Learning how to learn: can embedded discussion boards help first-year students discover new learning strategies?

Louise Ainscough, Richard Leung, and Kay Colthorpe
School of Biomedical Science, Faculty of Medicine, The University of Queensland, Brisbane, Queensland, Australia

Submitted 17 May 2019; accepted in final form 30 October 2019

INTRODUCTION

The transition from secondary to tertiary education can be challenging for students, as they must adapt to the independent nature of learning at university (33, 34). For students studying Science, Technology, Engineering, and Math (STEM) courses, such as anatomy and physiology, these challenges are compounded by the complexity of the discipline. Both anatomy and physiology have their own language, which may need to be learned before attempting to understand more complex topics, such as integration of body systems (25, 27, 31). Perhaps not surprisingly, STEM courses often have a high attrition rate (31), suggesting that students in these disciplines may require help developing an effective learning approach. Indeed, reasons for university attrition include the inability to maintain motivation, prioritize learning, and maintain academic standards (22, 23). Essentially, some students may struggle to regulate their own learning.

Self-regulated learning encompasses the thoughts, behaviors, and feelings that learners employ to achieve a learning goal (35). There are multiple theories of self-regulated learning, which all describe a cyclical process of preparation, action, and reflection on a learning task (30). Zimmerman’s model (35) includes forethought, performance, and self-reflection phases. Forethought involves planning, goal setting, and motivational beliefs that precede a learning task. Performance includes the actions and strategies employed during the learning task. Finally, self-reflection involves evaluation of performance and reflection on improvements for future tasks. An important aspect of self-regulated learning is developing an awareness of different learning strategies, evaluating which strategies are most effective, and knowing how to choose learning strategies that are appropriate for a task (12).

High-achieving university students use more learning strategies than low-achieving students (32, 37); therefore, it is valuable for students to have a broad understanding of the learning strategies available to them. Our laboratory’s previous research (3) has shown that second-year pharmacy students studying physiology are aware of and have used a wide variety of learning strategies, ranging from 3 to 14 different strategies. Most students had previously used strategies from all three phases of the self-regulated learning cycle (73%); however, when asked which strategies they relied on, the majority of students reported strategies from only one phase of the cycle (61%), most commonly the performance phase. When prompted to reflect on forethought and self-reflection strategies (such as goal setting and self-evaluation, respectively), the quality of students’ reflections correlated positively with academic achievement. These results suggest that, although students are aware of a variety of learning strategies by their second year, they may need prompting to engage in strategies that complete the self-regulated learning cycle.

Once students have developed an awareness of the different learning strategies available, how do they determine which strategies are the most effective? Some students seem to prefer learning strategies that require minimal effort (3, 16). For example, Colthorpe et al. (3) found that the most frequently reported learning strategies by students studying physiology were keeping records (such as notetaking) and reviewing records (such as rereading). However, the most effective learning strategies often require cognitive effort and may expose students to mistakes during the learning process (1). Previous studies conducted with students studying anatomy and physi-
ology have shown that, when studying for longer term retrieval of information, testing oneself is more effective than simply reading or reading combined with notetaking (6), and the best results are obtained when learning is spaced across multiple days rather than massed on a single day (7). In a related study, university students were asked to learn five physiology texts individually (blocked) or together (interleaved) using the method of either simply reading or reading and testing (19). When asked to identify common themes across the physiology texts, the interleaved reading and testing condition was most effective for long-term retrieval, although interleaving was not valuable for simple recall of facts. In addition, concept mapping improved exam results for students studying physiological psychology, but not statistics (21). These results suggest that the effectiveness of learning strategies may be task or discipline specific.

