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Mini Review

Interpreting the Pharmacogenomics Literature: Effectiveness and Pharmacy Students' Perceptions of an Independent Learning Assignment in an Integrated Biological Sciences Course

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Abstract

Background: Lack of time and creativity to develop effective activities can be a deterrent for some instructors to incorporate more active learning into their courses. Very few active learning activities relating to pharmacogenomics have been described and evaluated in the peer-reviewed literature. Thus, the aim of this study was to describe and evaluate the perceptions and effectiveness of an active learning assignment that may be easily utilized to teach health science students how to interpret the pharmacogenomics literature. **Methods:** The active learning assignment was implemented and assessed in an integrated biological sciences course during the first semester of a doctor of pharmacy program. A journal article and open ended questions were assigned to be completed outside of class followed by an in-class clicker question session before taking a course exam. A perception survey of the assignment was also administered. **Results and Conclusion:** The majority of students were able to answer correctly the majority of the questions on the course exam. Completion of the assignment improved students' perceived ability and confidence to accurately interpret the pharmacogenomics literature and it provided a useful opportunity to apply basic science knowledge to clinical practice.

Keywords: Single nucleotide polymorphisms; Personalized medicine; Pharmacogenomics; Active learning; Higher education; Pharmacy; Curriculum; Teaching

Introduction

Active learning teaching methods have proven to be more effective for student learning and retention compared to traditional approaches, such as lecture [1-6]. Active learning methods promote higher-order objectives, such as analysis, synthesis and evaluation, on Bloom's taxonomy [7,8]. Most educators are likely aware of the advantages that active learning methods confer, however, have difficulty incorporating this style of teaching [7,9]. Reasons include a high comfort level with traditional lecture, lack of class time, and insufficient time to develop materials [7]. Tied to insufficient time to develop materials may be the lack of creativity in designing activities specific for particular subject matters. It was found that biology educators were more successful integrating active learning into their classes when they were provided with curricular units that included instructional commentary that guided the implementation of structured activities [10]. Currently, very few active learning activities have been described and assessed in the peer-reviewed literature relating to the teaching of pharmacogenomics [11-13]. One study evaluated the effects of the flipped classroom on student performance in a pharmacogenomics course [13]. Two other studies described the use of genomic testing on colon cancer cells [12] and personal genomic testing [12] as a means to enhance understanding of pharmacogenomics. Although, the active learning methods described were effective and perceived well by students, they are methods that would be difficult and time consuming to incorporate into any course. Thus, the aim of this study was to describe and evaluate an active learning assignment that may be easily utilized to teach health science students, such as student pharmacists, how to interpret the pharmacogenomics literature. The goals of the assignment were: 1. To introduce the field of pharmacogenomics and what it entails, 2. To improve understanding of how single nucleotide polymorphisms can affect drug response and drug dosing of individual patients, 3. To introduce commonly used terms and symbols and the interpretation of the pharmacogenomics literature, and 4. To provide an opportunity to apply basic biological science knowledge to clinical practice. The Accreditation Council for Pharmacy Education Standards include competencies in pharmacogenomics and the application of biomedical science knowledge to solve therapeutic problems and advance patient-centered care [14,15]. Furthermore, professional position statements advocate for pharmacists to play a leadership role in pharmacogenomics-based patient care. However, most pharmacists are not confident with pharmacogenomics data [16-18]. Thus, the purpose of the assignment was to apply basic science knowledge to a clinically relevant topic while simultaneously introducing pharmacy students to pharmacogenomics early in their educational career.

Methods

Experimental design

101 first year Pharm.D. pharmacy students enrolled in an

integrated biological sciences course [19] completed an active learning assignment. The assignment was completed outside of class and was ungraded, however, the questions and content covered in the assignment were included on a course exam. Class performance on specific exam questions pertaining to the material covered in the assignment was used to assess content mastery. Once the students completed the assignment and the course exam, a survey was administered to determine student perceptions of its effectiveness. All procedures were approved by the Institutional Research Review Board.

Active learning assignment

The active learning assignment entailed reading a review article entitled, "Warfarin dose and the pharmacogenomics of CYP2C9 and VKORC1-rationale and perspective [20]," and answering specific open-ended questions tailored to define terms and interpret the symbolism commonly used in the pharmacogenomics literature. Questions were also designed to assess their ability to correctly interpret the data and to lead them to acknowledge the important take-home points of the article. See Appendix 1 for Assignment Questions. Students completed the assignment outside of class in parallel to learning in-class course content on the topics of genomics and gene expression. This segment of the course included a discussion on the definition of "single nucleotide polymorphisms (SNPs)" and how the location of the SNPs in the genome determine the effects on phenotype. Students were allowed a three-week period to complete the assignment before taking the related course exam. Answers to assignment questions #9-20 were posted on the course website for students to access 3 days prior to the course exam. Answers to questions #1-8 were not posted since these were definitions of terms that could easily be accessed in a medical dictionary or other online resources. At the time that the assignment was assigned, students were not made aware that they would have access to an answer key and students were encouraged to complete the assignment at least 3 days before the exam. They were asked to complete the assignment before this day since clicker questions using Turning Point technology were used in class 2 days before the exam to review some of the same questions that were assigned in the assignment. The clicker questions addressed mostly the interpretation of the symbolism and data used in the pharmacogenomics literature specifying the SNP location, nucleotide change, and effects on the phenotype. Clicker questions did not include definition of terms.

