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Detecting Student Cooperation on Learning Management System Exams

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Instructors develop courses to promote student learning and a multitude of strategies to measure if learning occurs through exams, projects, and other assignments. However, the measurements may also be an indication of how well the students cheat. In the classroom, proctors and multiple versions of an exam help to deter cheating, and comparing right and wrong answers among students helps to detect it. Video proctors for Online exams prove effective at preventing cheating, but they pose privacy and other issues. Comparing right and wrong answers between students remains a useful tool to detect online cheating. We propose analyzing learning management system (LMS) data to support and possibly replace other detection methods. LMS data have the potential to reveal cooperating students through a statistical analysis of student answer times. The proposed methodology is accessible to instructors without involving administrators in data collection.

Key Words: Cooperation, Cheating, Learning Management System (LMS), Online Education, Detection Method, Exam

Introduction

Online education is increasing in higher education to meet growing demand while also providing more flexible higher education opportunities to students (Seaman, Allen, & Seaman, 2018). Elaine et al. (2016) reported that over 70% of academic leaders rate learning outcomes the same or higher in online education than face-to-face but clarify that the ratings are based on personal perceptions. Caspersen et al. (2017) note that learning outcomes are often self-assessed by students, and they advocate including the use of grades because tests on which the grades are based determine "students' level of acquired knowledge and skills." Sadler (2010) emphasizes that when using grades to measure student achievement, the grades should not include "transactional credits or debits" that fail to measure achievement such as attendance, participation, or deductions for a late submission.

However, grades as a measurement of learning outcomes must consider cheating on fact-based exams. Watson et al. (2010) surveyed 635 undergraduate and graduate students, and they found that the rate of admitted cheating was the same between online and face-to-face courses. Yet, the same students indicated that they were almost four times more likely to cheat online compared to face-to-face (Watson & Sottile, 2010). The students had a lower opinion of their peers' propensity to cheat online with a perception that exceeded five times more likely than face-to-face (Watson & Sottile, 2010).

The students' perception is supported by Alessio et al. (2018) research that found students achieved lower grades online when remote proctor was introduced for exams, suggesting that cheating occurs in the absence of prevention measures.

The increase in online courses and students' ability to cheat brings into question among faculty and administration the equality of learning outcomes between online and face-to-face courses (Prince, Fulton, & Garsombke, 2009). This research will detail a cheating detection methodology utilizing access logs in most learning management systems (LMS). We begin with a discussion of cheating strategies and recommended solutions from the literature and build upon that knowledge to reinforce cheating detection. Further, the study will demonstrate how some online exam best practices to prevent cheating obfuscates cheating detection.

Review of the Literature

Many researchers agree that mitigating cheating in online courses involves both prevention and detection (Moore, Head, & Griffin, 2017; Moten Jr., Fitterer, Brazier, Leonard, & Brown, 2013; Cluskey, Jr., Ehlen, & Raiborn, 2011; Prince, Fulton, & Garsombke, 2009; Christe, 2003). Norris (2019) suggests that prevention has the "potential to be more effective and produce superior results" than detection and offers cheating education and its consequences as a solution. Norris (2019) perceives detection as "invasive and expensive," but draws this conclusion from only one form of detection – remote proctors. Bain (2015) takes a contrary view to Norris (2019) by noting that some students will cheat despite prevention techniques, making detection necessary. The following is a review of prevention and detection techniques that address students' strategies for cheating.