Students with a broad knowledge of learning strategies have a wide repertoire to choose from when faced with different learning tasks or when studying different disciplines. However, students still need to judge if and/or when to adapt their learning strategies to suit the task at hand. For example, second-year university students were asked to identify the most difficult modules in physiology, and to report the learning strategies they used to assist their understanding of these modules (5). Students most frequently reported reviewing records or seeking information to cope with the most difficult modules; however, certain strategies were more frequently reported for specific modules. For example, 42% of students who reported difficulties with metabolism used transforming records (such as drawing diagrams) to assist their understanding, whereas <20% of students reported this strategy for the other difficult modules. These results suggest that students are choosing specific strategies to match the nature of the topic to be learned, such as the complex biochemical pathways of metabolism. The way that course content is assessed will also influence the strategies used. For example, the majority of first- and second-year medical students preferred to use constructivist study strategies (such as concept maps and explain in own words) for all basic science courses, except for those courses that had a higher proportion of recall questions in the examinations (24). For these courses (anatomy and pharmacology), rote learning strategies, such as flash cards, were preferred.

The journey to become an effective self-regulated learner at university is pivotal in the first year. The transition from school to university is likely to be a time of flux, where students experiment with new learning strategies to find the approach that works best for them. Despite these challenges, little is currently known about how student adapt their approach to suit university learning of anatomy and physiology, or where students learn about new strategies. The aim of the present study was to use small-group discussion boards embedded into an anatomy and physiology course to encourage first-year undergraduates to share learning strategies with one another. It was hypothesized that the discussion board intervention would introduce students to new learning strategies, which would increase their repertoire of available strategies when studying for their examinations and, therefore, improve examination performance.

METHODS

Participants, course structure, and assessment. Participants were undergraduate students from the University of Queensland, which is a research-intensive university in Australia servicing ~36,000 undergraduate and 15,000 postgraduate students. Participants were recruited from the student cohort enrolled in a first-year second-semester anatomy and physiology course (BIOM1052) during 2016 as part of their degree program in the Bachelors of Pharmacy (n = 167), Occupational Health and Safety Science (n = 25), or Dental Science (n = 67). The median age of students enrolled in the course was 19 yr, with a range from 17 to 47 yr. The majority of students (68%) were 19 yr or younger.

This course introduces students to the structure and function of the integumentary, nervous, cardiovascular, respiratory, renal, and reproductive systems. The course had three 1-h lectures per week and four 3-h practical classes spread across the semester. Assessment included a midsemester (20%) and end-of-semester (50%) exam, a concept map assignment (18%), and four meta-learning tasks. Each meta-learning task was worth 3% each and consisted of six open-ended questions designed to encourage students to think about the effectiveness of their learning strategies, their goals and motivations, and their current understanding of course material (4). The meta-learning tasks were spread throughout the semester, with two tasks due before the midsemester exam, and two due after. Meta-learning tasks were completed online through the learning management system, Blackboard (Blackboard Inc., Washington, DC), and were open for 1 wk before the due date. As part of the meta-learning tasks, students shared answers to specific meta-learning questions on a group discussion board. Students self-selected into “meta-learning groups” of three to seven students. The decision to allow students to self-select their group was intentional and based on the idea that students would feel more comfortable sharing their learning strategies in a group with familiar peers. It was also hoped that self-selection would encourage engagement with the discussion board. During each meta-learning task, students were either directed to post responses onto their discussion board, or to read and reflect on their peers’ discussion board posts from the previous meta-learning task. Questions from three out of four meta-learning tasks were analyzed for this study, as outlined below.

Identifying and coding student learning strategies. As part of their first meta-learning task, students were required to post their answers to the following questions on their group discussion board:

1. There are various strategies that students use to aid their learning, for example, students may change where they study (moving themselves from distractions), or spend time regularly reviewing lecture notes. What learning strategies have you employed in the past? Write down as many strategies as you can think of that you have used.

2. Which one of these strategies do you rely on the most, and why do you think that is most effective for you?

During their second meta-learning task, students were directed to go to their group discussion board from the previous task, read through the responses from their peers, and then answer the following question: Which of the strategies posted by your group members (if any) are new to you and worth trying, leading up to the midsemester exam? Why do you think these strategies might be useful?

