N
Horneffer et al. (2016)	NPT	Anatomy	Tutor prep course	285 tutees, 27 tutors	N	Y
Hurley et al. (2003)	NPT	Study of Disease	Small groups	85 tutees	N	Y
Jackson et al. (2012)	NPT	Physiology	Small groups	94 tutees	N	Y
Jayakumar et al. (2015)	NPT	Basic sciences	One-on-one	47 tutees	N	Y
Kibble (2009)	NPT	Physiology	Case-based small groups	68 tutees	N	Y
Lockspeiser et al. (2008)	NPT	Basic sciences	Small groups	47 tutees, 16 tutors	Y	N
Morgan et al. (2017)	NPT	Basic sciences	USMLE question-based sessions	200 tutees	N	Y
Nagraj et al. (2019)	NPT	Basic sciences	PBL sessions	598 tutees	Y	N
Nelson et al. (2013)	NPT	Basic sciences	Medical education rotation	358 tutees, 24 tutors	Y	N
Oda et al. (2014)	NPT	Basic sciences	PBL sessions	191 tutees, 29 tutors	Y	N
Rengier et al. (2010)	NPT	Anatomy	Review sessions	64 tutees	N	Y
Reyes Hernandez et al. (2015)	NPT	Anatomy	One-on-one and group reviews	120 tutors	Y	N
Sammaraiee et al. (2016)	NPT	Basic sciences	Case-based sessions	205 tutees	N	Y
Sawyer et al. (1996)	NPT	Basic sciences	Small groups	127 tutees	N	Y
Schaffer et al. (1990)	NPT	Basic sciences	One-on-one and small groups	316 tutees	N	Y
Shankar et al. (2011)	NPT	Basic concepts	Review sessions	75 tutees	Y	N
Sobral (1994)	NPT	Basic sciences	PBL sessions	421 tutees	Y	Y
Sobral (2002)	NPT	All	Retrospective lit. Review	447 total	N	Y
Swindle et al. (2015)	NPT	Basic sciences	One-on-one	51 tutees	Y	Y
Tayler et al. (2015)	NPT	Pathology	Tutorial sessions	487 tutees	Y	N
Ten Cate et al. (2012)	NPT	Basic sciences	Retrospective lit. Review	9923 tutees	N	Y
Walker-Bartnick et al. (1984)	NPT	Basic sciences	One-on-one	122 tutees	N	Y
Wong et al. (2007)	NPT	Basic sciences	Small groups	212 tutors	N	Y
Abedini et al. (2013)	RPT	Pharmacology	Lecture sessions	32 total	N	Y
Bentley et al. (2009)	RPT	Anatomy	Dissections	297 total	Y	Y
Han et al. (2015)	RPT	Anatomy	Dissections	134 total	Y	Y
Krych et al. (2005)	RPT	Anatomy	Dissections	44 total	Y	N
Manyama et al. (2016)	RPT	Anatomy	Dissections	148 total	Y	Y
Peets et al. (2009)	RPT	Pathophysiology	Small groups	135 total	N	Y
Steele et al. (2000)	RPT	Basic sciences	PBL sessions	127 total	N	Y
Agius et al. (2018)	P2P	Anatomy	Anatomy dissections	147 tutees	Y	Y
Kassab et al. (2005)	P2P	Hematology	Problem-based learning sessions	91 tutees	Y	Y
Moore (2017)	P2P	Behavior	Small groups	~100 tutees	Y	N
Provencio et al. (2018)	P2P	Basic sciences	One-on-one	30 tutees	N	Y
Trottier (1999)	P2P	Pharmacology	Small groups	~350 tutees	N	Y
Turk et al. (2015)	P2P	Anatomy	Small groups	56 tutees	N	Y

higher on USMLE Step 1 compared to students who did not participate in the program [23]. Another study compared end-of-course examination results for students who participated in small group PBL sessions led by near-peers versus faculty and found that students who attended peer-led sessions had higher scores in 29 out of 36 courses evaluated over 5 years. On average for all courses, the groups tutored by near-peers had significantly higher scores than faculty-led groups [24]. Studies have also demonstrated that when small group sessions incorporate NPT, tutee understanding of course content improves; this has been demonstrated in multiple voluntary, small-group, supplementary NPT programs in medical school basic science courses where post-tutorial quiz scores were higher than pre-tutorial quiz scores [25–27]. This has also been demonstrated in a 3-day rapid review course of anatomy taught in a NPT large group format [28].

