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Evaluation of Engineering Teaching Effectiveness through Cheat-Sheet Data-Mining

Dr. Philip Appiah-Kubi, University of Dayton

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Abstract

This research paper describes the study of cheat-sheets and how Engineering Educators can utilize them to evaluate students' ability to identify critical information. Effective teaching has different definitions, which make it a challenge to settle on a single definitive definition. Some of the common words or phrases characterizing an effective teacher are: interesting, helpful, approachable, makes subject interesting, being available, motivating students, setting high but achievable standards, presents material well, and stimulating interest in subject. As good as these attributes are, they may not always guarantee the desired learning outcome. For this reason, it is important to evaluate effective teaching in conjunction with students' learning. Student learning is normally done by evaluating their performances in exams, quizzes, class discussions and other assignments. One area full of information but has received no attention is cheat-sheets prepared students in some exams. These sheets usually contain what students perceive as difficult course material to understand, memorize or pertinent to the exam. Since exams usually contain the core concept of the subjects taught, students prepare cheat-sheets to aid them to prove that they received and understood the core concept of the various subjects. From this study, we conclude that studying the structure and content of cheat-sheets may help engineering educators to gain invaluable knowledge of how students identify the core content of class material, hence, gaining an insight on how to propagate the main subject matter of the courses they teach.

Keywords: Teaching effectiveness, assessment, cheat sheet, summative assessment, formative assessment.

1.0. Introduction

Students are expected to retain the content of the course materials covered by their educators. Material retention is usually assessed and evaluated through various means such class discussions, homeworks, quizzes, and exams. Class discussion, homework and quizzes are normally used for in-process assessment, referred to as formative assessment. Formative assessment helps educators to evaluate students' academic development. It furnishes educators with invaluable knowledge which helps them to adjust teaching methods to achieve the course objectives. Since most homeworks allow students access to class notes, textbooks, and several online resources, it may not be the best approach for engineering educators to assess material retention. Also, the period between the times a lesson is taught, and the time a homework is typically given, does not offer educators the requisite time frame to evaluate material retention. However, formative assessment, helps instructors to save a situation by readjusting teaching methods and directing students to the main course concepts; thus, both parties (educators and students), benefit from the knowledge loop in formative assessment.

Summative assessment, an alternative to formative assessment, is well suited for evaluating material retention. This is usually done at the end of a cycle with a mid-term exam, final exam, a research paper or project presentation. Exams are conducted in various forms: take-home, open-notes-open-book, closed-notes-closed-book, closed-notes-closed-book with cheat-sheets. Closed-

notes-closed-book exams are the orthodox form of exams which many educators believe to be the best way to assess knowledge retention[1]. However, take-home, open-notes-open-book, and cheat-sheet exams are also popular in engineering education. With open-notes-open-book exams, students are permitted to assess their textbook, personal notes, and lecture materials[2]. Cheat-sheet exams also permit students to prepare notes on a sheet, which they use as reference material for the exam. For the cheat sheets, students are sometimes limited on the font and number of sheets used.

In assessing material retention, opinions continue to differ on the best form for an exam[1]. A good exam for summative assessment depends on a lot of factors, such as the type of course, volume of material covered, level and difficulty of the course under evaluation, exam content, and also the results of the formative assessment. If an educator perceives a course to be very difficult, s/he may allow students to use cheat-sheet. However, these factors are all subjective, and depend on the educator. It is therefore, not surprising that no consensus exists among educators on the most effective type of exams[1].

From students' perspective, open-book-open-notes exam is preferred to closed book exams[2] due to decreased test anxiety[1] that comes with the former. Most students believe that take-home exam, cheat-sheets, and open-book-open-notes exams help to increase exam scores and decrease test anxiety[1]. Some students also complain that take home exams are time consuming, due to the nature of exam questions. Take home exams usually require a lot of research to compensate for the time and resources available to students.

