Online Cheating Amid COVID-19

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Abstract. Proctoring has been the major tool for educational institutions to ensure academic integrity on examinations. However, lockdowns and the suspension of face-to-face education due to the COVID-19 pandemic in early 2020 made proctoring very difficult (or impossible) in many situations. We present evidence of cheating that took place in online examinations during COVID-19 lockdowns. We then propose a solution for the cheating problem based on the experience accumulated by online chess communities over the past two decades. Currently, many colleges are forcing students to purchase and use a camera to record themselves while taking an exam in order to crack down on cheating, but these rules conflict with privacy rights from some students' perspectives. In order to address this issue, we suggest that instructors present their students with two options: (1) If the student voluntarily agrees to use a camera to record themselves while taking an exam, this record can be used as evidence of innocence if the student is accused of cheating. (2) If the student refuses to use a camera due to privacy concerns, the instructor should be allowed to make the final decision on whether or not the student is guilty of cheating (with evidence of cheating remaining private to the instructor). Since cheating can never be fully detected online, we suggest that instructors stay away from curving their grades.

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1. Introduction

"No matter what the game is, when there are benefits from winning, you have cheating."

–Arkady Dvorkovich, FIDE President, 2020.*

The COVID-19 pandemic changed the lives of all people globally with most activities being forced to move online, including teaching. Most schools and universities moved from face-to-face to online delivery in March 2020. Among other difficulties related to online teaching, measuring student performance became one of the chief concerns of instructors. The 2020 Advanced Placement (AP) examinations illustrate the difficulty of measuring student performance on online examinations without proctoring. Figure 1 shows surges of Google searches on keywords related to exam topics perfectly correlating with the time of the examinations. Since the online environments used for the 2020 AP exams had no proctoring, many students took advantage of having immediate access to Google search.[1]

This behavior relates to the mounting evidence that the lack of "perfect honesty" exists in situations where the returns to dishonesty are high. Numerous studies using different settings and samples investigated in Gächter and Schulz (2016), Fischbacher and Föllmi-Heusi (2013), Vanberg (2017), and Gneezy (2005) show that people are more likely to deceive if the marginal benefit from deception is significantly large. Given the possibility of the lack of perfect honesty, professional competitions and examinations have to use extensive monitoring to prevent cheating.

However, lockdowns due to the COVID-19 pandemic in early 2020 made monitoring very difficult (or impossible) in many situations. Online tests are done without proctoring, which implies that students can use their notes, internet search, and any other assistance to help them solve questions. What's more, they can communicate via teleconference and collaborate during their exams. This cheating behavior on online examinations imposes a negative externality on students who don't cheat, especially if the instructor curves the exam scores.

*The International Chess Federation (FIDE) is the governing body of chess, and it regulates all international chess competitions.