Cheating Prevention

As mentioned previously, an often-mentioned first strategy to prevent cheating is through student education that describes cheating and documents it in the syllabus and course material (Nicholls & Lewis, 2017; Bain, 2015; Moten Jr., Fitterer, Brazier, Leonard, & Brown, 2013; Jones, 2009; Rowe, 2004; Olt, 2002). While most strategies employed to prevent cheating are specific to a type of cheating, one appears to be universal, the use of a remote proctor (Moore, Head, & Griffin, 2017; Nicholls & Lewis, 2017; Moten Jr., Fitterer, Brazier, Leonard, & Brown, 2013; Rowe, 2004; Christe, 2003). Remote proctors use a computer's camera to view and record student activity during an exam, which is evaluated for unusual behavior by human observers or artificial intelligence (Cluskey, Jr., Ehlen, & Raiborn, 2011). Christe (2003) says that remote proctors and other monitoring tools are essential and refers to them as "Big Brother." Nicholls et al. (2017) credit remote proctoring for a dramatic reduction in cheating. A discussion of cheating prevention techniques follows and the cheating strategies they aim to mitigate.

Exam Questions

Use randomly selected questions from a large bank of questions to mitigate issues that arise from students obtaining prior year exams, publishers' answer keys, and student cooperation on an online exam (Olt, 2002; Rowe, 2004; Mott, 2010; Cluskey, Jr., Ehlen, & Raiborn, 2011; Moten Jr., Fitterer, Brazier, Leonard, & Brown, 2013). This strategy produces a different exam for each student (Santos, Richman, & Jiang, 2019), making cooperation and question memorization less likely. As an added deterrent, Moore (2017) suggests that questions from book publishers be altered. Similarly, several researchers recommend randomized answers for multiple-choice questions to add an additional level of complexity to cheating (Moore, Head, & Griffin, 2017; Norris, 2019; Cluskey, Jr., Ehlen, & Raiborn, 2011; Moten Jr., Fitterer, Brazier, Leonard, & Brown, 2013).

Exam Time

To limit students' ability to use notes, textbooks, internet searches, and resources web sites such as Chegg and Course Hero, researchers recommend a timed assessment that presents one question at a time without the ability to go back to prior questions (Moore, Head, & Griffin, 2017; Cluskey, Jr., Ehlen, & Raiborn, 2011; Moten Jr., Fitterer, Brazier, Leonard, & Brown, 2013). Cluskey (2011) suggests that the exam time be limited to what "A" and "B" students can complete because students that use notes will take more time, and Moten (2013) believes that the limited time is a deterrent to future cheating. Cluskey (2011) further believes that preventing students from going back to previous questions will curtail cooperation.

Lockdown Browser

Lockdown browsers prevent students from accessing anything other than an exam on the device the exam is taken (Cluskey, Jr., Ehlen, & Raiborn, 2011). For an online course exam that lacks a remote proctor, nothing prevents the students from using other computers, tablets, smartphones, printed notes, textbooks, or other material. A student's ability to circumvent the restrictions provided by a lockdown browser in an un-proctored online class limits the usefulness of this strategy.

Verified Identity

One of the advantages of online education is its indifference to the students' geographical location. This geographical indifference that allows students to log in from anywhere is also a disadvantage because someone other than the student may log in to complete an exam or assignment (Moore, Head, & Griffin, 2017; Nicholls & Lewis, 2017). Nicholls et al. (2017) recommend limiting access to an exam based on the internet protocol (IP) addresses of the students. This solution requires knowing the internet protocol addresses of students that are geographically dispersed. IP address verification as a cheating detection strategy by comparing students' access IP addresses over assignments and exams (Nicholls & Lewis, 2017) avoids the obstacles presented by limiting IP address access.

Cheating Detection

When it comes to cheating detection, online education has a distinct data advantage over its traditional counterpart of classroom-based education. Learning management systems (LMS) record all student actions by date and time, which provides an audit trail for casual and statistical examination. Cizek (1999) wrote the book on cheating that focused on the classroom, and his discussion on the use of statistics is also applicable to online courses. While statistics may provide compelling evidence for cheating, Cizek (1999) warns with a quote from Dwyer (1996) that, ". . . one should never accept probabilistic evidence as sufficient evidence of cheating merely because a pattern of answers is deemed to be statistically improbable" (p. 133). The following discussion on cheating detection techniques examines student answers and LMS activity logs.