Student responses to this question in the second meta-learning task were deductively coded (2) against the self-regulated learning strategies outlined in Zimmerman and Martinez-Pons (37) and Nota et al. (26) to categorize the types of strategies students identified as new to them from the discussion board (Table 1). All coding was performed using NVivo 11 (QSR International, MA). To determine the coding accuracy for learning strategies, a subset of student responses (n = 49) was coded by two researchers and compared. The percentage of coding agreement was 89%, which is comparable to the published interrater reliability scores for self-regulated learning strategies (26).
DISCUSSION BOARDS HELP STUDENTS DISCOVER NEW STRATEGIES

Table 1. Coding scheme for strategies identified on the discussion board

| Strategy Categories                                                                 | Example Responses                                                                 |
|------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Environmental structuring: Arranging the physical/virtual environment to enhance learning/reduce distractions. | “Put my phone away when I am studying to minimise distractions to allow me to focus on my work.” |
| Keeping records: Writing/typing notes, recording lectures, or printing lecture notes. | “Watching lecture recordings at my own pace and making notes about them is worthwhile before the exam.” |
| Planning: Making study more regular or efficient. Includes efforts to enhance mental alertness, time management, and enhanced efficiency. | “Going over my study notes on the bus to/from university. I think this would be effective as I spend almost 2 h on public transport daily and this would help use the time efficiently.” |
| Reviewing records: Reading or listening to provided course materials. | “Watching the lectures over again regularly to ensure no information has been missed in the lead up to exams.” |
| Seeking information: Looking for information from nonsocial sources such as textbooks, the internet, or videos. | “I’m really interested in trying out YouTube videos as an alternative explanation of concepts I don’t understand.” |
| Seeking social assistance: Seeking help from peers, lecturers, or tutors.       | “Studying concepts with a group of friends is new to me, but I believe it would be worth trying for the upcoming exam.” |
| Includes learning from peers in groups.                                        | “Rewarding myself with a break, or several minutes of Facebook, could serve as a good reward for all that I have completed for the day, and keep me interested and engaged.” |
| Self-consequences: Attempts to improve motivation through rewards or punishment. | “Studying in groups could be a good strategy because you can always discuss missed in the lead up to exams.” |
| Self-evaluation: Strategies that aim to test understanding, including group study or completing practice quizzes. | “Other members suggest that drawing diagrams and images is a helpful strategy to improve knowledge and understanding of the topic, and therefore, I may attempt this strategy.” |
| Transforming records: Changing learning materials to aid study. Includes creating summaries, diagrams, flash cards, or practice questions. | “Recalling what we have learned in the past (perhaps during high school or college) and writing it down on our lecture notes now and making connections to enhance our understanding.” |
| Other: Infrequently mentioned strategies.                                        |                                                                                   |

Strategies were grouped into categories based on the self-regulated learning cycle (26, 37).

Discrepant coding was agreed upon by both researchers and then revised.

Identifying students who adopted new learning strategies. During the final meta-learning task, students were asked the following questions:
1. List any learning strategies that you used for the first time this semester, or that you modified this semester.
2. If you used new or modified strategies this semester, where did you learn about these strategies?

The student responses to the first question were coded to identify students who used strategies that were new to them or modified strategies during the semester (adopters), and those who did not (nonadopters). The adopters’ responses to the second question were then inductively coded (2) to determine the source of each new strategy.

Academic achievement of adopters and nonadopters. To determine whether there were baseline differences in academic achievement between adopters and nonadopters, the mean cumulative grade point average (GPA) of students at the beginning of the semester was compared between these groups. At the University of Queensland, GPA is measured on a 7-point scale, where 1–3 are failing GPAs, 4 is a pass, and 7 represents a high distinction. Cumulative GPA was chosen as a measure of baseline academic performance to account for the diversity of courses undertaken by individual students before the commencement of this study.

Students’ academic achievement in BIOM1052 was determined by their final exam performance. To determine whether students had improved since semester 1, their BIOM1052 exam performance was compared with their final exam performance in a first-semester companion course, BIOM1051, which covered cell physiology, biochemistry, and systems physiology. Both courses had comparable exams that included a combination of multiple-choice questions and short-answer questions that integrated two body systems or modules. Both exams included a combination of questions, some of which tested simple recall, while others tested higher order skills, such as understanding and applying. Normalized change scores (20) were calculated using each student’s final exams scores for both courses. The normalized change calculation indicates a student’s gain or loss in academic achievement relevant to the maximum gain or loss that they could achieve. Normalized change scores range from −1 (100% decrease in exam score) to +1 (100% increase in exam score). For example, a normalized change score of 0.5 would be achieved if a student improved from 50 to 75%, or 80 to 90%, as in both cases the student improved by 50% of their maximum possible gain.