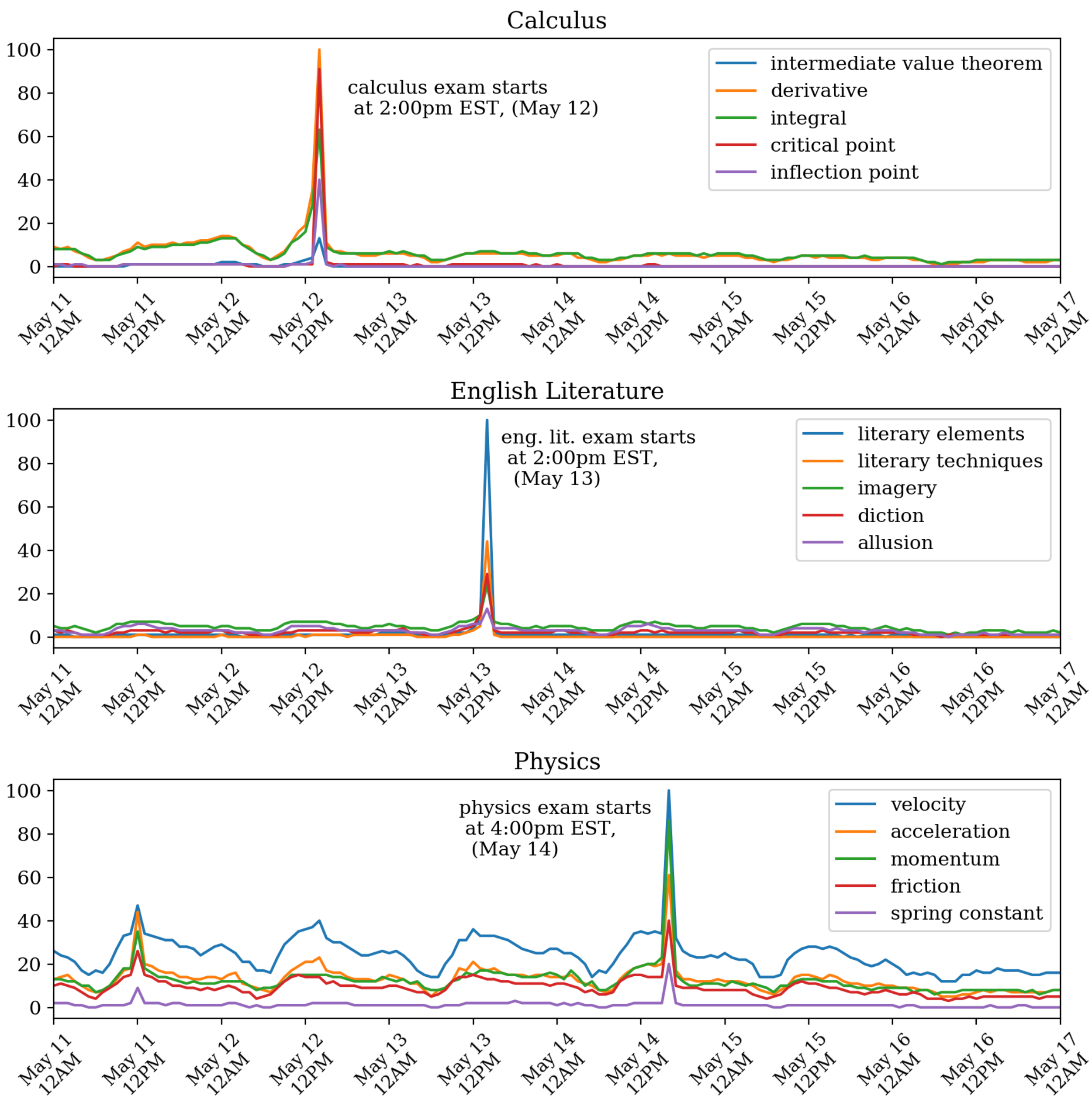
[1] College Board did not consider internet search to be cheating for the 2020 AP examinations. However, even if internet search was considered cheating, ensuring that students not use internet search during the test would be a challenging task.

In this paper we present evidence of cheating that took place in an online examination held as part of a course taught at a large public university in Spring 2020 during COVID-19 lockdowns. Using timestamps from the students' Access Logs, we identify cases where students were able to correctly type in several answers under thirty seconds per question. A solution key for the exam was distributed online, and these students must have simply typed in the correct answers using the solution key they had at hand, even with matching incorrect answers.

Currently, many colleges are forcing students to purchase and use a camera to record themselves while taking an exam in order to crack down on cheating, but these rules conflict with privacy rights from some students' perspectives. In order to address this issue, we suggest that instructors present their students with two options: (1) If a student voluntarily agrees to use a camera to record themselves while taking an exam, this record can be used as evidence of innocence if the student is accused of cheating; (2) If the student refuses to use a camera due to privacy concerns, the instructor should be allowed to make the final decision on whether or not the student is guilty of cheating, with evidence of cheating remaining private to the instructor. Since cheating can never be fully detected online, we suggest that instructors stay away from curving their grades.