To minimize exam anxiety, and still assess material retention, the cheat-sheet exam has become an alternative; with this, students prepare cheat-sheets with course content they perceive to be the main points of the class material. Since there are restrictions such as the size of sheet, font, and the number of pages of cheat-sheets, the optimal way to go about preparing a cheat-sheet is to ensure that the main ideas examinable, but "difficult" to memorize or understand are captured.

Cheat sheets, therefore, may serve as a useful source of information for educators to evaluate their students' ability to identify the core concept of their classes. However, there is no information in the literature concerning how educators can mine this data source to help them improve on course delivery. Instructors usually collect cheat-sheets at the end of the exam to ensure that students did not abuse the limits. An example of abuse is exceeding the font size or number of pages permitted for the cheat-sheet. This research, therefore, looks into how educators stand to benefits by evaluating the content of cheat sheets prepared by their students instead of only checking for quantity variations.

No literature was found on the importance of reviewing cheat-sheets, and how engineering educators can use them to assess students' ability to identify main concepts of course material. The famous saying: "you don't have to know everything. You just have to know where to find it" has been attributed to Albert Einstein and a host of other distinguished people[3]. Einstein was once asked if he knows the speed of sound, and his response was: "I don't know. I don't burden my memory with such facts that I can easily find in any textbook[3]." Social Scientist and educator, Sophonisba Breckinridge also expressed similar sentiments in one of her speeches to students[3]. These sentiments give credence to cheat sheet, take-home and open-book-open-notes

exams. It was in the light of the above reasons that this research was carried out. The methodology used has been explained in the next section.

2.0. Methodology

Cheat-sheets from a class (Industrial and Environmental Safety) of 29 students were used for this study. About 58% of the students were enrolled in the Industrial Engineering Technology Department. The remainder of the students were either Mechanical Engineering Technology (MCT) or Electronic and Computer Engineering Technology (ECT) majors. Industrial and Environmental Safety is taught as an elective course in the Industrial Engineering Technology Department. The main objectives of the class were for students to be able to identify unsafe conditions, be familiar with pertinent OSHA regulations and understand how to manage safety issues.

In two different exams, students were allowed to prepare a one-page cheat sheet on an A4 paper. Hand or type-written cheat-sheets was not enforced: students were allowed to choose between the two. Both exams had 40 questions, comprised of about 28 multiple choice, 7 true or false, and 5 fill in the blanks questions. The study guide for both exams only talked about the topics from which the exams were prepared, and both exams covered different topics with no overlaps. The exams were also conducted for the same students in one semester. Both exams were scored out of 40 points, with an average of 35 and 32 points respectively for Exam 1 and Exam 2.

The cheat-sheets were collected after both exams to ensure that the page limit was not abused, and also for this analysis. The instructor, acting as an expert system, studied the cheat-sheets to determine if the information provided by the students on the sheets could be used to correctly answer 50% of the exams questions. If the expert determines that the information was relevant, and could help to correctly answer at least half of the exam questions, the sheet was classified as effective. However, if the information was not relevant to correctly answer 50% of the exam questions, the sheet was categorized as not effective. The information was then coded into SPSS statistical software as:

$$\text{Is cheat sheet effective?} = \begin{cases} 0, (Yes) \\ 1, (No) \end{cases} \quad (1)$$

For the first exam, every student prepared a cheat sheet. For the second exam, only 23 students prepared the cheat sheet. The exam scores for each exam were respectively categorized as either above or below average. For the first exam, 15 students scored above average while 17 students scored above average in the second exam. The exam score (above or below average) was treated as the dependent variable, while the effectiveness of the cheat-sheet was treated as the independent variable. The dependent variable was coded in SPSS as:

$$\text{Is exam score above average?} = \begin{cases} 0, (No) \\ 1, (Yes) \end{cases} \quad (2)$$

Since both the dependent and independent variables are dichotomous, binary logistic regression was used for the analysis. For binary logistic regression assumptions, the reader is referred to Field[4]. The results are presented in the next section.