Student perceptions of the group discussion board. At the completion of the meta-learning tasks, students were asked the following open-ended question: Please feel free to make any comment on whether you thought the group discussion boards have or have not been useful to you, and explain either how they may have helped, or could be made more helpful for you.

Student responses were coded inductively to identify the proportion of students who identified positive or negative impacts of the discussion board and the types of impacts.

Statistical analysis. Statistical analyses were conducted with either GraphPad Prism version 6 (San Diego, CA) or IBM SPSS Statistics version 22 (Somers, NY). Significance was determined at P < 0.05. All means are reported with the standard deviation (SD). Effect sizes were calculated using Cohen’s d.

Ethics statement. This study was approved by the University of Queensland Behavioral and Social Sciences Ethical Review Committee (approval no. 2013000898). The consent rate for participation in the study was 73% (n = 189). An unpaired t test was used to compare the final exam mark between consenting students [65.83% (SD 15.44)] and the whole cohort [64.93% (SD 15.5)]. There was no significant difference between these groups (P = 0.55), suggesting that the consenting students were representative of the cohort.

RESULTS

Identifying new strategies from the discussion board. Students were asked to read through the learning strategies posted on their group discussion board, and to reflect on whether any of these strategies were new to them and worth trying during their preparation for the midsemester exam. Of the 189 students who consented to the study, 175 students completed this...
meta-learning question. Ninety-one percent of students identified at least one new strategy, with students identifying 2.5 (SD 1.5) strategies on average, with a range from 1 to 8. The strategies were coded into categories based on the self-regulated learning framework (26, 37), with transforming records being the most frequently reported category, reported by 34% of students (Fig. 1). Within this category, students frequently reported transforming records by drawing diagrams, flow charts, or figures (12% of students), creating flash cards (12%), and writing summaries (10%) as potentially useful to them during study. Students also reported strategies within the categories of planning (19%), self-evaluation (19%), and environmental structuring (18%). Planning strategies included those that aimed to improve time management (such as revising lecture recordings within 24 h) or enhance mental alertness (such as studying in intervals with regular breaks). Self-evaluation strategies most frequently included using group work to test understanding and completing practice questions. Within the environmental structuring category, students reported strategies to remove distractions either by changing location (such as going to the library) or restricting digital device use.

Adopting new strategies and impact on academic achievement. At the end of semester, students were asked to list any learning strategies they had used for the first time or modified that semester and to identify where they learned about these strategies. Of the 189 students who consented to the study, 173 students completed this meta-learning question. Seventy-six percent of these students (n = 132) implemented a strategy that was new to them or modified an existing strategy during the semester (adopters). Adopters had a significantly lower GPA at the start of semester compared with students who did not change their strategies (nonadopters; n = 41) (P = 0.01; d = 0.49; Fig. 2A). Despite trying strategies that were new to them, the adopters also performed significantly more poorly on their final BIOM1052 exam compared with students who did not adopt new strategies (P = 0.04; d = 0.35; Fig. 2B). These results suggest that nonadopters have identified strategies that work for them, whereas adopters may still be attempting to identify strategies that will improve their academic performance. To test this hypothesis, exam-normalized change scores were calculated using final exam marks from a similar first-semester physiology course (BIOM1051) and final exam marks for BIOM1052 (Fig. 2C). The average normalized change scores were calculated from final exam marks for a subset of students who had completed a companion physiology course in semester 1 (114 adopters and 37 nonadopters). Data represent means and SDs analyzed with an unpaired t test. *P < 0.05.

