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Abstract

As future healthcare practitioners, kinesiology students must become expert learners who choose strategies resulting in deep and durable learning. Metacognitive instruction goes beyond the use of study skills as it focuses on student reflection and evaluation of their learning success, and ultimately establishes effective learning skills, a requirement for professional practice. To examine if an intervention in a kinesiology course affected metacognitive awareness and use of metacognitive strategies, a quasi-experimental research design utilized a convenience sample of 89 upper division undergraduate occupational therapy students and master's level athletic training students enrolled in kinesiology courses. Using an online survey including the Metacognitive Awareness Inventory (Schraw & Dennison, 1994) and three Likert scale questions about perception of study skills, pre-test and post-test data were collected over three years, and 6-month follow-up data were collected during the final two years of the study. The intervention included information about metacognition and key study tips, five learning activities, and teaching techniques to promote metacognition. Treating the pre-test group as the reference group, the results showed that the post-test and 6-month follow-up test groups were significant predictors of students' scores on the Metacognitive Awareness Inventory, indicating an improved and sustained metacognitive awareness after completing the course. The intervention was found to have a positive association with scores of planning, information management, comprehension monitoring, and evaluation. These results indicate the value of metacognition instruction. Considering that not all students come equipped with metacognitive skills, instruction in this area could be beneficial to students.

Keywords

Metacognition, athletic training, occupational therapy, instruction, education

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Using Metacognitive Training with Kinesiology Students

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ABSTRACT

As future healthcare practitioners, kinesiology students must become expert learners who choose strategies resulting in deep and durable learning. Metacognitive instruction goes beyond the use of study skills as it focuses on student reflection and evaluation of their learning success, and ultimately establishes effective learning skills, a requirement for professional practice. To examine if an intervention in a kinesiology course affected metacognitive awareness and use of metacognitive strategies, a quasi-experimental research design utilized a convenience sample of 89 upper division undergraduate occupational therapy students and master's level athletic training students enrolled in kinesiology courses. Using an online survey including the Metacognitive Awareness Inventory (Schraw & Dennison, 1994) and three Likert scale questions about perception of study skills, pre-test and post-test data were collected over three years, and 6-month follow-up data were collected during the final two years of the study. The intervention included information about metacognition and key study tips, five learning activities, and teaching techniques to promote metacognition. Treating the pre-test group as the reference group, the results showed that the post-test and 6-month follow-up test groups were significant predictors of students' scores on the Metacognitive Awareness Inventory, indicating an improved and sustained metacognitive awareness after completing the course. The intervention was found to have a positive association with scores of planning, information management, comprehension monitoring, and evaluation. These results indicate the value of metacognition instruction. Considering that not all students come equipped with metacognitive skills, instruction in this area could be beneficial to students.

Introduction

A common definition of metacognition is how one thinks about their own thinking. Flavell (1987) delineated this process as having four classes: metacognitive knowledge, metacognitive experiences, goals and tasks, and action and strategies of learning. Building upon Flavell's (1979) interpretation of metacognition, Schraw and Moshman (1995) further expanded the concept to include knowledge of one's own thought processes (metacognitive knowledge) and the regulation of metacognition. Regulation of metacognition includes activities such as planning, choosing learning strategies, and monitoring of one's learning (Niedwiecki, 2012; Schraw & Dennison, 1994).

Studies have shown a positive association between metacognitive skills and academic success (Agha & Rehman, 2016; Kaur et al., 2018; Yilmaz & Baydas, 2017). However, research also suggests that we should not assume that high achieving students have adequate metacognitive skills (Preston et al., 2015; Turan et al., 2009). For example, Turan et al. (2009) in a study of 862 medical students from four different medical schools found many students had lower levels of metacognitive skills. Preston et al. (2015) found that law students at one university had similar metacognitive knowledge but lower metacognitive regulation scores than students in the education graduate program. Preston et al. (2015) suggested that it is possible for smart, successful students to have under-developed metacognitive skills. These students may simply rely on intelligence and hard work. Yet, the authors note that metacognitive skills are necessary for students to handle the professional challenges that they will face (Preston et al., 2015).

Metacognition is associated with the development of empathy (Eichbaum, 2014) and critical thinking (Kuiper & Pesut, 2004; Magno, 2010). Gönüllü and Artar et al. (2014) suggested that metacognitive skills are important in medicine because they allow us to check for bias in diagnostic thinking and see the illness from the patient's perspective. Similarly, learning metacognitive skills promotes empathy by allowing us to appreciate the need for more than factual knowledge (Eichbaum, 2014). Additionally, Legg and Locker (2009) found metacognition reduces negative, anxiety-related mental processes, suggesting that students with higher metacognitive skills may be able to focus more on problem-solving and less on feelings of anxiety. In healthcare professions, such as athletic training and occupational therapy, metacognition is crucial for diagnostic reasoning and solving clinical problems (Kuiper & Pesut, 2004).