The rest of the paper is organized as follows: Section 2 presents mixed evidence about online and face-to-face cheating. Section 3 describes online chess experience with cheating. Section 4 provides two simple theoretical models for face-to-face and online exams. Section 5 presents examples of online cheating. Section 6 concludes.

Figure 1: Google search trends around the time of the 2020 AP Exams



Note: 2020 AP Exams were held online due to COVID-19 related school closures. Hourly online search data is obtained from Google Trends.

2. Related Literature

There is a vast literature that explores cheating and deception. On his seminal work, Becker (1968) provides an understanding on the rationale for individuals who take part in illegal activities. An early empirical investigation on cheaters and their incentives in Duggan and Levitt (2002) show that individuals are indeed more likely to cheat if they view returns to cheating are high and that these returns come with little cost.[2] Field experiments using different settings reveal that individuals deceive more if the cost of deception is small (Gneezy 2005, Erat and Gneezy 2012, Gächter and Schulz 2016, Vanberg 2017, Martinelli et. al. 2018, Charness et. al. 2019, Alan et. al. 2019, Maggioni and Rossignoli 2020).

Educational institutions have traditionally been using proctoring in order to ensure academic integrity on examinations. Online education, however, typically relies on unproctored examinations that are held online. Previous surveys exploring cheating in online examinations generally claim that there is little to no difference between face-to-face and online examinations in terms of cheating. Watson and Sottile (2010) surveyed 635 students from a medium-sized university, and asked whether or not they had previously cheated on an examination. They found that 32.1% of students from face-to-face courses admitted to cheating. For students from online courses, the admitted cheating rate was 32.7%. Observing that these rates are very similar, they claim that online courses do not involve more cheating. However, the main concern on their methodology is that they rely on self-reporting which requires students admitting they have cheated, rather than actually using a mechanism to detect cheating.

The next set of research addressing cheating concerns in online education includes Fask et. al. (2014) which used random assignment of students to face-to-face and online examinations. They first assessed student performance using practice tests and found that the online test-takers scored 14% lower than those who took the practice test held proctored in class. However, on the actual test, online test-takers scored 10% higher than the face-to-face test-takers. While their methodology had limitations in terms of detecting cheating, it provides suggestive evidence on cheating for students who take unproctored online examinations.

More concrete evidence on cheating in online environments is presented in Dee and Jacob (2012), Karim et. al. (2014), and Diedenhofen and Musch (2017). Using a text-based algorithm that detects plagiarism, Dee and Jacob (2012) show that 112 out of 1,200 papers submitted on the Blackboard from a sample of 28 universities were plagiarized. They suggest that giving a quick tutorial explaining how plagiarism jeopardizes academic integrity at the beginning of

[2] Along with Jacob and Levitt (2003) these papers are later included in the Freakonomics book, documentary, and podcast series.

the semester is an effective tool in preventing plagiarism. However, this may not be as effective for more direct cases of cheating. Using evidence from laboratory and online experiments, Diedenhofen and Musch (2017) show that participants cheat more (via Google search) when monetary incentives are higher. They use a computer program that triggers a pop-up message if a participant frequently changes browser tabs in a short period of time with the message stating that the researchers are aware of the participant's cheating activity, which reduces cheating sharply. In another experimental setting using participants from Amazon's Mechanical Turk, Karim et. al. (2014) show that low-cost technology, such as web-cameras, are effective at decreasing cheating without necessarily impacting test performance. However, they observe negative reactions from a portion of the participants pointing out that these web-cameras may be viewed as invasive and thus raise feelings of pressure and tension.

3. Lessons from Online Chess

The problem of cheating in online environments is not new. Online chess, in particular, has been plagued by cheating ever since chess was first introduced to the internet, with players gaining an unfair advantage by using computer assistance. What can we learn from online chess case studies, and how can we use them to reduce online cheating on exams?