When asked to identify where they learned about strategies that were new to them, 35 students did not provide a source. Of the remaining students, the most commonly reported sources were peers (33%), self-discovery (32%), and the group discussion board (32%) (Fig. 3). Students most commonly reported friends, fellow students, or siblings as peers. Students learning about strategies through self-discovery described introducing...
DISCUSSION

The present study describes how a discussion board can be used to help first-year university students gain exposure to new learning strategies from their peers. Students self-selected into small group discussion boards where they were prompted to share their learning strategies with each other as part of a meta-learning assessment task (4).

Ninety-one percent of students were able to identify at least one strategy from their discussion board that was new to them and worth trying leading up to the midsemester exam (Fig. 1). The most frequently reported group of strategies was transforming records, a broad category of strategies that involve students recreating learning materials to use as study tools (37). Within this category, students most frequently reported creating diagrams, flow charts or figures, flash cards, or summaries. Students’ efforts to transform records have been significantly associated with higher grades in school students (26) and better test scores in university students (17). Strategies in the transforming records category can be used by students for different learning purposes. For example, flash cards can be a useful tool for rehearsing and memorizing, which is an effective approach for consolidating surface learning (12). Writing summaries is an effective form of elaboration, where students make connections between current and new knowledge (9), whereas drawing flowcharts and figures is an organizational strategy that students can use to select relevant information and make connections (9, 10, 28). Both elaboration and organization strategies are considered effective for deep learning (12). Together, this suggests that students may be identifying effective new strategies from the discussion board.

Other strategy categories commonly identified through the group discussion boards included self-evaluation, planning, and environmental structuring. Planning is part of the forethought phase in the self-regulated learning cycle (35) and is, therefore, important when preparing for a learning task. Kintsants (17) has shown that university students who score highly on tests use more goal setting and planning strategies both before and during test taking compared with those who have low scores. In addition, a meta-analysis has shown that self-regulated learning interventions for school students are more effective when they include planning strategies compared with when they do not (9). Self-evaluation involves students determining the effectiveness of their learning and falls within the self-reflection phase of the self-regulated learning cycle, where students judge the effectiveness of their learning and reasons for success or failure. Through the discussion board, students most commonly reported group study and practice testing as evaluation strategies that are new to them. Forethought and self-reflection strategies are considered to be more advanced than performance strategies, which occur during a learning task (29, 35). Although university students are familiar with forethought and self-reflection strategies, they tend to rely predomin-
inantly on performance strategies (3). Therefore, it is encouraging that students are identifying planning and self-evaluation strategies from their discussion board as potentially useful.

Three-fourths of the students in the cohort tried strategies that were new to them or modified existing strategies during the semester (adopters), indicating that most students were actively adapting their learning approach. The students who did not try new strategies (nonadopters) had higher grades at the beginning of semester compared with those who did try new strategies (Fig. 2A). These results suggest that the non-adopters may have been satisfied with their learning approach and, therefore, did not want to change. For example, one student said, “I have trialed a diverse range of strategies previously, and I am confident that I know which strategies work best for me and which strategies are best for different subjects.” Colthorpe et al. (4) also found that students who adopted new learning strategies had lower academic achievement in physiology compared with students who did not.

However, in their study, the students who adopted new strategies also improved their academic performance in physiology across two semesters of study. In contrast, adopters in the present study did not improve their academic performance (Fig. 2B and 3). One possible reason for this discrepancy could be that students did not have enough time to practice new learning strategies in the present study, where changes in performance were only measured across one semester. Perhaps this time frame is too short for students to experiment with different strategies, choose those that work best for them, and subsequently see improvements in academic achievement.

It is also possible that the new strategies were helping students to learn anatomy and physiology, but not necessarily improve their exam performance, which was the indicator of academic achievement in this study. Some students may perform more poorly on an exam than expected because they are lacking “test-taking” skills, such as time management during the exam, or strategies for answering multiple-choice questions (8). Indeed, although 19% of students identified planning strategies from the discussion board as useful leading up to the exam, none of the responses mentioned time management during the exam, suggesting that students were focusing on their learning leading up to the exam rather than test taking. To address this limitation, future studies could evaluate whether these learning strategies were valuable to students’ learning of anatomy and physiology through other modes of assessment, such as written assignments. Learning can take many forms, both within and beyond the classroom (11), and the fact that 91% of students learned a new strategy from the discussion board is an important outcome in itself.

