Assessing Academic Self-Efficacy, Knowledge, and Attitudes in Undergraduate Physiology Students

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Abstract Academic self-efficacy affects the success of students in the sciences. Our goals were to develop an instrument to assess the self-efficacy and attitudes toward science of students in an undergraduate physiology course. We hypothesized 1) that our instrument would demonstrate that students taking this course would exhibit greater self-efficacy and more positive attitudes toward science than students in a non-science undergraduate course, and 2) that the physiology students' self-efficacy and attitudes would improve after completing the course. A 25-question survey instrument was developed with items investigating demographic information, self-efficacy, content knowledge, confidence, and attitudes regarding science. Students in either an undergraduate physiology course (Group P) or a history course (Group H) completed the survey. Forty-eight students in Group P completed both PRE- and POST-class surveys, while 50 students in Group H completed the pre-class survey. The academic self-efficacy of Group P as assessed by the PRE-survey was significantly higher than Group H (p=0.0003). Interestingly, there was no significant difference between groups in content knowledge in the PRE-survey. The self-efficacy of Group P was significantly higher as assessed by the POST-survey, when compared to the PRE-survey (p<0.0001) coincident with an improvement (p<0.001) in content knowledge for Group P in the POST-survey. This study established a survey instrument with utility in assessing self-efficacy, attitudes, and content knowledge. Our approach has applicability to studies designed to determine the impact of instructional variables on academic self-efficacy, attitudes, and confidence of students in the sciences.

Keywords: self-efficacy, physiology, cardiovascular

1. Introduction

Self-efficacy has been defined as "the belief in one's capabilities to organize and execute a course of action required to produce given attainments" [1]. This differs from mere confidence by its emphasis on undertaking a course of action, as compared to simply holding an opinion or belief. In an educational setting, this definition was refined further to include the belief in one's capabilities to successfully complete assigned academic tasks [2]. Academic self-efficacy has been extensively studied as a variable in student learning. A meta-analysis investigating the relationship between academic self-efficacy and achievements showed that increased academic self-efficacy made a positive contribution to academic performance [3]. In addition to its influences on learning and performance, academic self-efficacy can affect learning strategies, specifically self-regulated learning [4]. Self-regulated learning, which includes self-monitoring, self-evaluation, goal setting, and planning, contributes positively to academic achievement [2].

While many variables affect a person's self-efficacy, four broad categories contribute most to its development. The first of these categories, past experience with a given task, plays an important role in the development of one's belief that one could succeed at that task in the future [1]. Secondly, present-day experiences, whether vicarious, in which the individual either observes or indirectly participates in the task, or mastery, in which the individual is a direct participant in the task, contribute to self-efficacy. The third category contributing to the development of self-efficacy is verbal persuasion, which emphasizes the role of teachers in cultivating the academic self-efficacy of their students [2]. Lastly, biochemical changes (e.g. emotional responses) occur within the brain when one succeeds at a task, and this physiological arousal has been shown to contribute to the development of self-efficacy [2].

Computer-based instruction can increase academic self-efficacy in certain settings [5]. This mode of instruction places an increased burden on the learner's motivation and encourages self-regulated learning [6]. The development of computer-based instruction utilizing interactive, case-based models of physiology has been attempted

[5,7,8,9,10]. At our institution, a novel computer-based approach to the cardiovascular portion of an undergraduate physiology course is being developed, with the hope that this approach will improve the students' academic self-efficacy, and presumably, academic achievement.

Before incorporating the computer-based approach into the aforementioned physiology course, we undertook the present study to document the self-efficacy, achievements, and attitudes of the students enrolled in the course in its current format. This study was performed in a manner similar to prior research evaluating the self-efficacy of high school students in science classes based on their responses to questionnaires regarding belief, motivation, and confidence [3,11,12,13,14,15]. The objectives of the present study were to develop and use a survey instrument to evaluate the academic self-efficacy, content knowledge and confidence in these responses, as well as attitudes of students in an undergraduate physiology course. We hypothesized that students in an undergraduate physiology course would have a higher academic self-efficacy regarding scientific curriculum than students in an undergraduate non-science (i.e., history) course. Additionally, we hypothesized that students in an undergraduate physiology course would have improved academic self-efficacy and academic performance regarding scientific curriculum after completing the course compared with their baseline characteristics.