However, one study by Batchelder et al. (2010) did not find a significant difference in examination results between students who attended 11 peer-led system-based review sessions, which included large group lecture and small group case studies and students who did not attend the sessions. Nevertheless, the authors concluded that the program was beneficial given significant increases in students' perception of preparedness for the examination after attending NPT sessions compared to students who did not attend [29]. This demonstrates that although measuring changes in examination scores is an important method to evaluate NPT programs, lack of quantitative improvement should not necessarily preclude program implementation.

Studies have also demonstrated that NPT is particularly beneficial for students who struggle with a course (Table 1). A retrospective analysis of 3 years of data from a primarily one-on-one, voluntary NPT program found that unsatisfactory examination performance had a statistically significant relationship with participation in the program, indicating that students who had difficulty in a course may have sought peer tutoring [30]. Morgan et al. (2017) examined whether first year medical student participation in a NPT program improved in second semester course grades compared to first semester course grades. Among students with first semester course grade averages between 70 and 79%, only those with high or moderate attendance significantly improved their grades, while those in the 70–79% grade range with low attendance showed no significant improvement [31]. Swindle et al. (2015) examined the effect of a near-peer tutoring program in an osteopathic medical school for anatomy, histology, genetics, physiology, and/or osteopathic principles and practice. They found that students who were most at risk of failing the course had significant improvements in their course grades after both 3–4 months of tutoring and after 8–9 months of tutoring [32]. A study by Jayakumar et al. (2015) in an allopathic medical school demonstrated that failing medical students participating in a one-on-one NPT program for system-based courses significantly improved their examination scores by 11% after receiving tutoring [4]. Another one-on-one peer tutoring program implemented mainly for students having difficulty with basic science courses in an allopathic medical school reported that 86% of students passed the course in which they were tutored; however, no comparisons were drawn between examination scores pre-and post-tutoring [33]. Sawyer et al. (1996) found that implementation of a program supplementing basic science courses with peer-led small group sessions led to decreased failure rates on the first two examinations for students identified as at-risk for failure compared to previous years without the program (although not all changes were statistically significant) [34]. Thus, studies have demonstrated that NPT improves tutee examination scores and may potentially prevent medical school basic science course failure.

Horneffer et al. (2016) evaluated the impact of tutor training programs on tutee examination grades in anatomy. During a 2-day training period, tutors participated in a series of workshops covering topics including methods of feedback, teaching strategies, lesson structure, group dynamics, and handling difficult teaching situations. The study found the overall failure rate was lower, and two course examination grades were significantly higher in tutees taught by trained tutors compared to tutees taught by non-trained tutors [35]. Thus, tutor training has demonstrated value.

Subjective Outcomes for Tutors

Multiple studies have concluded that NPT programs benefit tutors (Table 1). Qualitative feedback from tutors included reported increased ability to solidify knowledge and improved teaching and communication skills [7, 11, 25, 26, 32, 36–40]. Furthermore, most tutors felt NPT programs should be continued in future years and/or would recommend that other students participate as tutors [11, 21, 25]. Alvarez et al. (2019) further noted that student tutors for an anatomy course developed resiliency, as they had to overcome the fear of admitting when they did not know something [41]. Thus, overall, subjective assessment of NPT programs support their implementation, as they are reported to foster an open and encouraging learning atmosphere while helping tutors develop skills necessary for careers in medicine.

Objective Outcomes for Tutors

Overall, studies indicate that NPT is beneficial for both tutors and tutees (Table 1). A study by Wong et al. (2007) evaluated whether serving as a near-peer tutor for small groups affected standardized examination scores and academic performance; they found that tutors had significantly higher Step 1 scores, Step 2 CK scores, and medical school GPAs compared to a matched cohort of non-tutors with similar demographics and

metrics at admissions [42]. Similarly, Sobral (2002) found a positive relationship between the number of courses for which a student tutored and medical school GPA; among peer tutors, a higher number of courses tutored were associated with greater increases in GPA [43]. Of note, the authors of this study did not mention whether tutors had similar baseline GPA and thus similar room for improvement.