Alternatively, perhaps the adopters were not considering the effectiveness or appropriateness of the strategies they are trying. Deciding whether a learning strategy is effective or not can be difficult for students. For example, during interleaving, students intertwine study on different topics, such as learning about the nervous system and endocrine system together, rather than block learning each topic separately (10). Self-testing during interleaved study can increase students’ exposure to mistakes during learning, making the learning process seem more difficult (10). Students may perceive these strategies to be ineffective, yet these “desirable difficulties” actually enhance learning in the long term (1). In addition, some learning strategies may have less impact than others (10, 12). For example, 18% of students identified environmental structuring strategies from the discussion board as new to them and worth trying leading up to the midsemester exam (Fig. 1). Although changing the learning environment may appear to make learning easier, its impact on performance has a smaller effect size than other strategies, such as transforming records (12). These results suggest that students need more guidance in selecting effective strategies. Although the discussion board increased students’ exposure to learning strategies, changes to the intervention are required to increase students’ understanding of the effectiveness of different strategies and enhance their ability to select appropriate strategies.

Of the 132 students who identified as adopters, 97 students provided a source for the strategies they adopted. Students most commonly reported learning about strategies from social sources. Specifically, from their peers (33%), through the discussion board posts (32%), or from school or university (16%). This is not surprising, as a new skill can be learned by observing others (through watching, hearing, or reading), followed by independent attempts to enact the skill, and adapt it to one’s own circumstances (35, 36). For example, when learning from peers, students either mentioned seeing their peers using a strategy, “I learned this strategy while observing other students in the lecture hall,” or talking to peers about a strategy, “I talked to my friend about how I am struggling with studying this time and she gave me her notes and told me to study using them.”

Most social sources reported were from peers, either through the discussion board or from friends and family in social environments, rather than from formal sources, such as school teachers or university staff. The low number of students identifying strategies from university staff may indicate that strategies appropriate for university are not being formally taught [see Bjork et al. (1) for a review]. The heavy reliance on peers as sources for learning strategies may also indicate that students value the skills and experience of fellow students. For example, some students appeared to be strategic when learning about strategies, choosing to incorporate strategies from peers who were doing well at university, or those who had progressed further into their degree: “A friend of mine that did really well in previous semesters, showed me her own notes; I took the idea from there.” In some cases, the sharing of learning strategies with peers may be incidental, occurring organically when students interact in learning environments. It is well supported that students learn more when they work in groups (15, 18), and they can develop self-regulatory skills during group activities (14). When students work together, they may share learning strategies either directly or indirectly through observation. For example, Hurme and Järvelä (13) noted that students verbalized a variety of meta-cognitive strategies (such as discussing how to solve problems in different ways), while working on mathematical problems together online. These results indicate that social sources are important for identifying new strategies, and the discussion board may be a valuable resource for students who are new to university and have not yet made social connections. A significant proportion of students in this study also identified strategies through self-discovery. The reliance on self-discovery may become less pronounced in later year students, as they become more confident in their learning approach and develop more extensive social networks.
The transition from secondary school to university can be challenging for students, especially in anatomy and physiology, where students need to adapt to the complexity and volume of material covered in each course (5, 25, 31). Learning strategies are rarely formally taught at university (1), and strategies that are appropriate at school may no longer be effective or efficient when learning at university. In the present study, small-group discussion boards were introduced to encourage first-year students to share learning strategies with one another. The majority of students found the discussion board to be useful to them, with most students citing value in the discussion board as a forum for providing ideas for new learning strategies, or insight into how others learn. Although most students in the present study adopted strategies that were new to them, their exam performance did not improve across the semester. These results suggest that identifying new strategies is just the first step in the learning journey. Students need to judge whether a strategy is likely to be effective or not, and value judgements regarding effectiveness may not always be accurate (1). Therefore, self-regulated learning interventions should expand the dialogue about learning strategies, giving students the opportunity to discuss the types of learning strategies available, the effectiveness of each learning strategy, and their value at different stages of the learning cycle.