2. Methods

2.1. Survey Instrument

A bank of survey questions was developed, designed to collect demographic information, measures of academic self-efficacy, content knowledge and confidence in one's responses, and attitudes regarding the subject matter. A subset of questions selected randomly from this bank was used to create each of four versions of a survey. Students enrolled in an undergraduate physiology course who participated in the present study comprise Group P. Students enrolled in an undergraduate history course who participated in the study comprise Group H.

Immediately following the first lecture of the cardiovascular physiology unit, students in Group P completed one of the four versions of the survey (PRE-survey). The four versions were distributed randomly, but in equal numbers throughout the student population. The students in Group P completed the survey a second time, immediately following the final lecture on cardiovascular physiology (POST-survey), and each student took a different version of the survey as the POST test than he/she had taken as the PRE test. The students in Group H completed one of the four versions of the survey on the same day that the Group P students completed the PRE-survey, with all four versions distributed randomly to the population. The students in Group H did not complete a POST-survey as they did not receive any cardiovascular physiology lectures. An example of the survey instrument is included in Appendix A. The survey and its use were approved by the institutional instructional review board (IRB).[1]

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[1] University of Georgia Institutional Review Board (IRB) ID:STUDY00000728.

2.1.1. Demographic Information

Information about the participants including gender, age, race/ethnicity, and year in college was collected. In addition, participants were asked if they had previously completed any anatomy or physiology courses. This final question had only "yes" or "no" as possible responses, so participants were not able to specify at what point in their education they took such courses, nor could they provide titles of the courses.

2.1.2. Academic Self-Efficacy

A 5-item measure was developed for the present study. Participants were asked to rate, on a 5-point Likert scale, their agreement with statements reflecting their level of confidence in their ability to explain certain concepts to their classmates. A sample item is as follows; "How confident are you that you could describe the path of blood flow through the heart chambers to your classmates?" The response scale ranged from 1 (totally confident) to 5 (not at all confident). The participants were not asked to anticipate their performance in comparison to their classmates, only to rate their confidence in explaining a concept to their classmates. Classmates were specifically selected as the target audience to encourage participants to view them as peers, an attempt to minimize the introduction of an element of performance anxiety which may have arisen had an authority figure been included.

2.1.3. Content Knowledge

Five multiple-choice questions related to cardiovascular physiology were included in each survey. These questions were intended to reflect pertinent content that could appear on a formal examination for the physiology course in which the students of Group P were enrolled. The lecturer for this course (SAB) was not involved in the creation of these questions, nor did he have access to them prior to the course lectures or survey administration. The lecturer also was not present in the classroom when the students were completing the survey. All other authors were involved in the creation of the survey questions. The students' content knowledge was assessed by two different types of questions; questions that required memorization or recall of terms/definitions, and questions that required higher-order thinking skills. Each version of the survey contained two memory/recall questions and three higher-order thinking skills questions. Students were presented with four possible responses to each question, with one correct response and three distractors per question. Because completion of the survey was voluntary, these questions had no impact on the participants' course grade. The authors did not have access to any survey results prior to completion of the course and submission of grades.

2.1.4. Confidence

Immediately after each cardiovascular physiology content question, participants were asked to rate, on a 5-point Likert scale, their confidence in their responses to the previous questions. Thus, each survey contained a five-item measure of post-question confidence. The response scale included the following choices: 1 (very confident; I am sure that I chose the correct answer), 2

(somewhat confident; It is very likely that I chose the correct answer), 3 (slightly confident; I made an educated guess when choosing an answer), 4 (somewhat unconfident; I was able to eliminate a few choices, but ultimately had to guess); 5 (very unconfident; My answer was a complete guess). For each respondent, confidence scores for each question were averaged to provide a single score for post-question confidence for that individual respondent.