Answers

Students that collaborate on an exam and students that copy answers from other students have similar right and wrong answers. Statistical methods can determine if the probability of students having identical answers and common wrong answers provides sufficient evidence to suspect cheating (Cizek, 1999). The omega (ω) statistic developed by Wollack (1997) is considered "one of the best indices in testing for answer copying" on multiple-choice exams (Maeda & Zhang, 2017). A modified omega (ω) statistic developed by Maeda et al. (2017) improves the algorithm to better estimate the ability of copiers, a necessary component of the calculations. Because the omega (ω) statistic is "computationally intensive" (Maeda & Zhang, 2017), software such as SIFT is available to compute many of the statistics that help detect exam fraud (Davis, 2018). As Cizek (1999) points out, the statistical methods associated with students copying from one another do not detect the other often-used forms of cheating, such as cheat sheets, impersonation, and electronic communication. Cheating strategies other than copying may be detected by analyzing the LMS activity logs and will be discussed next.

LMS Activity Logs

Learning management systems are ubiquitous within education as a tool for both online and face-to-face courses to deliver content and assess students' learning (De Sande, Ariero, & Fraile, 2010). The LMS logs students' activity by recording each unique event, such as page access, file access, quiz start, question answered, etc., with the date and time the access occurred (Metzger & Maudoodi, 2020). The LMS access logs provide instructors information to aid cheating detection by comparing page access details to exam actions and exam actions among students (Metzger & Maudoodi, 2020).

Metzger et al. (2020) recommended two analyses: LMS item access records that correspond to the beginning and submission times of exams and the question order and timing of answers between students on an exam. Unfortunately, as Metzger et al. (2020) point out, the access logs available to instructors list each LMS item's latest access by the student. Therefore, if a student accesses a page both during an exam and after the exam, the access log lists the access after the exam only. The detail available to instructors is often limited, and a more detailed investigation may require administrative-level access (Metzger & Maudoodi, 2020).

Cheating Detection Method Using LMS Activity Logs

There is a significant amount of data provided in the LMS activity logs that can detect cheating on exams. Metzger et al. (2020) described an approach to compare exam logs among students and student activity logs to exam logs. The approach Metzger et al. (2020) propose, comparing logs of different students side by side, is demanding for two students and impracticable for many students because the data lacks synchronization. Each student's exam action log begins when the student starts the exam and time stamps each action record from the start time. When comparing students' action logs, consideration must be given to the time the student started the exam. For example, two students may both answer question three at the one-minute mark, but if one student started the exam ten minutes after another student, their responses to question three are separated by ten minutes. Extrapolate the different exam start times, response times, and the number of students to understand the difficulty in observing potential cheating with a visual inspection.

This study expands upon Metzger et al. (2020) by providing a methodology available to instructors without involving administrators to structure and analyze access log data. Also, we will provide information on different exam configurations and their impact on analysis. The Canvas LMS is the basis for this study, but other LMS have similar capabilities.

Exam log

As previously mentioned, the exam log is a time-stamped list of student actions taken during an LMS delivered exam. Unfortunately, the exam log data is accessible for one student at a time without the ability to capture all students' activity at once. View a student's exam log by clicking the "View Log" option available when grading a student's exam. The log begins with "Session Information," detailing the date and time the student started the exam and the number of attempts. Each exam attempt has a separate log that can be viewed by clicking the exam attempt number under "Session Information." The "Action Log" follows the "Session Information" and lists the time in hours, minutes, and seconds that lapse between the exam start time and the action.

The following method to extract and structure exam log data from one or more students provides the foundation for synchronizing all student answer times and performing statistical analysis. The method described below is dependent upon an exam configuration with non-random, identical questions.