REFERENCES

1. Bjork RA, Dunlosky J, Kornell N. Self-regulated learning: beliefs, techniques, and illusions. Annu Rev Psychol 64: 417–444, 2013. doi: 10.1146/annurev-psych-113011-143823.
2. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol 3: 77–101, 2006. doi: 10.1191/147808706aqp063oa.
3. Colthorpe K, Ogiji J, Ainscough L, Zimbardi K, Anderson S. Effect of metacognitive prompts on undergraduate pharmacy students’ self-regulated learning behavior. Am J Pharm Educ 83: 6664, 2019. doi: 10.5688/aje6646.
4. Colthorpe K, Sharifirad T, Ainscough L, Anderson S, Zimbardi K. Prompting undergraduate students’ metacognition of learning: implementing ‘meta-learning’ assessment tools in the biomedical sciences. Asses Eval High Educ 43: 272–285, 2018. doi: 10.1080/02602930.2017.1334872.
5. Colthorpe KL, Abe H, Ainscough L. How do students deal with difficult physiological knowledge? Adv Physiol Educ 42: 555–564, 2018. doi: 10.5684/apjte10248.
6. Dobson JL, Linderholm T. Self-testing promotes superior retention of anatomy and physiology information. Adv Health Sci Educ Theory Pract 20: 149–161, 2015. doi: 10.1007/s10459-014-9514-8.
7. Dobson JL, Perez J, Linderholm T. Distributed retrieval practice promotes superior recall of anatomy information. Anat Sci Educ 10: 339–347, 2017. doi: 10.1002/ase.1668.
8. Dodeen H. Assessing test-taking strategies of university students: developing a scale and estimating its psychometric indices. Assess Eval High Educ 33: 409–419, 2008. doi: 10.1080/02602930701562874.
9. Donker AS, de Boer H, Kostonds P, Dignath Van Ewijk CC, van der Werf MP. Effectiveness of learning strategy instruction on academic performance: a meta-analysis. Educ Res Rev 11: 1–26, 2014. doi: 10.1016/j.edurev.2013.11.002.
10. Dunlosky J, Rawson KA, Marsh Ej, Nathan MJ, Willingham DT. Improving students’ learning with effective learning techniques: promising directions from cognitive and educational psychology. Psychol Sci Public Interest 14: 4–58, 2013. doi: 10.11717/s5291006124532607.
11. Entwistle NJ, Peterson ER. Conceptions of learning and knowledge in higher education: relationships with study behaviour and influences of learning environments. Int J Educ Res 41: 407–428, 2004. doi: 10.1016/j.ijer.2005.08.009.
12. Hattie JAC, Donoghue GM. Learning strategies: a synthesis and Conceptual model. NPSi Learn 1: 16013, 2016. doi: 10.1016/j.npsiclean.2016.13.
13. Hurme T-R, Järvelä S. Students’ activity in computer-supported collaborative problem solving in mathematics. Int J Comput Math Learn 10: 49–73, 2005. doi: 10.1007/s10758-005-4579-3.
14. Jarvela S, Jarvenoja H. Socially constructed self-regulated learning and motivation regulation in collaborative learning groups. Teach Coll Rec 113: 350–374, 2011.
15. Johnson DW, Johnson RT. An educational psychology success story: social interdependence and cooperative learning. Educ Res 38: 365–379, 2009. doi: 10.3102/0013189X039339057.
16. Karpicke JD, Butler AC, Roediger H. Metacognitive strategies in student learning: do students practise retrieval when they study on their own? Memory 17: 471–479, 2009. doi: 10.1080/096582110802647009.
17. Kitsantas A. Test preparation and performance: a self-regulatory analysis. J Educ Psychol 70: 101–113, 2002. doi: 10.1037//0022-0663.70.1.101.
18. Kyndt E, Raes E, Lismont B, Timmers F,Casacular E, Dochy F. A meta-analysis of the effects of face-to-face cooperative learning. Do recent studies falsify or verify earlier findings? Educ Res Rev 10: 133–149, 2013. doi: 10.1016/j.edurev.2013.02.002.