2.1.5. Attitudes

A five-item measure of student attitudes was designed for the present study. Participants were asked to rate on a 5-point Likert scale their agreement with statements regarding cardiovascular physiology and biomedical research. The response scale ranged from 1 (strongly agree) to 5 (strongly disagree). Sample items are as follows: "Diseases of the cardiovascular system are particularly important and common," and "It is interesting when professors incorporate research findings into their lectures."

2.2. Study Groups

2.2.1. Physiology Group (Group P)

The participants in Group P were members of an undergraduate physiology course titled "Elements of Physiology." This course has a maximum enrollment of 250 students. Students in this course were introduced to the study by a verbal presentation from one of the investigators (ADW), and all students were provided with written consent forms for their inclusion in the study. All survey participants in Group P were assigned an indirect identification number so that their PRE and POST surveys could be collated. Students were made aware that none of the investigators would have access to the indirect identifiers, and that their responses would have no impact their course grade.

2.2.2. History Group (Group H)

The participants in Group H were members of an undergraduate history course titled "American History since 1865." This course was chosen as it had a similar enrollment (maximum 250 students), and was not a course within the natural sciences. Students in this course were introduced to the study by a verbal presentation from one of the investigators (ADW). All students were provided with an informational document about the study, as well as the fact that their completion of the survey would act as non-written consent for inclusion.

2.3. Statistical Analysis

Data between groups for gender, age category, race and previous coursework experience were compared by a chi-square test. Year in school was compared by a Mann-Whitney test. Scores from self-efficacy and confidence questions, and number of correct answers to content questions were evaluated for normality by examining histograms and Shapiro-Wilk tests. As evidence of consistent departures from normality was identified, non-parametric tests were employed. A Mann-Whitney test was used to compare the scores of self-efficacy and confidence questions, and performance on the content

questions of Group P (PRE) vs. Group P (POST), and Group P (PRE) vs. Group H. A Wilcoxon signed-rank test was used to compare PRE vs. POST surveys for only those students in Group P who completed both surveys. Spearman correlation was utilized to test for correlations in change in number of correct content questions and change in self-efficacy and confidence question responses for students completing both the PRE and POST surveys. A p-value of less than 0.05 was taken to be indicative of a statistically significant difference.

Mann-Whitney tests were used to compare Group P (PRE) vs. Group P (POST) and Group H for each attitude question response. A Bonferroni correction was performed and set p<0.0017 as the significance threshold.

All analyses were performed using professional statistical software.[2]

3. Results

3.1. Demographics

Forty-eight students in Group P completed both surveys (matched pairs). Forty-nine students in Group H completed the PRE survey. There was a significantly higher proportion of females in Group H (78% female, 22% male) compared to Group P (54% female, 46% male) (p=0.0012). Race was significantly different between groups (p=0.0003), and breakdown of these demographic characteristics is summarized in Table 1. Group P was significantly older than Group H (p<0.0001), and the year in school was significantly higher for the Group P than for Group H (p<0.0001). There was no significant difference between groups in previous anatomy/physiology course experience.

Table 1. Demographic Characteristics of the Students Enrolled in the Undergraduate Physiology Course (Group P) and the Undergraduate History Course (Group H)

*denotes a significant difference between groups		Group P	Group H
Gender*	Male	44.6%	22.2%
	Female	55.3%	77.8%
Age*	18-20 years old	5.7%	74.6%
	21-25 years old	94.3%	25.4%
Race/Ethnicity*	Asian/Pacific Islander	19.5%	3.2%
	Black	13.2%	1.6%
	Hispanic	5%	9.5%
	Native American	0.6%	0%
	White	57.2%	84.1%
	Other	2.5%	1.6%
	No Answer	1.9%	0%
Year in School*	Freshman	0%	42.9%
	Sophomore	3.8%	27%
	Junior	69.8%	15.9%
	Senior	23.3%	11.1%
	Other	3.1%	3.1%
Previous Physio Course	Yes	26.4%	25.4%
	No	73.6%	74.6%