Healthcare professionals need to learn effectively throughout their careers to solve challenging clinical problems. Therefore, they need to be expert learners who choose strategies that result in deep and durable learning. Metacognitive instruction goes beyond the use of study skills by focusing on student reflection and evaluation of their learning success. To develop metacognition, Schraw (1998) proposed direct instruction, teacher and peer modeling, and opportunities to reflect on one's metacognition. Tanner (2012) presented several techniques designed to promote metacognition in the areas of planning, monitoring, and evaluation: using reflective journals as a method for students to monitor their own thinking, using pre-assessments to help students examine their current thinking, and using the "muddiest point" technique to provide students with practice identifying confusions. Tanner (2012) also encouraged educators to create a culture of metacognition by integrating metacognition throughout the course. Bowering et al. (2017) found that instruction in metacognitive skills enabled 60% of students on academic probation to improve their academic performance well enough to end probation status. Also, Hargrove and Nietfield (2015) reported that design students who had participated in metacognitive training produced final projects with higher scores than those produced by students with no additional metacognitive training.

A student must know metacognitive strategies to be able to use them. Pintrich (2002) identified the need to teach metacognition explicitly by embedding aspects of it within the course content and structure, including instructor/peer modeling of techniques. Studies have shown metacognitive instruction improves student metacognitive skills (Apaydin & Hossary, 2017; Gönüllü & Artar et al., 2014). Gönüllü and Artar et al. (2014) in a study of medical students found metacognitive capabilities can be enhanced by training. Additionally, Apaydin and Hossary (2017) found students who participated in metacognitive training had higher cognitive skills than the control group.

However, not all metacognitive interventions have had positive results and the type of instruction may affect student knowledge of cognition (De Boer et al., 2014; Langdon et al., 2019). For example, Langdon et al. (2019) compared three types of instruction in an anatomy and physiology course, using the Metacognitive Awareness Inventory (MAI) as a pre/post measure. Study participants were randomly assigned to a reflective practice group, passive knowledge acquisition group, or a collaborative learning group. Authors reported that only the students in the reflective practice group that used exam wrappers (i.e. questionnaire after an exam that promoted student reflection about preparation, errors, and ideas to improve future learning) showed an increase in their knowledge of cognition. However, collaborative learning has worked as an intervention for participants in other subject areas (Abu Bakar & Ismail, 2020; Chiu, 1998), suggesting the effects of metacognitive strategies and interventions may be dependent on subject type and task requirements (Muijs & Bokhove, 2020).

Kinesiology is foundational knowledge for both athletic training and occupational therapy. Understanding kinesiology concepts allows students to build advanced therapeutic knowledge and skills, vital to clinical care. As presented, there is a strong recommendation to teach metacognitive skills to positively influence student learning now and well into the future. The purpose of this study was to examine if an intervention in a kinesiology course improves metacognitive awareness and use of metacognitive strategies in occupational therapy and athletic training students. Overall, this study strove to determine kinesiology students' knowledge and use of metacognition before and after participating in an intervention focused on metacognition.

Methods

The study employed a quasi-experimental research design, consisting of a pre-test, an intervention, and a post-test with no control group, which was approved by an Institutional Review Board (IRB). While the researchers were course instructors, confidential data was not viewed or analyzed until after grades were posted to the registrar. At the end of the first year of the study, investigators decided to add a 6-month follow-up test to examine if changes in metacognitive awareness existed 6-months after completion of the kinesiology courses. This required a study modification, for which IRB approval was obtained.

Through this study, data were collected for three years in a repeated measures design – pre-test, post-test, and a 6-month follow up on the same subjects. In aggregate, 89 subjects completed the pre-test, 65 the post-test, and 26 the 6-month follow-up. We account for this repeated measures design by fitting mixed effects models with a random intercept for student. The random intercepts allow for the score to be lower or higher for each student while measuring the effect of the intervention.

Participants

A convenience sample of upper division undergraduate occupational therapy students and master's level athletic training students enrolled in kinesiology courses at a private mid-western university participated in this study. Participants were included in this study if they were actively enrolled in an occupational therapy kinesiology course, or an athletic training kinesiology course at the participating university. Both kinesiology courses included an in-depth study of musculoskeletal anatomy, principles of human movement, and biomechanics. Emphasis was placed on application of content in a real-world setting. Participants were excluded from the study if they declined participation or did not complete the survey or interventions. Participation was voluntary. No financial incentives were provided for participants. A total of 89 students participated in the study (75 occupational therapy students and 14 athletic training students). There were 82 females and 7 males. The mean age was 21 ± 1 years. The majority of participants indicated their race as White/European American (93%), with the remaining participants identifying as Asian (5%) or preferring not to answer (2%).

Pre-test, Post-test, Follow-up Test

An online survey was designed that incorporated the 52 questions from the Schraw and Dennison (1994) MAI, and three general questions about perception of study skills and demographic questions. This survey was used as the pre-test, post-test, and the 6-month follow-up test. The pre-test was completed at the beginning of the kinesiology course. The post-test was completed during the final week of the course and the 6-month follow-up survey was completed 6-months after completion of the kinesiology course. A "score" on the 52 question MAI survey refers to the proportion of times each student answered "true," and will be referred to throughout the article in this manner.

Measuring Metacognition

The MAI is a reliable (i.e., α =.90) and valid (r =.54) test of metacognitive awareness (Schraw & Dennison, 1994). The MAI evaluates knowledge of cognition and regulation of cognition awareness (Schraw & Denison, 1994). The MAI consists of 52 True/False questions, with "True" indicating use of the strategy, and "False" indicating non-use. The MAI is divided into two domains: knowledge of cognition and regulation of cognition. The knowledge domain has 16 questions and broken down into three categories: declarative knowledge, procedural knowledge, and conditional knowledge. The

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remaining 36 questions pertain to the regulation of cognition domain broken down into five categories: planning, information management strategies, comprehension monitoring, debugging strategies, and evaluation. Table 1 shows this breakdown and includes a short description of each category.