Course exam

The course exam consisted of 100 multiple choice questions on the following lecture topics: Introduction to Cells and Organelles, Protein Structure, Protein Function, DNA and Chromosomal Structure, Gene Expression, Epigenetics, Pharmacogenomics, Membrane Structure, and Membrane Transport. Eight questions were included that stemmed from the pharmacogenomics assignment (See Appendix B). Three of the questions were based on definition of terms. The remaining five questions were based on interpretation of the information provided in an insert from the pharmacogenomics assignment, which was included in the stem of the exam question. The questions regarding the assignment were multiple choice with 2-5 answer choices per question. Exam and question analyses were performed using ExamSoft software (ExamSoft Worldwide, Dallas, TX), which included the assessment score reliability (KR-20) in addition to the point biserial (rpb) and discrimination index for each question. The exam was the first given in the Biological Sciences Integrated course during the first semester of a 4-year Pharm.D. program.

Perception survey

A survey was developed which included eight rating type questions with a Likert scale. The questions aimed to determine the students' perceived effectiveness of the assignment on improving their ability to interpret the pharmacogenomics literature. The students completed a paper copy of the survey during the class period. See Table 2 for survey questions.

Results

Students completed the pharmacogenomics assignment outside of class before taking the course exam which included questions from the assignment. 101 students completed the course exam. The course exam consisted of 100 questions including 8 stemming from the assignment. The mean score on the course exam was 75.3% with a low of 47% and high of 96%. The assessment score reliability (KR-20) was 0.89. The percent correct for each question stemming from the pharmacogenomics assignment is as follows. Question 1: 38.4% correctly identified the definition of "haplotype." Question 2: 64.7% were able to identify an incorrect definition of "allele." Question 3: 82.8% correctly identified the definition of "single nucleotide polymorphism." Question 4: 65.7% correctly identified an example of a phenotype. Question 5: 86.9% were able to correctly identify which genotype is the most warfarin resistant. Question 6: 42.2% correctly interpreted the phrase "VKORC1 1173 CT." Question 7: 92.3% were able to correctly interpret the phrase "CYP2C9*2 (Arg144Cys)." Question 8: 83.8% correctly identified that an SNP that leads to a change in the amino acid sequence of a protein would more likely be found in an exon, rather than an intron, of a protein encoding gene. See Table 1 for Question Statistics.

	% Correct	**Point Biserial (rpb)**	**Discrimination Index**
Question 1	38.4	0.27	0.4
Question 2	64.7	0.34	0.41
Question 3	82.8	0.21	0.17
Question 4	65.7	0.33	0.44
Question 5	86.9	0.24	0.17
Question 6	41.4	0.29	0.26
Question 7	92.9	0.15	0.1
Question 8	83.8	0.26	0.27

Table 1: Exam question statistics.

A survey was administered to the students during class on the day following the exam. Students received their exam grades before completing the survey, but did not receive a breakdown of questions they missed. See Table 2 for survey questions and student responses. 100% of the students (N=101) enrolled in the course completed the survey. The survey revealed that the students believed the assignment was beneficial in improving their understanding of the field of pharmacogenomics and their ability to read and interpret the pharmacogenomics literature. Before enrolling in the integrated biological sciences course and completing the assignment, approximately 70% of students had little confidence to read and accurately interpret the pharmacogenomics literature; they chose 1 (38%) or 2 (33%) on a 5-point scale rating confidence with 1=poor and 5=excellent. After enrolling in the course and completing the assignment, only 19% of students had little confidence while 29%, 47%, and 7% of the students rated their confidence as 3, 4, or 5 respectively. 88% believed that it is important for student pharmacists to learn to read and interpret the pharmacogenomics literature.

	Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
The assignment broadened my understanding of what the field of pharmacogenomics entails.	15 (14.9%)	54 (53.5%)	24 (23.8%)	7 (6.9%)	1 (1.0%)
The assignment improved my understanding of how single nucleotide polymorphisms can affect drug response and drug dosing.	30 (29.7%)	49 (48.5%)	16 (15.8%)	6 (5.9%)	0 (0%)
The assignment improved my understanding of common terms used in the pharmacogenomics literature.	25 (24.8%)	53 (52.5%)	19 (18.8%)	4 (4.0%)	0 (0%)
The assignment improved my ability to interpret symbols and nomenclature (e.g. CYP2C9*2, Arg144Cys, 269T>C) commonly used in the pharmacogenomics literature.	53 (52.5%)	35 (34.7%)	11 (10.9%)	1 (1.0%)	2 (2.0%)
By completing the assignment, my ability to read and interpret the pharmacogenomics literature improved.	18 (17.8%)	45 (44.6%)	32 (31.7%)	6 (5.9%)	0 (0%)
I believe that it is important for student pharmacists to learn to read and interpret the pharmacogenomics literature.	57 (56.4%)	32 (31.7%)	8 (7.9%)	1 (1.0%)	2 (2.0%)
	1 (Poor)	2	3	4	5 (Excellent)
Before taking this course and completing the assignment, how would you rate your confidence to read and accurately interpret the pharmacogenomics literature?	38 (37.6%)	33 (32.7%)	18 (17.8%)	10 (9.9%)	1 (1.0%)
After taking this course and completing the assignment, how would you rate your confidence to read and accurately interpret the pharmacogenomics literature?	2 (2.0%)	17 (16.9%)	29 (28.7%)	47 (46.5%)	7 (6.9%)

Table 2: Perception Survey Responses. Number of responses (percentage of responses).

Discussion

It can be time consuming and difficult to develop original learning activities to facilitate understanding of specific curricular content. Thus, the purpose of this study was to evaluate a specific active learning assignment used to introduce and teach first year pharmacy students to interpret the pharmacogenomics literature. Since the subjects in the study are in the first semester of their pharmacy education, the expectation was to expose them to the pharmacogenomics literature and improve their ability to interpret the reading with the understanding that what they learned from the assignment would be expanded upon in later years of the curriculum. Learning of pharmacogenomics was not a course objective, but was rather an exercise to apply basic science to a clinically relevant topic while at the same time introducing them to a subject area that is a program level outcome.

After completing the pharmacogenomics assignment that coincided with teaching of genomics and gene expression in the first three weeks of a biological sciences integrated course and participating in a clicker question session, the students' knowledge was assessed by a multiple choice course exam. The mean on the exam was 75.3% with an assessment score reliability of 0.89. Out of the 8 questions pertaining to the assignment, at least 80% of the class answered correctly on 4 of them. At least 64% of the class answered correctly on 6 of them. The point biserials ranged between 0.15-0.34. The point biserials suggest that those who were more prepared for the exam, were also better prepared to answer the assignment-related questions. Although mastery of the content and perceptions of improvement were evaluated, actual improvement in knowledge cannot be determined since baseline data was not collected. This is a limitation to the study.

The activity was an ungraded assignment and therefore was not submitted to the professor. It cannot be determined who completed the assignment. Intuitively, those who completed and studied the assignment for the course exam performed better on the related exam questions. A suggestion to improve class performance on the pharmacogenomics questions would be for the professor to require students to submit the assignment to ensure completion by all students. Furthermore, the students seemed to perform better on types of questions that were asked and discussed in the clicker question class session. Incorporation of more in class clicker questions could improve performance on the exam. Due to time restraints, other than the clicker question session, the assignment was not reviewed or extensively discussed in class. This was meant to be more of an independent learning assignment to be done outside of class. If more time was devoted to reviewing the assignment in class, it is believed that the performance on the associated exam questions would have been much improved.

The responses to the perception survey support the attainment of the assignment goals. The majority of the class agreed that the assignment broadened their understanding of what the field of pharmacogenomics entailed, improved understanding of how SNPs can affect drug response and drug dosing, improved understanding of commonly used terms, improved ability to interpret commonly used symbols and nomenclature, and improved their ability and confidence to read and interpret the pharmacogenomics literature. A small percentage of students did not feel the assignment improved their understanding. Unfortunately, based on the data collected, it cannot be determined the reason for their lack of perceived improvement. 11% of students chose 4 or 5 (5 = excellent) when asked how they would rate their confidence to read and accurately interpret the pharmacogenomics literature before taking the course and completing the assignment. This may suggest that since their baseline knowledge was already high that their improvement was minimal. Alternatively, it is possible that this small percentage felt that the assignment was ineffective despite baseline knowledge. It is possible that devoting more class-time discussion reviewing the assignment would improve its effectiveness for some. The response rate of the perception survey was 100% indicating no response bias.

The last goal of the active learning assignment was to apply basic science knowledge to clinical practice. Many health science professional students, such as student pharmacists, are clinically-minded and sometimes do not appreciate the importance of basic science. Thus, this assignment was an opportunity to apply the basic science content taught in the course, genomics and gene expression, to a real-world clinically relevant case. 89% of the students believed that it was important for pharmacists to learn to read and interpret the pharmacogenomics literature; only 3% disagreed. Thus, the utilization of this activity to apply basic science knowledge is a relevant and useful active learning tool.

Conclusion

In conclusion, the active learning assignment improved students' perceived ability and confidence to accurately interpret the pharmacogenomics literature and it provided a useful opportunity to apply basic science knowledge to a clinically relevant case. It is an activity that can easily be incorporated into any course.

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