Extracting the Exam Log Data

The exam log data looks nicely structured on the web page, showing a row for each action, but it requires manipulation to make it useful data. Begin by selecting and copying the action log data starting with the first action and ending with the last action for a single student. Paste, as plain text, the copied action log data into a text editor such as Microsoft Word. The action log data inserts a carriage return between the time stamp and the action for most, but not all, actions and may insert extra spaces, two or more consecutive spaces, throughout the file. Replace two or more consecutive spaces with a single space, and remove carriage returns within actions to create a text document with one time-stamped action per row. Copy the modified text to a spreadsheet by pasting it in a column of the spreadsheet. When properly formatted, the text should fill the column by placing a single action item in each row of the spreadsheet. Enter the student's name or identification for the exam log data in another column of the spreadsheet. This process, repeated for each student, creates a spreadsheet of all student actions for an exam.

The next step in analyzing the exam logs is to parse the action log record into distinct data fields used for the analysis. The action log provides information on time, action, and question, which become new columns in the spreadsheet. The action log time is formatted in hours, minutes, and seconds for when the action occurred after starting the exam. Six student actions are recorded – view, flag and unflag questions, stop and resume viewing the exam, and answer a question. This methodology will focus on when students answer questions.

Time begins each activity record with the first five or eight characters depending on the length of the exam. The time is eight characters (an hour or more) when the sixth character is a colon and five characters (under an hour) when the sixth character is not a colon. Convert the time to seconds by summing the hours multiplied by 60^2, the minutes multiplied by 60, and the seconds. For example, an activity that occurs one hour, twelve minutes, and eighteen seconds (01:12:18) into the exam is 4338 seconds.

The activity may be parsed from the activity record using the spreadsheet FIND formula. The FIND formula throws an error if the string is not found, which can be handled with the IFERROR formula. In other words, you can FIND the string "Answered" in the action records to determine which activities record the student answering a question and return "Answered" in the action column. Otherwise, leave the column blank.

The question number is always preceded by "question" or "questions." When an action log event references multiple questions, the data is not reliable for analysis because it is not possible for a student to view or answer multiple questions at one time. This appears to be a limitation of the LMS in recording student actions when multiple questions are displayed at one time. Activities with "questions" are ignored, and the question number for activities with "question" is returned to the question column.

With the exam log data extracted and properly formatted in the spreadsheet, our focus turns to synchronizing the activity times to prepare the data for analysis.

Synchronizing Activity Times

The activity time parsed from the data described above is expressed in seconds from each student's exam start time. An analysis comparing students' answer times requires the times to have the same base. We achieve synchronizing times to a common base by adding the student's start time in seconds (0 seconds equal to 12:00 a.m. on exam day) to their activity time. The exam log provides the student's exam start time within the session information. Convert the exam start time to seconds using the same procedure described for converting the activity time to seconds, summing the hours multiplied by 60^2, the minutes multiplied by 60, and the seconds. The exam start time, unique for each student, is recorded in a new column. The synchronized time, the sum of the exam start time and the activity time go in a new column and is the basis for the analysis.

Establishing a Record ID

Exams that permit moving back and forth among questions or exams with short answer questions may have multiple answers for a single question. Multiple answers to the same question by the same student will skew the data and make it more difficult to detect cooperation. We can see the issue from the example of a student answering question once at the beginning of the exam, again in the middle of an exam, and again at the end of the exam. The mean answer time for question one will be in the middle of the exam. The solution is to create a unique activity record identifier for each student each time they answer a question and consider the first time they answer a question in the statistical analysis. We chose a unique activity record identifier by concatenating the StudentID, the action, the question number, and, beginning with zero, the sequential occurrence of the question for the student and action. For example, Student X1231 answering question four for the third time would have a unique activity record of X1231Answered004.02.

Statistical Analysis

This methodology assumes that the time at which the population of non-cooperating students answers a question on an exam will be normally distributed with mean μ and standard deviation σ. The data collected for this study indicate that students answer questions in the provided order without previewing questions in advance. However, further into an exam, students will often view a previous question and return to the current question. The variance of question answer times will be larger for questions later in an exam than they are for questions earlier in the exam because students answer questions at different rates, which compounds the delay in answering later questions. Therefore, students answering an early question at approximately the same time is less significant than it is for later questions.