Table 1

Operational Definitions of Component Categories (Schraw & Dennison, 1994).

Knowledge of Cognition	
Declarative Knowledge	knowledge of one's skills, intellectual resources, and abilities as a learner
Procedural Knowledge	knowledge about *how* to implement learning procedures (e.g. strategies)
Conditional Knowledge	knowledge about *when* and *why* to use learning procedures
Regulation of Cognition	
Planning	planning, goal setting, and allocating resources *prior* to learning
Information management	skills and strategy sequences used on-line to process information more efficiently (e.g., organizing, elaborating, summarizing, selective focusing)
Comprehension Monitoring	assessment of one's learning or strategy use during a learning episode
Debugging	strategies used to correct comprehension and performance errors
Evaluating	analysis of performance and strategy effectiveness after a learning episode

General Study Skills Questions
Additionally, participants were asked three general questions about their study skills and were asked to respond on a 5-point Likert scale (not at all - absolutely). The three questions included "To what degree are your study skills efficient?", "To what degree are your study skills effective?", and "To what degree are you satisfied with the outcome of your study skills?"

Intervention
The intervention included a handout with information about metacognition and key study tips, a series of five learning activities, and teaching techniques designed to promote metacognition.

Handout
Students were introduced to metacognition and provided with a handout. The handout was inspired by Cutting and Saks (2012), who presented study tips for medical students. The handout outlined seven key study tips that included: 1) Use the principle of spaced practice to plan study time and enhance learning; 2) Use cumulative review strategies to promote long-term retention; 3) Make effective use of the testing effect to improve retention by providing frequent opportunities for self-assessment and cumulative testing; 4) Organization effects: To promote integration, synthesis, and more

effective learning, reorganize important content and transform it into a new format; 5) Metamotivation: Use motivational strategies; 6) Use metacognition strategies, such as identifying task requirements / types of learning tasks and knowing and using strategies that work best for different types of learning tasks; and 7) Self-Regulation: Planning and monitoring learning. The instructors encouraged the application of these strategies through a series of required learning activities. Finally, instructors used numerous instructional techniques designed to promote metacognition.

Learning Activities

All students in the kinesiology courses completed a series of learning activities. The first five assignments were completed in the first two weeks of the term after first completing the pre-test survey. Content related to this study was part of the course, but it was intermingled with other course content.

Learning Activity 1: Make a Plan to Study

Students were asked to watch the video entitled “What do top students do differently” (Barton, 2017). Students then completed a learning activity using the principles from the video and the aforementioned handout, to identify times during each day when they could study. Reinforcing one of the ideas presented in the video, students were encouraged to start by blocking out time when they were not going to study (i.e., when they are in class, exercising or at their job). They were further encouraged to remember that sleep is essential for learning, and to avoid long chunks of study time by breaking up study time with exercising or relaxing. Students were also asked to recognize when they are most mentally alert, and to consider altering their plan so they could take advantage of those time periods for studying. This activity was designed to help them learn to take advantage of tip 1: Use the principle of spaced practice to plan study time to enhance learning and tip 2: Use cumulative review strategies to promote long-term retention.

Learning Activity 2: Plan How to Use Resources

The next learning activity was designed to encourage students to plan for how they would use their resources. In the first part of this activity, students were provided with a resource list of ten items and asked to mark or highlight the resources they planned to use to prepare for their first exam based on the exam format and the types of questions they expected to be tested on. In the second part of this activity, students were asked to explain why they thought each highlighted resource would be useful for exam preparation and when, where, and how they planned to use each resource. The main purpose of this learning activity was to reinforce the concepts in tip 6: Use metacognition strategies, such as identifying task requirements/types of learning tasks and knowing and using strategies that work best for different types of learning tasks, and tip 7: Self-Regulation: Planning and monitoring learning.

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Learning Activity 3: Motivation

Students were asked to plan how they would study and stay motivated. Students were provided with a list of metacognitive activities and learning strategies. Students identified the activities and strategies they planned to use and then identified which strategies they thought would be more effective and why. Students then answered a series of questions about motivation including questions prompting them to consider who they could help by knowing the information, how they could learn this information in an interesting or fun way, and what they might do if they found themselves struggling or feeling overwhelmed. This learning activity was designed to reinforce tip 5: Metamotivation: use of motivational strategies.

Learning Activity 4: Assess the Plan

Students were asked to critically assess their plan. They were provided with 8 questions to make sure they were assessing each aspect of their plan. Five of the questions were specific to the key tips outlined in the handout mentioned above.

Learning Activity 5: Assess the Plan - Following Exam 1

Students completed a series of reflection questions following the first exam. The purpose was to encourage students to reflect on how they were studying and to thoughtfully consider if their strategies and practices were effective. Students were asked about: 1) study techniques they used that were the most beneficial, and those that they thought were least beneficial, 2) how they studied in terms of time, 3) use of reorganizing information, 4) use of rehearsal strategies, and 5) use of metacognition strategies, such as using specific learning strategies for declarative knowledge like attaching pictures to memories.