3.2. Academic Self-Efficacy

Group P (PRE) had significantly higher academic self-efficacy than Group H (p=0.0003). Group P (POST) had

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[2] SAS v9.2; SAS Institute Inc. Cary, NC

significantly higher academic self-efficacy than Group P (PRE). This was true when Group P was analyzed for all students who completed the surveys (p<0.0001) and for the matched pairs only (p<0.0001). Medians and quartile ranges of self-efficacy responses for each group are depicted in Figure 1.
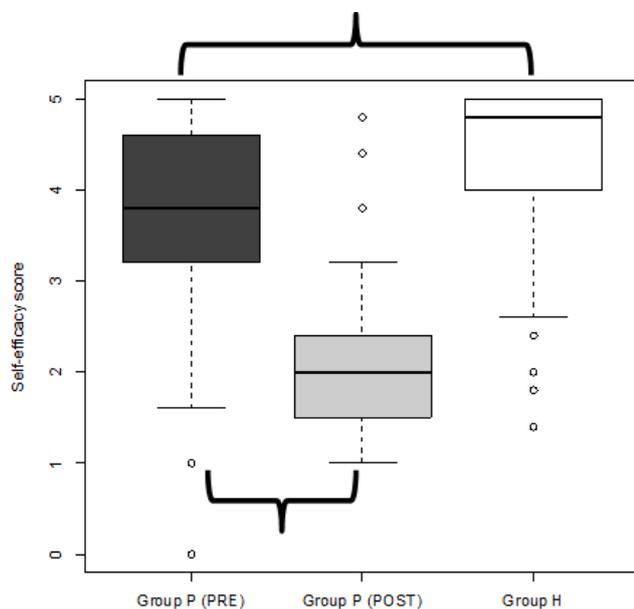

Figure 1. Medians and quartile ranges of responses to the academic self-efficacy items for each group. Self-efficacy scores range from 1 (very confident) to 5 (very unconfident). Significant differences between groups are contained within brackets.

3.3. Content Knowledge and Confidence

The number of correct responses for the five cardiovascular physiology content questions was not significantly different between Group P (PRE) and Group H (p=0.7684), although Group P (PRE) had significantly higher confidence regarding their responses than Group H (p=0.0013). The number of correct responses was significantly higher for Group P (POST) than for Group P (PRE) for all students who completed the surveys (p<0.0001) and within matched pairs (p=0.0018). Group P had significantly higher confidence in their responses on the POST survey than the PRE survey (p<0.0001). Average performance on the content-related questions is depicted in Figure 2. There were significant positive correlations between change in performance on the cardiovascular physiology content questions and students' confidence in their responses on the POST survey (r=0.39, p=0.0061), as well as with overall change in confidence between the two surveys (r=0.33, p=0.0241).

3.4. Attitudes

There were no significant differences in students' responses to attitude-based items between the PRE and POST-surveys from Group P. Three items were identified which elicited significantly different responses when comparing Group P (PRE) with Group H. For the items that stated, "Diseases of the cardiovascular system are particularly important and common," and "The cardiovascular system is fascinating," Group P agreed significantly more than Group H (p<0.0001). For the item, "Cardiovascular physiology is difficult to understand,"

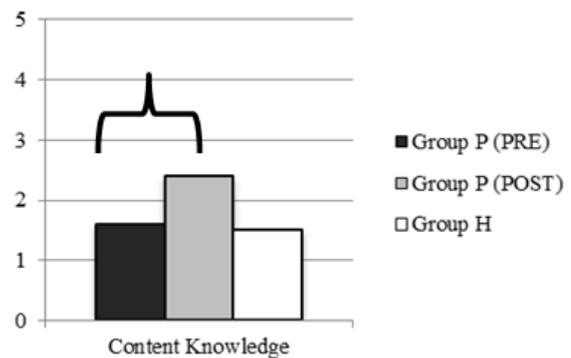Group H agreed significantly more than Group P (p=0.0001).