3.0. Results

For the first exam, all the students prepared a cheat sheet. However, only 23 students prepared a cheat sheet for the second exam. The reason(s) for not preparing the cheat sheet was not explored. The cheat sheets were individually evaluated and analyzed using binary logistic regression. The summary statistical outputs from SPSS statistical software are respectively presented for exam 1 and exam 2 in the table 1 and table 2 below.

Table 1: Statistical output from exam 1

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Effective(1)	-3.178	1.000	10.100	1	.001	.042	.006	.296
	Constant	1.792	.764	5.504	1	.019	6.000		

a. Variable(s) entered on step 1: Effective.

Table 2: Statistical output from exam 2

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Effective(1)	-2.485	1.218	4.163	1	.041	.083	.008	.907
	Constant	2.485	1.041	5.700	1	.017	12.000		

a. Variable(s) entered on step 1: Effective.

For both exams, it was observed that an "effective" cheat sheet was highly likely to aid a student to score an above-average mark. For example, in exam 1, the probability *(P(Y))* of scoring above-average score with effective cheat sheet is about 86%. This is given by:

$$P(Y) = \frac{1}{1+e^{-(\beta_o+\beta_1 X)}} \tag{3}$$

Where β_o is the constant, β_1 is the coefficient of the independent variable, and x is the independent variable. Both the constant, and the coefficient of the independent variable are statistically significantly different from zero ($p < 0.05$) at $\alpha = 0.05$ level, hence their inclusion in the model.

For the second exam, the coefficient of the independent variable and the constant are again statistically significantly different from zero ($p < 0.05$) at $\alpha = 0.05$ level, leading to the predictive model:

$$P(Y) = \frac{1}{1+e^{-(2.485-2.485X)}} \tag{4}$$

From exam 2, the probability that an effective cheat sheet aided in a student scoring an above-average score was approximately 92.31%. Furthermore, the *Exp(B)s* in table 1 and table 2 indicate that the odds of a student obtaining an above-average score in both exam 1 and exam 2 decreased with an ineffective cheat sheet. This is because the *Exp(B)s* for both exams are less than 1. In other words, the odds of a student obtaining an above-average score in exam 1 with an effective cheat sheet is 6.14 times higher than a student with a non-effective cheat sheet. For exam 2, the odds of obtaining an above-average score was 12.00 times higher with an effective cheat sheet than for students with non-effective cheat sheet. Thus, the odds of an event *Y*, is defined as the chances of the event occurring divided by the chances of the event not occurring, as shown in equation 5.

$$Odds\,of\ an\,event\ Y = \frac{P(Y)}{1 - P(Y)} \tag{5}$$

For the first exam, it was observed that if the status of a cheat-sheet changes from No (not effective) to Yes (effective), the odds of the student scoring an above average exam score was 6.14 times higher. Similarly, the odds of a student obtaining an above average score in exam 2, with an effective cheat-sheet was 12 times higher than with a non-effective cheat sheet. The next section talks about the conclusion drawn from this study.

4.0. Conclusion

This paper demonstrates the association between effective cheat sheets and above-average exam scores. The research used cheat sheets prepared for two different exams of the same course in a semester by the same group of students. In both exams, it was observed that effective cheat sheets are associated with above-average exam scores. The odds of a student scoring above-average with an effective cheat sheet were higher in both exams. It, therefore, suffices to say that instructors who teach qualitative courses, such as the one used in this study, can add cheat sheets prepared by students as an assessment tool. Another way of doing this is tasking students to prepare a summary after each topic. This may provide the means for instructors to assess, evaluate and understand students who suffer from exam anxiety. Although this cannot be a substitute for a traditional exam, it will serve as a useful resource for instructors to assess the abilities of their students to identify the most important course content. As Albert Einstein once said, one doesn't always have to know everything, but must know where and how to find the most important things. Instructors can use cheat sheet to assess students' ability to identify the most important topics in class material. This also provides a sublime feedback, which instructors can use to improve the delivery of lectures.

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