Course Design and Teaching Activities Designed to Promote Metacognition

Instructors used numerous instructional techniques and teaching activities designed to promote metacognition. For example, to facilitate acquisition of declarative knowledge, instructors explicitly identified what students needed to memorize, and they provided additional resources for students with insufficient backgrounds. In order to promote the use of cumulative review strategies, each exam after the first included material from previous sections. To help with procedural knowledge, instructors explained each step as they worked through movement analysis examples. They also provided materials that emphasized the thinking process and the application of kinesiology concepts in various situations. Instructors gave regular quizzes and feedback and emphasized all the various available resources. This was done to encourage planning. To promote comprehension and monitoring skills, instructors required students to regularly reflect on the learning strategies they were using. They also suggested alternative learning strategies and employed exam wrappers.

Results

All results including summary statistics and model output, were computed using R (R Core Team, 2018) and all graphical displays were created using the “ggplot2” package for R (Wickham, 2016). There was a total of 89 subjects. We observed pre-test scores (n=89), post-test scores (n=65), and 6-month follow up scores (n=26), for a total of N=180 total observations from the 89 subjects. Though the sample size across the test groups is not equal, our model utilizes the full data set.

Research Question 1: Are there overall differences in scores on the MAI survey between the pre-test, post-test, and 6-month follow-up groups? Recall that a “score” refers to the proportion of times each student answered “true” on the 52-question MAI survey. Students in 2017 completed the MAI survey before the intervention and after the intervention, while students in 2018 and 2019 completed the same MAI survey before the intervention, after the intervention, and 6-months after the conclusion of the semester. Summary statistics of the MAI scores can be seen in Table 2.

Table 2

Summary Statistics of MAI Scores by Test Group

Test Group	Pre-test (n = 89)	Post-test (n = 65)	Follow-up (n = 26)
$\bar{x}$ (s)	0.736 (0.120)	0.774 (0.119)	0.812 (0.110)
$\hat{m}$ (IQR)	0.750 (0.170)	0.788 (0.196)	0.816 (0.170)

Note: $\bar{x}$ (s) represents the sample mean (sample standard deviation)
Note: $\hat{m}$ (IQR) represents the sample median (sample interquartile range)

Since our response variable of interest is a proportion (i.e., a number between 0 and 1), we decided to use a model which assumes such a response. Additionally, the authors wanted to take the repeated measures design of the experiment into account (i.e., multiple responses per some students); therefore, we fit a beta regression mixed effects model with a random intercept for student. The predictor variable of the model was the test group, with the pre-test group defined as the reference group.

The fixed effects beta regression model is given by:

$$\text{logit}(p_i) = \mu_i + 1.082 + 0.445\, I(\text{Group=Follow-up}) + 0.292\, I(\text{Group=Post-test}),$$

where $\text{logit}(p_i) = \log(p_i/(1-p_i))$, p_i is the proportion of “true” responses, and μ_i is the random intercept for participant *i*. We note that the coefficients of this model are on the logit scale.

The authors found the post-test group (z = 3.433, *p*-value= 0.001) and 6-month follow-up group (z = 3.387, *p*-value= 0.001) to be significant predictors of students’ scores on the MAI. See Table 3. Critically, compared to the pre-test scores, scores were on average higher on the post-test and through the 6-month follow-up test, which did not

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significantly differ from each other (*t*=1.102, *p*-value=0.2722). These results indicate the intervention is associated with improved metacognitive awareness and the improvements were sustained 6-months after completion of the course.

Table 3

Fixed Effects Model Output for The Beta Mixed Effects Model (Logit Scale)

	Estimate	Std. Error	z−value	*p*−value	95% CI Lower	95% CI Upper
Intercept	1.082	0.076	14.304	< 0.0001	0.934	1.231
Follow-up	0.445	0.131	3.387	0.001	0.187	0.702
Post-test	0.292	0.085	3.433	0.001	0.125	0.459

Research Question 2: Are there overall differences in scores on the MAI survey between the pre-test, post-test, and 6-month follow-up groups for each of the following eight categories: Declarative, procedural, conditional, planning, information management, comprehension monitoring, debugging strategies, evaluation? The categories have between four and ten questions and no categories contain the same questions. The “score” refers to the proportion of times a student answered “true” on the pre-test, post-test, and 6-month follow-up within each respective category (i.e., declarative, procedural, etc.). Summary statistics of the scores by test group within each category can be seen in Table 4. Within each category, a mixed effects beta regression model with a random intercept for student was used.

The results suggest the intervention is associated with improved metacognitive awareness on average in several categories. Specifically, we found students’ scores were higher on the post-test as compared to the pre-test on average for the procedural knowledge category (*z*=1.987, *p*-value= 0.049), the planning category (*z*=3.399, *p*-value=0.001), the information management category (*z*=2.017, *p*-value=0.045), the comprehension monitoring category (*z*=3.052, *p*-value=0.001), and the evaluation category (*z*=3.063, *p*-value=0.003).

Additionally, the authors found that students’ scores were higher on the 6-month follow-up as compared to the pre-test on average for the information management category (*z*=3.424, *p*-value=0.001), the comprehension monitoring category (*z*=2.142, *p*-value=0.034), and the evaluation category (*z*=3.478, *p*-value=0.001).

Critically, we found that the increased scores from pre-test to post-test were not significantly different, on average, at the 6-month follow up for the information management category (*t*=1.985, *p*-value=0.119), the comprehension monitoring category (*t*=-0.207, *p*-value=0.836), and the evaluation category (*t*=1.318, *p*-value=0.189).