Online chess started when the Internet Chess Club (ICC) was established in 1995. The ICC first ran annual Dos Hermanas online blitz tournaments with monetary prizes in early 2000s. Games were not proctored, and a whole array of cheating scandals consequently arose, with many ways to cheat in those events. In order to function, ICC had to disqualify numerous people, including a former Junior World Champion, a top Chinese player, a top German player, hundreds of title players, and thousands of amateurs (who enjoyed beating title players). The main way to cheat was to use chess computer programs to find the best moves. Once suspected of cheating, however, the ICC disqualification was final, and players could not appeal.

Now, Chess.com is the most popular online chess club, with many tournaments including monetary prizes. Unsurprisingly, cheating has surfaced as a huge problem, prompting Chess.com to create its own cheating detection unit. See Chess.com Fair Play And Cheat-Detection.[3] The website states: *"Though legal and practical considerations prevent Chess.com from revealing the full set of data, metrics, and tracking used to evaluate games in our fair-play tool, we can say that at the core of Chess.com's system is a statistical model that evaluates the*

[3] https://www.chess.com/article/view/chess-com-fair-play-and-cheat-detection

probability of a human player matching an engine's top choices, and surpassing the confirmed clean play of some of the greatest chess players in history."

Both the ICC and Chess.com have been successful to some degree in dealing with the cheating problem although it is nowhere near to being solved. Interestingly, we can notice some similarities in addressing the problem by both chess websites. First, they do not reveal their detection systems. Second, their disqualification decision is final. This approach admits that the detection system is vulnerable to the knowledgeable cheaters. Since the websites do not have the resources to check millions of games, they implement a simple way to address the problem: a chess website monitors particular characteristics of play and these characteristics are not revealed to the players. Players do not know what the website is looking for, which makes cheating more difficult. For example, many title players admitted that they were cheating and were caught by Chess.com.

4. Some Theory

We will consider two cheating games in this section. The sequential-move game corresponds to in-class exams when a professor can observe a student's action (cheating or not) and make their informed decision based on that action. The simultaneous-move game approximates online exams when the professor cannot observe a student and has to decide whether or not the student cheated based on indirect evidence only.

Of course, these two games are an over-simplistic way to model in-class and online exams. However, even this simple approach gives qualitative and intuitive predictions: a student should not cheat in the unique subgame perfect equilibrium in the sequential game, and student cheating is part of a unique equilibrium in the simultaneous-move game.

4.1 Sequential-move game

In the sequential-move game, the student chooses to either cheat or be honest. The professor observes the student choice and decides either to report the student for cheating or not.

There are four outcomes in this game, but the professor and the student rank these outcomes differently. The professor's outcomes from the best to the worst are (honest, do not report), (cheat, report), (cheat, do not report), (honest, report), where we record paths of play in brackets. The student's outcomes from the best to the worst are (cheat, do not report), (honest, do not report), (honest, report), (cheat, report). See Figure 2.

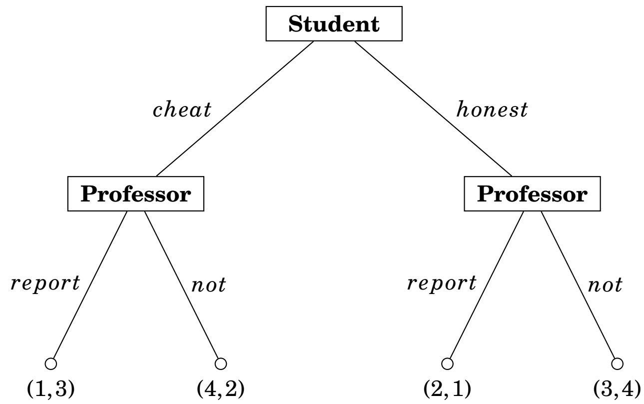


Figure 2: Game Tree for the sequential move game

It is easy to find a unique subgame perfect equilibrium outcome, where the student is honest and the professor does not report the student. Note that this is the best outcome for the professor and the second best outcome for the student.