19. Linderholm T, Dobson J, Yarbrough MB. The benefit of self-testing and interleaving for synthesizing concepts across multiple psychology texts. Adv Physiol Educ 40: 329–334, 2016. doi: 10.1152/advan.00157.2015.
20. Marx JD, Cummings K. Normalized change. Am J Phys 75: 87–91, 2007. doi: 10.1191/1.2372468.
21. McCagg EC, Dansereau DF. A convergent paradigm for examining knowledge mapping as a learning strategy. J Educ Res 84: 317–324, 1991. doi: 10.1080/00220671.1991.9941812.
22. McMillan J. Course Change and Attrition from Higher Education. LSAY Research Reports. Longitudinal Surveys of Australian Youth Research Reports. Camberwell, Victoria, Australia: Australian Council for Education Research, 2005, no. 39.
23. McMillan J. University Study in Australia: Persistence, Completion and Beyond. LSAY Briefing Reports, Camberwell, Victoria, Australia: Australian Council for Education Research, 2008, no. 18.
24. McNulty JA, Ensminger DC, Hoyt AE, Chandrasekhar AJ, Gruener G, Espiritu B. Study strategies are associated with performance in basic science courses in the medical curriculum. J Educ Learn 1: 1–12, 2012. doi: 10.5359/jel.v1i1p1.
25. Michael J. What makes physiology hard for students to learn? Results of a faculty survey. Adv Physiol Educ 31: 34–40, 2007. doi: 10.1152/advan.00057.2006.
26. Nota L, Sorensi S, Zimmerman BJ. Self-regulation and academic achievement and resilience: a longitudinal study. Int J Educ Res 41: 198–215, 2004. doi: 10.1016/j.inter.2005.07.001.
27. Pandey P, Zimitat C. Medical students’ learning of anatomy: memori-sation, understanding and visualisation. Med Educ 41: 7–14, 2007. doi: 10.1111/j.1365-2929.2006.02643.x.
28. Pintrich PR. A Manual for the Use of the Motivated Strategies for Learning Questionnaire (MSLQ). Ann Arbor, MI: University of Michigan, 1991.
29. Pintrich PR. Understanding self regulated learning. New Dir Teach Learn 1995: 3–15, 1995. doi: 10.1002/107319956304.
30. Puustinen M, Pulkkinen L. Models of self-regulated learning: a review. Scand J Educ Res 45: 269–286, 2001. doi: 10.1080/03183301207004206.
31. Schutte AF. Who is repeating anatomy? Trends in an undergraduate anatomy course. Anat Sci Educ 9: 171–178, 2016. doi: 10.1002/ase.1553.
32. Simsek A, Balaban J. Learning strategies of successful and unsuccessful university students. Contemp Educ Technol 3: 36–45, 2010.
33. van der Meer J. ‘I don’t really see where they’re going with it’: communicating purpose and rationale to first-year students. J Furth High Educ 36: 81–94, 2012. doi: 10.1080/0390977X.2011.596195.
34. van der Meer J, Jansen E, Torenbeek M. It’s almost a mindset that teachers need to change: first-year students’ need to be inducted into time management. *Stud High Educ* 35: 777–791, 2010. doi:10.1080/03075070903383211.

35. Zimmerman BJ. Attaining self-regulation: a social cognitive perspective. In: *Handbook of Self-Regulation*, edited by Boekaerts M, Pintrich P, Zeidner M. San Diego, CA: Academic, 2000, p. 13–39.

36. Zimmerman BJ, Kitsantas A. Acquiring writing revision and self-regulatory skill through observation and emulation. *J Educ Psychol* 94: 660–668, 2002. doi:10.1037/0022-0663.94.4.660.

37. Zimmerman BJ, Martinez-Pons M. Development of a structured interview for assessing student use of self-regulated learning strategies. *Am Educ Res J* 23: 614–628, 1986. doi:10.3102/00028312023004614.