Table 4

Summary Statistics of MAI Scores by Test Group Within Each Category

Category	Test Group	Pre-test	Post-test	Follow-up
Declarative	$\bar{x}$ (s)	0.813 (0.174)	0.802 (0.209)	0.870 (0.160)
	$\hat{m}$ (IQR)	0.875 (0.250)	0.875 (0.375)	0.875 (0.125)
Procedural	$\bar{x}$ (s)	0.837 (0.196)	0.919 (0.147)	0.865 (0.176)
	$\hat{m}$ (IQR)	1.000 (0.250)	1.000 (0.250)	1.000 (0.250)
Conditional	$\bar{x}$ (s)	0.841 (0.202)	0.852 (0.185)	0.838 (0.173)
	$\hat{m}$ *(IQR)*	1.000 (0.250)	1.000 (0.250)	0.800 (0.250)
Planning	$\bar{x}$ (s)	0.607 (0.233)	0.664 (0.241)	0.703 (0.202)
	$\hat{m}$ (IQR)	0.571 (0.286)	0.714 (0.429)	0.714 (0.286)
Information Management	$\bar{x}$ (s)	0.769 (0.157)	0.808 (0.153)	0.850 (0.139)
	$\hat{m}$ (IQR)	0.800 (0.200)	0.800 (0.200)	0.900 (0.300)
Comprehension Monitoring	$\bar{x}$ (s)	0.688 (0.225)	0.736 (0.219)	0.786 (0.203)
	$\hat{m}$ (IQR)	0.714 (0.286)	0.714 (0.286)	0.857 (0.286)
Debugging Strategies	$\bar{x}$ (s)	0.906 (0.151)	0.932 (0.124)	0.946 (0.107)
	$\hat{m}$ (IQR)	1.000 (0.200)	1.000 (0.200)	1.000 (0.000)
Evaluation	$\bar{x}$ (s)	0.489 (0.250)	0.569 (0.263)	0.660 (0.252)
	$\hat{m}$ (IQR)	0.500 (0.333)	0.667 (0.500)	0.667 (0.292)

Research Question 3: Is the intervention associated with the three Likert scale questions regarding skill efficiency, effectiveness, and satisfaction? The first question asked, “To what degree are your study skills efficient?” The second question asked, “To what degree are your study skills effective?” The third question asked, “To what degree are you satisfied with the outcome of your study skills?” The outcomes to these questions along with summary statistics of the proportion of students within each test group who answered each outcome can be seen in Table 5, while a visual representation can be seen in Figure 1. We see that most students responded in the positive to these three questions; i.e., most students answered either slightly or absolutely efficient, slightly or absolutely effective, or slightly satisfied or absolutely satisfied.

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Table 5

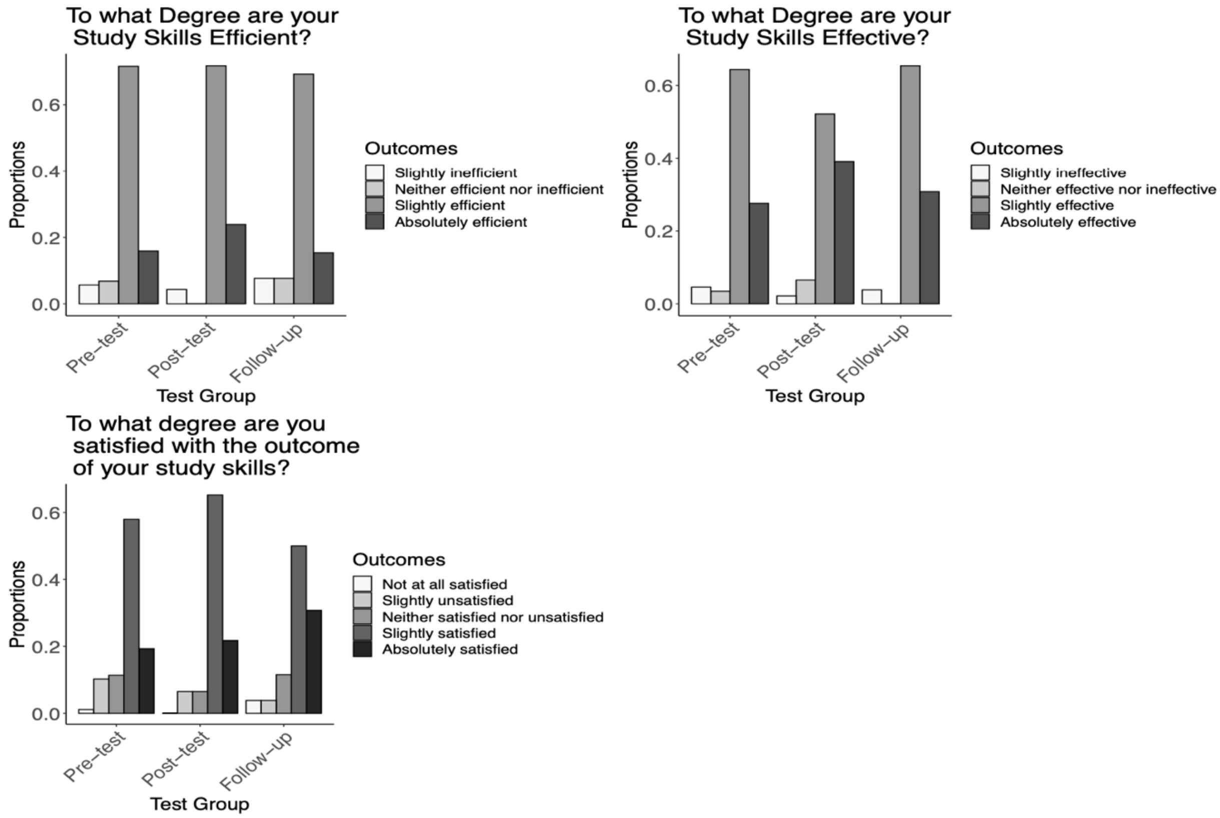
Proportions of Students Within Each Test Group Who Answered Each Question Outcome