This sequential-move game is supposed to be played between the student and the professor during in-class exams. In the current situation, one way to implement this game is to use a camera to record the student while taking an exam. However, many students say that camera use conflicts with privacy rights and advocate taking exams without cameras. In other words, these students suggest to play the following simultaneous-move game.

4.2 Simultaneous-move game

Let us consider a simple simultaneous-move game between a student and a professor. The student has two actions: cheat or be honest, and the professor also has two actions: report the student for cheating or not.[4] There are four outcomes in this game, and the professor and the student rank these outcomes differently. The professor's outcomes from the best to the worst are (honest, do not report), (cheat, report), (cheat, do not report), (honest, report). The student's outcomes from the best to the worst are (cheat, do not report), (honest, do not report), (honest, report), (cheat, report). Table 1 gives an example of players' payoffs. This game has a unique mixed-strategy equilibrium, which means that the student and the professor should randomize between their two actions in equilibrium. Thus cheating as well as reporting is part of the equilibrium (Walker and Wooders 2001).

[4] In fact, the game can be played sequentially without the professor knowing the student's action. The normal-form of this game and our results are the same.

		Professor	
		Report	*Not*
Student	*Cheat*	1,3	4,2
	Honest	2,1	3,4

Table 1: Payoff Matrix for the simultaneous move game

In the mixed-strategy equilibrium, the student randomizes between her two choices in such a way to make the professor indifferent between his two choices. So, in order to determine the equilibrium probability of the student's cheating, we have to look at the professor's payoffs. To make our point clear, we restrict our attention on a simplified payoff Table 2, where we only record the professor's payoffs. Moreover, we normalize the best payoff at one and the worst payoff at zero, and $0 \leq c \leq b \leq 1$.

		Professor	
		Report	*Not*
Student	*Cheat*	$.,b$	$.,c$
	Honest	$.,0$	$.,1$

Table 2: Payoff Matrix for the Professor

It is easy to find now that the equilibrium probability of the student cheating, p, is equal to

$$p = \frac{1}{1+(b-c)}. \tag{1}$$

If the professor does not feel a big difference between (cheat, report) and (cheat, do not report) outcomes, or the difference $(b-c)$ is small and close to zero, then the cheating probability is the highest, and in the extreme case, if $(b-c) = 0$, this probability is equal to one, $p = 1$. However, if the professor is concerned and sees a significant difference between (cheat, report) and (cheat, do not report) outcomes, then the student cheating probability goes down.

4.3 The Problem and the Solution

Note that the student is honest in the unique subgame perfect equilibrium in the sequential-move game, which approximates in-class exams. However, the student is supposed to cheat in the unique mixed-strategy equilibrium in the simultaneous-move game, which is a proxy for the online exams. These findings demonstrate that cheating should be higher in online tests, and these observations are intuitive, with many instructors having first hand experience with them from face-to-face and online teaching. However, there is mixed evidence of that in the literature.

Unfortunately, the simultaneously-move game is not a good model for the online tests. The main problem is how to prove cheating. Typically, students require to see evidence of their cheating and the professor only has indirect evidence of cheating. Having only indirect evidence makes it much harder to prove that cheating took place in case of an academic integrity referral. Thus, the professor is reluctant to report cheating in online exams, or the difference $b-c$ is close to zero in expression (1) for the equilibrium cheating probability. This in turn encourages even more cheating. We believe that many instructors were indeed reluctant to report cheating in Spring 2020 through anectodal evidence. However, the number of reported cheating cases still went up by almost 10% in March−June 2020 relative to March−June 2019 at a large public university reported by their Academic Integrity Office.

How can this evidence problem be resolved? Many instructors have their own statistical evidence of students cheating. Some of these statistics are simple but very efficient. We present one such statistic – time spent per question – in the next section. However, once such a statistic is revealed to students, the instructor would not be able to use it again because students adjust accordingly. The solution is not to reveal information based on which the student was found guilty of cheating. In other words, if the professor claims that the student was cheating and this decision is final, then we indeed get the simultaneous-move game from the previous section.