Peer-to-Peer Tutoring Programs in Medical School Basic Science Courses

Subjective Outcomes for Tutees

Peer-to-peer tutoring programs were implemented primarily in PBL groups. Many studies have evaluated whether student-led groups were as effective as faculty-led groups (Table 1). Kassab et al. (2005) found that strengths of student-led small group PBL sessions covering hematology included a relaxed learning environment and a shared understanding of stressors of medical school. However, student tutors had more difficulty explaining and analyzing problems when compared to faculty [44]. Moore (2017) compared student-led and faculty-led small group PBL sessions in a human behavior course and found that certain reinforcement methods helped tutees clarify information; these included tutees attending faculty lectures or completing written reports after student-led PBL sessions [45]. One study examined peer-to-peer learning in anatomy laboratory sessions, where tutors guided peers in active dissections and led video dissections after 6 weeks of preparation with faculty. Tutees reported experiencing a positive learning environment and had confidence in their peers' ability to teach [46]. Collectively, these studies indicate that peer-led PBL groups can benefit tutees as they provide a supportive learning environment, but tutors may require additional training or reinforcement methods to address inexperience with course content.

Objective Outcomes for Tutees

Studies evaluating objective measures of peer-to-peer tutorials are limited (Table 1). Provencio et al. (2018) paired students, some who had previously failed a course and some who had not, with high-performing peers in the same course. The study found that five of the six tutees who had previously failed subsequently passed the course, and 22 of the 24 participating students passed overall [3]. Although many outside factors could have contributed to this passing rate and results were not compared to failing students who did not receive tutoring, this study suggests that peer-to-peer tutoring programs may help prevent course failure. Kassab et al. (2005) found that examination scores of students who attended peer-led hematology PBL sessions were not significantly different than those who attended faculty-led sessions [44]. Trottier et al. (1999) reported that students scored significantly higher on questions pertaining to content covered by peer-led small group sessions on 5 out of 11 examinations compared to questions associated with lecture-based content [47]. Based on these few studies, peer-to-peer tutorial PBL sessions appear to be as effective as faculty-led PBL sessions [44] and may be especially beneficial for students having difficulty in a course [3].

Objective Outcomes for Tutors

Studies assessing outcomes for tutors in PAL peer-to-peer tutoring programs are scarce (Table 1). In a study by Agius et al. (2018), scores on an anatomy examination were compared between tutors and non-tutors. Tutors were randomly selected from a group of students who expressed interest in teaching, regardless of their performance. Overall, tutors performed better on anatomy examinations and significantly better on the cumulative basic sciences examination. This study suggests that serving as a peer-to-peer tutor may contribute to higher examination scores [48].

Reciprocal-Peer Tutoring Programs in Medical School Basic Science Courses

Subjective Outcomes

Studies evaluating reciprocal-peer tutoring (RPT) programs primarily involved anatomy laboratory sessions (Table 1). Overall, subjective evaluations of these programs from participating students were positive, although multiple studies reported concern over inadequate training and teaching experience. Bentley et al. (2009) described a program where students either served as "primary dissectors," those who dissected the cadaver ahead of time and then taught their peers, or "peer learners." The study found that most students felt the program should continue but that more primary dissector training with faculty prior to teaching sessions should be implemented [49]. This is supported by Manyama et al.'s (2016) study, where student teachers received supplementary training prior to leading dissections, and 91% of "primary dissectors" believed their knowledge of anatomy improved. Participating students from both studies reported that a drawback of RPT programs was a reduction in hands-on dissection time [49, 50].

In contrast, the RPT program described by Krych et al. (2005) was supplementary, such that it did not detract from active dissection time in anatomy laboratory sessions. Students who were to provide demonstrations to their classmates ("demonstrators") were trained by faculty prior to laboratory sessions and were able to ask questions until they felt prepared to teach. The demonstrators performed the prepared exercise for four small groups of students. Student

demonstrator feedback indicated that serving as a teacher increased their understanding of anatomy concepts and the repetition enhanced long-term retention of the topic [51]. These studies suggest that RPT in anatomy laboratory sessions can strengthen students' anatomical knowledge particularly when serving as the teacher, but pre-session training by faculty is necessary, and the use of RPT should not reduce active dissection time.