Outcomes	Not at all efficient	Slightly efficient	Neither efficient nor inefficient	Slightly efficient	Absolutely efficient
Question: Efficient					
Pre-test	0.000	0.057	0.068	0.716	0.159
Post-test	0.000	0.043	0.000	0.717	0.239
Follow-up	0.000	0.077	0.077	0.692	0.154
Question: Effective					
Pre-test	0.000	0.064	0.034	0.644	0.276
Post-test	0.000	0.022	0.065	0.533	0.391
Follow-up	0.000	0.038	0.000	0.654	0.308
Question: Satisfaction					
Pre-test	0.011	0.102	0.114	0.508	0.193
Post-test	0.000	0.065	0.065	0.652	0.217
Follow-up	0.038	0.038	0.115	0.500	0.308

We found no evidence of any significant associations between test group (pre-test, post-test, follow-up) and the outcomes of the three Likert scale questions. Neither the follow-up group nor the post-test group (as compared to the pre-test group) were significantly associated to the outcomes of the three questions. However, when reviewing the responses to the self-reflective questions, the authors noticed an upward trend of the proportion of students reporting a slightly or absolutely increase in efficiency, effectiveness and satisfaction of their study skills on the post-survey. However, this trend did not sustain at follow-up.

Figure 1

Proportions of Students Within Each Test Group Who Answered Each Question Outcome



Research Question 4: Is there an association between each of the three Likert scale questions and the MAI scores. Similar to previous research questions, we fit a beta regression mixed effects model with a random intercept for student. However, in this model we used the question outcomes (with the neutral category of each question as the reference group) to predict for test score. Recall that the MAI "score" is the proportion of times a student answered "true" on the 52 question MAI survey. Summary statistics can be seen in Table 6, while a visual representation can be seen in Figure 2. In comparing the outcomes for the three Likert scale questions with MAI scores, only one significant association was detected. For the question that asked, "To what degree are your study skills efficient?" students who answered "Absolutely efficient" had significantly higher MAI scores as compared to students who answered "Neither efficient nor inefficient" (z=0.835, *p*-value=0.005). See Table 7.

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Table 6

Summary Statistics Comparing Scores on Each Outcome For Each Likert Question

Efficiency	Not at all efficient	Slightly inefficient	Neither efficient nor inefficient	Slightly efficient	Absolutely efficient
$n\ (\hat{p})$	0 (0)	9 (0.056)	8 (0.050)	114 (0.713)	29 (0.181)
$\bar{x}\ (s)$	–	0.722 (0.124)	0.637 (0.095)	0.754 (0.111)	0.849 (0.117)
$\hat{m}\ (IQR)$	–	0.745 (0.238)	0.608 (0.092)	0.765 (0.167)	0.846 (0.021)
Effectiveness	Not at all effective	Slightly ineffective	Neither effective nor ineffective	Slightly effective	Absolutely effective
$n\ (\hat{p})$	0 (0)	6 (0.038)	6 (0.038)	97 (0.610)	50 (0.315)
$\bar{x}\ (s)$	–	0.793 (0.103)	0.675 (0.100)	0.746 (0.112)	0.810 (0.120)
$\hat{m}\ (IQR)$	–	0.825 (0.060)	0.631 (0.115)	0.75 (0.160)	0.816 (0.153)
Satisfaction	Not at all satisfied	Slightly unsatisfied	Neither satisfied nor unsatisfied	Slightly satisfied	Absolutely satisfied
$n\ (\hat{p})$	2 (0.013)	13 (0.081)	16 (0.100)	94 (0.588)	35 (0.219)
$\bar{x}\ (s)$	0.707 (0.196)	0.717 (0.113)	0.724 (0.126)	0.750 (0.115)	0.831 (0.114)
$\hat{m}\ (IQR)$	0.707 (0.139)	0.706 (0.196)	0.738 (0.128)	0.750 (0.171)	0.846 (0.163)

Note: $n\ (\hat{p})$ represents the sample size (sample proportion)