Figure 2. Average number of correct responses on the five content-related questions for each group. Significant differences between groups are contained within brackets.

4. Discussion

In this study, we developed and utilized a survey instrument for assessing self-efficacy, content knowledge and confidence in that knowledge, and attitudes towards science in an undergraduate science class. As hypothesized, the students in the physiology course (Group P) had a higher academic self-efficacy for cardiovascular physiology than the students in the history course (Group H). In addition, the students in Group P had greater confidence in their answers to content questions when compared to the students in Group H. This latter finding is particularly interesting, as the actual performance on the cardiovascular physiology content questions in the PRE-survey was not significantly different between the two groups. The increased academic self-efficacy in the students in the physiology course implies that there are factors that increased the students' expectations of their performance, even when these expectations were unwarranted.

Motivation likely plays a vital role in the academic self-efficacy of the undergraduate physiology students when compared to the undergraduate history students. Motivation can be intrinsic or affected by extrinsic factors. In a previous study, students with greater intrinsic motivation generated a greater self-efficacy [16]. It is likely that the students in Group P had more intrinsic motivation to succeed in the physiology course as this was a component of their intended majors or career paths. As the students in Group P were older than the Group H students, it also is likely that their increased academic experience contributed to their increased self-efficacy.

The results of previous studies indicate that expectancy of future grades, which is comparable to academic self-efficacy, is based on previous academic achievement as well as actual subsequent achievement [13,17]. Students in their third year of undergraduate education were the most commonly represented group in the physiology course. These students have a more extensive academic history, which can contribute to their self-efficacy. This prior experience or expectation of academic achievement also may have contributed to the increased post-question confidence noted in the Group P students on the cardiovascular physiology content questions, even when

their performance was not superior to that of the Group H students. However, it is interesting that a similar percentage of students in both groups had previously completed an anatomy or physiology course. The authors hypothesized that the students in the undergraduate physiology course would be more likely to have completed related coursework in the past. It was presumed that this past experience would be a contributor to increased academic self-efficacy. While the survey did not investigate the extent of the student's background in the sciences, it is clear that past academic experience is not the sole factor affecting self-efficacy.

The survey used in this study documented increases in academic self-efficacy, performance on content-related questions, and confidence after undergraduate physiology students experienced the curriculum in its current, lecture-based format. While utilizing assessment of self-efficacy to evaluate novel curriculum is common in educational research, this is the first time academic self-efficacy, as well as the other parameters, have been evaluated in a population of undergraduate physiology students. In our study, 73% of the students in Group P had never taken an anatomy or physiology course, so it is possible that this course was their first exposure to the concepts of cardiovascular physiology. It is expected that students would become more confident and more capable of answering questions related to a concept after they have been presented material pertinent to this concept in a setting in which they expected to be tested.

Comparisons between self-efficacy and the theory of self-determination have been made previously [18]. This theory also incorporates intrinsic and extrinsic factors that affect motivation, and supposes that these have a cumulative effect on one's belief that one will succeed at a given task [18,19]. While the intrinsic motivation of the students in this study was not measured, the choice of undergraduate students enrolled in a history course *versus* a physiology course as participants reflects our assumption of a difference in motivation to pursue a career in science between these groups. This assumption is weakly supported, however, as information regarding each student's declared major of study was not collected. The most important extrinsic factor in this study is the format and delivery of the curricular content. In this study, the students in the undergraduate physiology course experienced the curriculum in its traditional format, which consists of lecture-based delivery. The findings of this study demonstrated that an improvement in academic self-efficacy, academic performance, and confidence in content knowledge can be seen when the students are exposed to this instructional method, and sets the stage for comparison of this curricular format to others.