Evidence of student cooperation on an exam may be obtained from a statistical analysis of students answering questions in the same order and at approximately the same time. We obtain this evidence by comparing each question's answer times for each student and determining which questions were answered within a predetermined amount of time (cooperation time). The proximity of the answer times is then evaluated against the probability that a sample mean of students answering the question will occur in the same time interval by chance. Creating the cooperation time as a variable in the spreadsheet provides a way to test several options easily. Exams with a limited amount of time to complete will limit the amount of time students have to cooperate. Exams, with a generous amount of time to complete, provide a greater window of opportunity to cooperate. This methodology was tested on a range of exams with cooperation times from 15 to 90 seconds.

The statistical analysis requires the sample size, mean, and standard deviation for each question time, which we calculate with a pivot table using the data created earlier as the source. The structure of the pivot table uses the question number for the rows, the count, average, and standard deviation of synchronized time for the values, and action as a filter set to "Answered." We examined only the first time each question was answered by each student to eliminate outliers that would skew the results. The pivot table provides the sample size, the mean and standard deviation of the answer times for each question, which is used later to calculate the probability of an answer occurring at a specific time.

The addition of a few columns to the main spreadsheet constructed earlier determines the probability of an answer occurring within a specified "cooperating time." First, create a time range by adding two columns to the spreadsheet and add and subtract the "cooperating time" to and from the synchronized time. Establish the critical values for the upper and lower range times by subtracting the question mean time from range time and dividing by the standard error (question standard deviation divided by the square root of the question sample size). Finally, subtract the t-distribution values of the critical values to establish the probability of the mean answer time occurring within the range. Students that answer questions within a range of low probability (0.05 and lower) are less likely to do so by chance compared to students that answer questions within a range of high probability.

Discussion and Conclusion

The focus of this study was to provide a method to detect student cooperation on exams using the student exam logs and statistical analysis. This information, together with a comparison of identical right and wrong answers, will help to detect student cooperation on exams. As Metzger et al. (2020) explain, a cursory comparison of the LMS exam logs between students can reveal apparent cooperation. Still, the extent of the cooperation and the number of students involved is difficult to ascertain from observation alone. Statistical analysis, such as the one presented in this study, is required to produce compelling evidence. Communicating to students the ability to detect cheating through the use of statistics may help prevent cheating. The methodology described above was tested on several exams in three different courses, and it detected student cooperation in groups of two to seven. Students confirmed the results when confronted with the statistical evidence.

This study relies on instructor accessible LMS data instead of data available from administrators. This allows an instructor to perform preliminary cheating detection without involving others in a way that is timely and discreet. It is important to note that the exam log data available to instructors is available for a limited time. There is no official declaration on how long exam logs are available, but a Tufts University web page says that they are available for six months (Tufts University, 2020). During this study, we discovered that the exam logs are not available after a course ended even when the exam was less than a few weeks old.

Limitations and Future Study

Different exam configurations have a profound impact on the usefulness of the methodology described above. For example, an exam configured to show all questions instead of one at a time causes anomalies in the exam log. These anomalies may cause several questions to be omitted in the log and subsequent analysis, providing less evidence of student cooperation. The setting to display one question at a time, with or without the ability to go back to a question, produces an exam log with more complete and accurate information.

An exam that uses non-random, identical questions for all students is not a best practice for preventing cooperation. Yet, the methodology described above does not work on exams with random questions or question banks. The challenge with detecting cooperation with random exam questions comes from the LMS assigning the random questions a sequential question number. Because exams have a random order of questions, each student's question numbers represent different exam questions. An extra step of cross-referencing each student's exam questions with a master question list is required to analyze answer times. Building a cross-reference of questions requires a review of each student's exam, one question at a time, which is an exercise that is too time consuming to be considered practical. Additional research is underway to determine how to apply the methodology to exams using random questions and question banks.

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