Figure 2

Students' MAI Scores Compared Across Responses to the Three Likert Questions

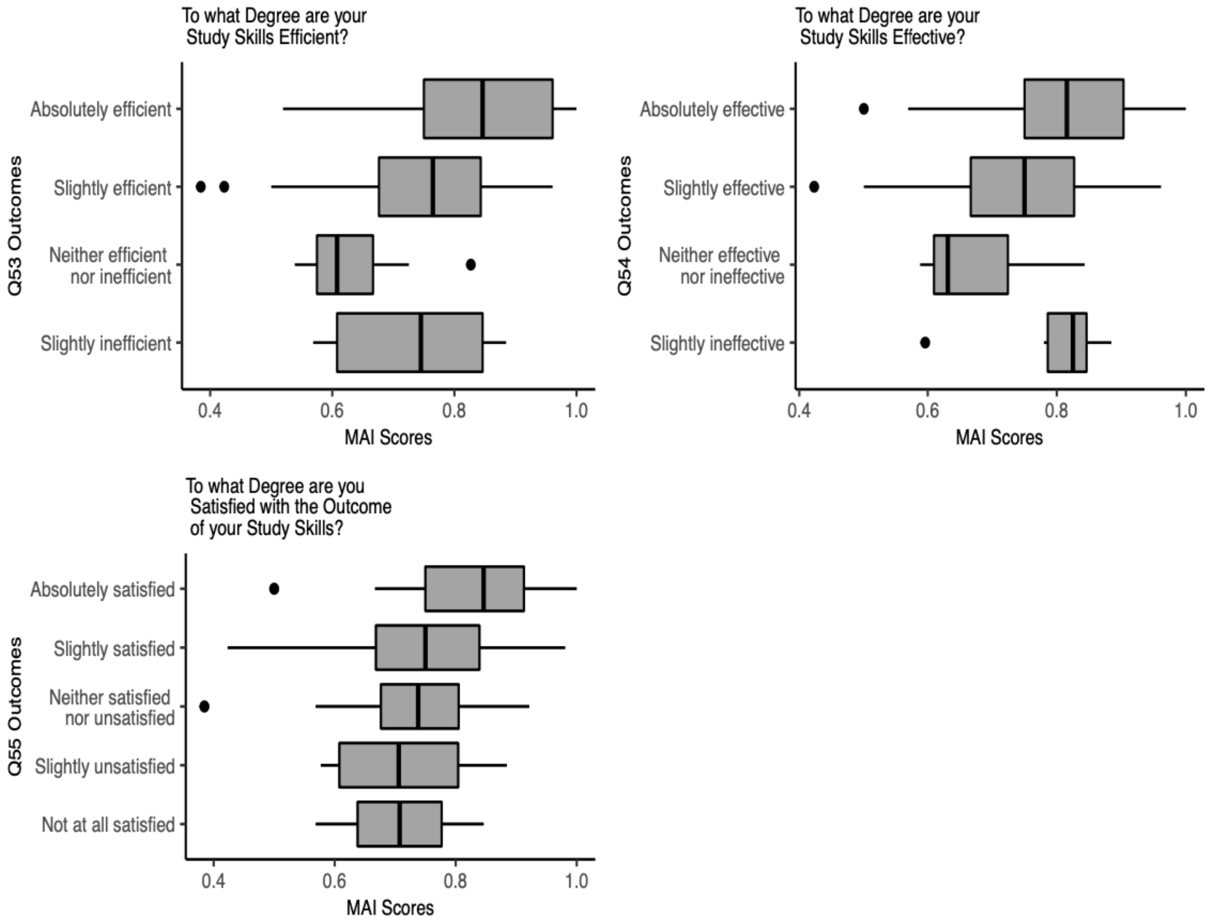

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Table 7

Fixed Effects Output for the Beta Mixed Effects Model (Logit Scale)

	Estimate	Std. Error	*z*−value	*p*−value	95% CI Lower	95% CI Upper
Intercept	0.885	0.340	2.603	0.009	0.219	1.551
Q53 Slightly inefficient	-0.048	0.393	-0.123	0.902	-0.818	0.722
Q53 Slightly efficient	0.356	0.215	1.658	0.097	-0.065	0.778
Q53 Absolutely efficient	0.835	0.294	2.844	0.005	0.260	1.411
Q54 Slightly ineffective	0.684	0.389	1.758	0.079	-0.078	1.446
Q54 Slightly effective	-0.219	0.286	-0.763	0.446	-0.780	0.343
Q54 Absolutely effective	-0.082	0.313	-0.264	0.792	-0.695	0.530
Q55 Not at all satisfied	-0.267	0.499	-0.536	0.592	-1.246	0.711
Q55 Slightly unsatisfied	-0.363	0.282	-1.290	0.197	-0.915	0.189
Q55 Slightly satisfied	0.112	0.176	0.634	0.526	-0.233	0.456
Q55 Absolutely satisfied	0.339	0.238	1.428	0.154	-0.127	0.805

Discussion

The findings of this research provide evidence that the use of teaching metacognitive skills enhanced students’ metacognitive awareness. Overall, our online module focused on reflective practice (e.g. exam wrappers) to promote metacognition. Langdon et al., (2019) also reported an increase in MAI scores for students who participated in reflective practice. Higher overall scores were observed in the post-test group and the 6-month follow-up group as compared to the pre-test group. There was no significant difference between the post-test scores and the 6-month follow-up scores, which indicates that the improvement held up over time. Gönüllü and Artar et al. (2014) found similar results with a group of medical students, i.e., metacognitive awareness scores for the post-test and follow-up tests were higher than the pre-test in the experimental group. Although the interventions were different, the current study also found that explicitly teaching metacognition improved metacognitive awareness.