The results of several previous studies have identified a direct relationship between increased academic self-efficacy and improved academic performance [12,20,21]. In addition, greater academic self-efficacy was shown to benefit academic performance indirectly through its effects on other factors. In a study evaluating the learning strategies employed by students, Diseth *et al* [13] demonstrated that students who utilized deeper learning strategies had a higher academic self-efficacy, and showed improved academic performance when compared with students utilizing more superficial learning strategies. Superficial learning strategies would include those used for the primary purpose of memorization, while deeper learning strategies prioritize comprehension and retention. A novel interactive, computer-based approach for teaching cardiovascular physiology with the goal of encouraging deeper learning strategies is being developed for use in the undergraduate physiology course whose students were surveyed in this study. The survey instrument presented here will be used to assess future students' self-efficacy after the new curriculum is introduced.

Computer-based learning tools are being used more commonly in classrooms. There is a versatility associated with computer and web-based instruction that allows for learning in and out of the classroom. Many students use web content to supplement their learning, and a previous study documented that students who sought information on the Internet had a higher academic self-efficacy, and ultimately better academic performance, when compared to students who did not utilize the Internet as a resource [22]. Therefore, an instructional design that incorporates a computer interface may encourage a similar increase in academic self-efficacy.

Previous research has shown that more efficacious learners view the demands of their academic workload as more of a challenge than a threat [12]. This may partially explain the lower academic self-efficacy of the history students, as they may have viewed the cardiovascular physiology material as threatening rather than challenging. Traditional lecture-based instruction, such as that used in the undergraduate physiology course of this study, indirectly places an emphasis on the volume of material to be learned, as opposed to the pertinent points and applicable knowledge. The use of this survey for this traditional instructional approach verifies that it adequately assessed the measures for which it was intended. An approach that incorporates computer-assisted instruction with case studies and interactive lessons, for example, might be expected to create more relatable content and to lower the perceived threat. The survey instrument evaluated here would provide a means for assessing the value and effects of such instructional interventions.

While the results of the present study provide valuable information about the utility of the survey instrument, there were several limitations to this study. The two courses (history and physiology) were selected due to their similar class size. However, the composition of the two groups was dissimilar, and identified by the demographics of the students in each group. Group H had significantly more female students, and had a significantly younger average age than Group P. These differences may impact the intrinsic factors contributing to academic self-efficacy, confidence, and attitude, which could have affected our results. In the present study, fewer students in Group P completed both surveys than we had anticipated. Therefore, future studies would benefit from focusing on recruitment and retention of survey participants throughout the semester.

Additionally, while self-report surveys can assess self-efficacy and aptitude, they may not be the best method to assess dynamic processes such as learning strategies or comprehension [23]. Future research could record actual behaviors to assess changes that may occur with the introduction of novel approaches to teaching.

The survey instrument designed for this study was not previously validated. It was the original intent to use this study as a means for validation, but due to the major demographic differences in the two populations as described above, validation was not going to be possible. While a validated instrument may have provided more statistical significance, the academic self-efficacy of undergraduate physiology students has not been previously investigated. We believe the discrepancy between academic self-efficacy and academic performance was highlighted through our results, and future research is warranted to investigate this further.

While the aforementioned limitations make it impossible to draw precise conclusions from some of the results of the present study, this survey instrument was developed to assess changes in specific educational variables that occur in response to instruction. Our survey instrument documented an improvement in academic self-efficacy, performance, and confidence in content knowledge in physiology students over the period of didactic exposure to a unit of content. This finding may seem self-evident, but these results, coupled with the differences in PRE-survey results between groups, support the argument that this instrument can detect differences in self-efficacy, content knowledge and confidence in knowledge, and attitudes. This instrument can now be used to document outcomes of future changes to instructional method. Our approach has applicability in studies designed to determine the impact of instructional variables on academic self-efficacy, content mastery, and attitudes of students in the sciences.

Acknowledgement

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