We suggest to offer two options to a student. If the student buys a camera and uses it during the exam, then the sequential-move game is played, cheating is not expected (in the equilibrium), and both the student and the professor have evidence of the student's behavior on the exam. Alternatively, the student can have an exam without a camera in the privacy of their own home. In this case the simultaneous-move game is played, some cheating is expected in the equilibrium, and if the professor has evidence of cheating and claims cheating, then the student cannot request any evidence and appeal the verdict.

5. Data: Evidence

The data comes from students who were enrolled in an intermediate-level course in Spring 2020 at a large public university. The course had three Midterms and had an optional Final Exam which replaces the lowest Midterm exam. First, two Midterms were held face-to-face with proctoring; the third Midterm and the Final Exam were held online asynchronously on the Blackboard following COVID-19 related campus closures. On these online exams, students received the same set of questions in a random order. The questions were all short answer questions: the student had to type in the correct answer to receive credit with no multiple choice options given. In order to move to the next question, the student had to save and submit their answer; no moving back and forward was allowed.

Finding concrete evidence on cheating in an online examination is potentially challenging, as demonstrated in earlier studies (Watson and Sottile 2010, Fask et. al. 2014). In this section, we present cases in which students were able to correctly solve several questions under thirty seconds per each question.[5] The mechanism we use to identify cheating is the "Access Log" provided on the Blackboard. The Access Log provides detailed timestamps which show exactly how much time a student spends on each question. Many students appear to be unaware that the time they spend on each question is recorded although they seem to expect that the information on the "total time" they take for the exam is recorded.[6]

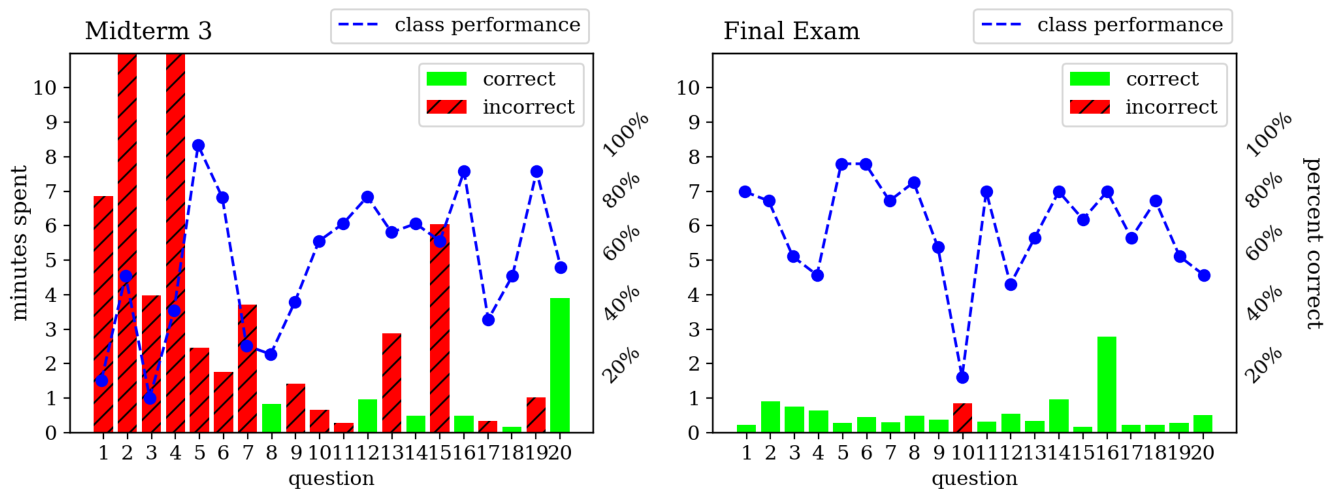
Figures 2–3 present two cases showing how much time students spent on each question during Midterm 3 and the Final Exam. On Midterm 3, students show a typical distribution for how much time they take on the questions. They have both correct and incorrect answers and had to spend some time reading the problems and work on solving them.[7] Their time allocation, combined with their performance, shows no strange results for Midterm 3. However, their Access Logs reveal very peculiar information for the Final Exam. They both reveal

[5]The questions on the exam are problem-solving questions which are arguably not-so-trivial in terms of finding the solutions. The exam is *not* multiple-choice – the student must type in the correct answer to receive credit.