When reviewing positive responses in the two metacognition domains (knowledge of cognition and regulation of cognition), the intervention seems to have had a greater influence on a few of the categories in the regulation of cognition domain. The intervention improved planning, information management, comprehension monitoring, and evaluation. These results were similar to other studies finding improved use of metacognition after instruction, which positively affected student learning (Akpunar, 2011; Apaydin & Hossary, 2017; Case & Gunstone, 2002; Erskine, 2009; Yilmaz & Baydas, 2017). There was no significant improvement in categories of knowledge of cognition. Considering that our participants were successful students, it seems possible that they possessed these skills and habits already.

In the regulation of cognition domain, the information management, comprehension monitoring, evaluation, and planning categories, the results were similar in that students' 6-month follow-up scores were, on average, either significantly higher than pre-test scores, students' post-test scores were, on average, significantly higher than pre-test scores, or both. This may be the result of becoming familiar with the course requirements and assessments as students progressed through the kinesiology course. We note that strategies in *information management* promote efficient learning and strategies in *comprehension monitoring* require reflection and assessment of one's learning or use of learning strategies. Strategies used to correct learning or performance errors, however, fall in the *debugging* category. Within this category, the authors found no evidence, on average, of differences in scores between the three test groups.

Furthermore, the results found within the regulation of cognition domain, information management, comprehension monitoring, evaluation, and planning categories highlight students' strategies used to process information efficiently (e.g., organizing, summarizing, etc.). Within these four categories, test scores and when the students took the tests are associated; i.e., the intervention is associated with improved metacognitive awareness. We also found the improvements to be sustained 6-months after the completion of the course within the evaluation categories, which indicates the effectiveness of a learning episode continued to increase after the kinesiology course concluded.

A visual inspection of Figure 1 shows that most students did seem to be responding in the positive to the self-reflection learning questions. Similarly, Figure 2 indicates that many students who had high test scores also answered positively regarding the same self-reflection learning questions. However, there were still some students who responded on the negative end of the spectrum and had high test scores. Though this was not a large proportion of students, we surmise this to be a potential reason why we were not able to delineate between question outcomes to find many significant associations between the three Likert scale question outcomes and test scores.

Our results indicate the value of metacognitive instruction early in the curriculum, preferably a foundation course. Understanding that not all students come equipped with metacognitive skills, the instruction provides an opportunity for that development. Other

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studies have also indicated an increase in metacognitive awareness and use of learning strategies with instruction (Akpunar, 2011; Yilmaz & Baydas, 2017). Additionally, instruction in metacognitive strategies can positively impact course grades (Cook et al., 2013) and has been shown to influence students to shift from a surface to a deep approach to learning (Case & Gunstone, 2002).

Limitations

Limitations of this study first include a relatively small sample size from two programs from a private mid-western university. The lack of participant diversity and use of a convenience sample may limit generalization of the results to a larger population of kinesiology students. A second limitation of our sample is the drop-out rate. Specifically, we obtained post-tests for 73% of the sample and 6-month follow up tests for 29% of the sample. Future studies should consider incentive structures that may improve the dropout rate. Third, the self-reporting nature of the instrument. Students have been found to be overconfident in their metacognitive awareness and may have overestimated their skills (Callender et al., 2016). Fourth, operational definitions of effectiveness, efficient, and satisfaction were not provided in the self-reflective study questions and were subjective in nature, limiting comparison among students. Fifth, as both athletic training and occupational therapy students are historically “good” students by meeting the admission and progression criteria of their programs, there may be a ceiling effect of the instrument, which affects the validity of changes in scores, as scores were relatively high in the pre-test (Portney & Watkins, 2009). The ceiling effect may have limited the amount of change possible.

Recommendations

The authors recommend future research with a larger sample size across health disciplines. Adjusting the MAI from a true/false format to a 5-point Likert scale might be more sensitive in measuring change between test administrations. Regarding the three Likert scale questions that asked students about their study skills, we recommend providing key qualities corresponding to each outcome to give students some guidance in determining which outcome best describes them.

Implications for Occupational Therapy Education

Students in both the athletic training and occupational therapy programs have a history of academic success, meeting rigorous admission and progression criteria. Yet, students may not be efficient in their studying approaches, increasing their levels of stress and anxiety (Legg & Locker, 2009). With metacognition instruction, students could potentially increase their studying efficiency allowing better management of rigorous program demands. Instruction in metacognition has been found to improve collaborative teamwork (Nonose et al., 2014) and creative problem solving skills (Hargrove & Nietfield, 2015). Both of these skills are paramount when practicing with others on an interprofessional team. Both disciplines do not work in isolation, and client-centered practice requires creative problem solving skills to meet the needs of the client.

Additionally, self-efficacy and metacognition are interactive (Yanqun, 2019). Gul and Shehzad (2012) found mastery learning goals correlated highly with metacognition. Instruction in metacognition has increased metacognition, including greater personal awareness and development (Apaydin & Hossary, 2017). Metacognition is necessary for lifelong learning and continued competence throughout one's career as a healthcare practitioner.

Our method of metacognition was not time intensive for the instructor and was coordinated within the curriculum in a foundational course. The kinesiology course content is the basis for many future courses, and learning must be long-term. Creating a learning environment to promote deep learning requires encouraging a growth mindset, self-efficacy and metacognition (Lumpkin, 2020).

Conclusion

Instruction and guided practice in metacognition positively influence students' use of metacognitive strategies. Students used improved regulation of cognition strategies after the instruction and after the completion of the course. Instructors should introduce students to metacognition strategies and provide learning activities that are designed to promote metacognition.

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