Objective Outcomes

Conflicting results have been reported about how RPT affects student examination grades (Table 1). In a study by Steele et al. (2000), small groups of 10 students were randomly assigned to attend case-based RPT or faculty-led sessions. There was no significant difference in examination scores between peer-led and faculty-led sessions, indicating that the RPT sessions were as effective as faculty-led sessions [52]. In contrast, Abedini et al. (2013) compared pre-session and post-session examination scores from students who attended faculty-led lectures to students in RPT sessions during a pharmacology course and found students in RPT groups had significantly greater increases in scores [53]. Similarly, a different study of RPT used in small group sessions covering limb anatomy found students in the peer-led RPT groups had significantly higher midterm and final examination scores compared to students who were in faculty-led groups [54].

Bentley et al. (2009) compared the average anatomy practical examination score of a class that did not use the RPT program to the average practical examination score of a class that used RPT and found no significant differences. Of note, the study did not control for differences in undergraduate GPA, MCAT scores, or other metrics [49]. In contrast, Manyama et al. (2016) instituted RPT halfway through the semester, which allowed for a comparison of grades within the same class prior and subsequent to program implementation. This study reported a significant increase in anatomy examination scores after RPT was implemented, with students who were previously failing examinations demonstrating the greatest degree of improvement [50]. Similarly, Han et al. (2015) reported that in an anatomy, RPT program examination scores were significantly higher in RPT groups compared to students in faculty-led dissection groups [55]. Another study reported the outcomes of a gastroenterology/hematology RPT program over 22 small group sessions. There was a significant increase in the average score on examination questions covering topics taught using RPT compared to the average score for questions not covered during RPT sessions. [56]. Thus, repetition, adequate preparation, and supervised training may enhance RPT strategies and contribute to beneficial outcomes.

Discussion

Overall, near-peer tutoring, peer-to-peer tutoring, and reciprocal-peer tutoring programs instituted in the basic science medical school curriculum appear to be beneficial for both tutors and tutees. Strengths of these programs include promoting a safe learning environment, discussions of applicable study strategies, mentorship about difficulties in medical school, and improving teaching and communication skills. Peer tutoring programs may help increase student grades and examination scores, especially among those who are at-risk of failing. Sufficient training of student teachers is necessary. Effective training covers both course content and pedagogical strategies to enhance tutors' content knowledge and ability to answer questions.

Results from studies focusing on peer-assisted learning in medical education are difficult to compare given differences in program structure, reasons for implementation, and methods of evaluation. Although a program may have positively impacted one institution, it may not have the same results when used at a different institution. Variations in resource availability, class size, faculty size, curriculum design, location, as well as the characteristics of medical student populations may contribute to program success. Even within an institution, the benefits of PAL programs to students may vary from one preclinical course to another. Obstacles encountered when implementing PAL programs, such as restrictions on funding and difficulties with scheduling or training, were rarely addressed in the included studies and would be helpful to explore as schools consider instituting or optimizing their own programs. Objective analyses often lacked control groups and did not always control for baseline characteristics such as MCAT scores, undergraduate GPA, age, and sex of tutees and tutors, thus making studies difficult to compare. Furthermore, it should be noted that many studies are subject to response bias and the Hawthorne effect, and thus their results should be viewed with some degree of caution.

Future studies should address other potential long-term outcomes associated with participation in PAL peer tutoring programs, such as whether participation affects teaching skills as a resident in training and practicing physician and whether receiving or providing tutoring has a relationship with the field of medicine students choose to pursue. While many studies focused on small group tutoring, few addressed one-on-one tutoring. Larger multiple institutional analyses of how tutoring programs affect examination and course grades would be useful. Qualities of the program, such as whether it is voluntary or mandatory and whether it supplements or replaces normal class time, have not been analyzed to determine if these factors affect student feedback and/or examination scores. Such information could help guide further

program development and help schools cater programs to best help students succeed.

Authors' Contributions Both Adele Shenoy and Kristina Petersen performed literature reviews and participated in drafting the manuscript.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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