[6]There were instances of students finishing their tests and waiting to submit them. Since students could not go back and recheck their answers, waiting could not improve or change their results. In one extreme case, a student finished the test in 11 minutes and waited more than 1 hour before submitting it, so that the total time spent on the test would look "normal". We believe this provides evidence on individuals involved in cheating attempting to "hide their trails" similar to what was observed in Jacob and Levitt (2003).

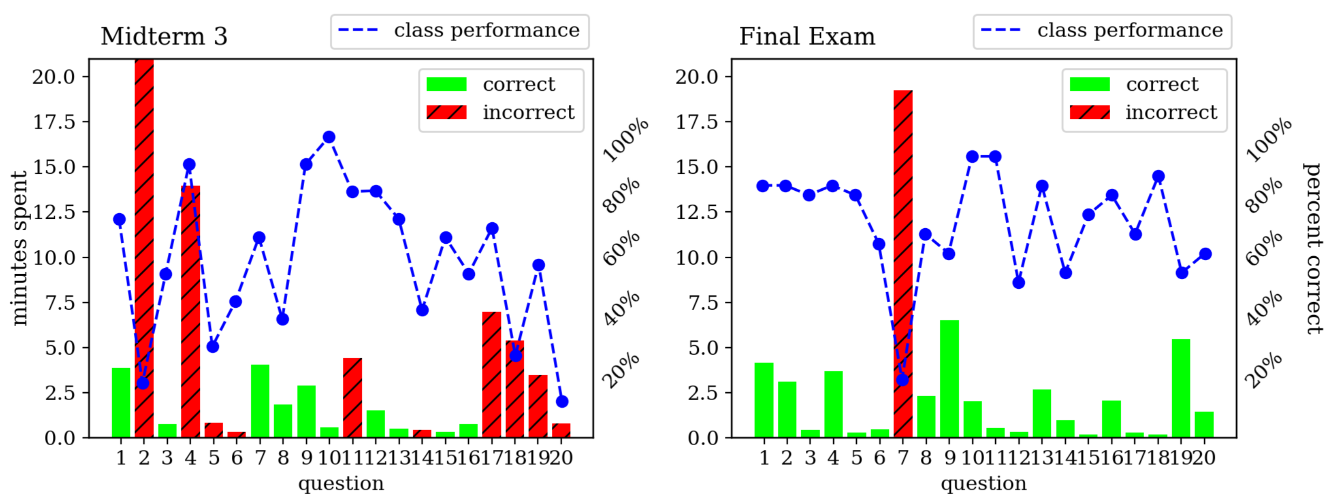
[7]The questions that these students were able to correctly solve under a minute on Midterm 3 require integer answers within a range of 0, 1, or 2. We believe this constitutes no strong evidence that cheating took place on Midterm 3. A student might easily submit 0, 1, or 2 and get the answer correctly.

Figure 2: Time spent per question for Student 1



Note: Student's Midterm 3 score is 6/20; Final score is 19/20.

Figure 3: Time spent per question for Student 2



Note: Student's Midterm 3 score is 10/20; Final score is 19/20.

cases where students had to spend less than thirty seconds to solve a question. However, each of these questions requires complex problem-solving skills, demonstrating that a student would need to spend a reasonable amount of time to find each solution. What is more, the students had to type in their answers since the exam was not a multiple choice exam. The questions typically had non-trivial answers such as "6534" or "650" which would make it very challenging to randomly guess the correct answers. In fact, the probability of randomly guessing the correct answers on this exam is much less than the probability of winning the lottery.[8]

Furthermore, there is evidence that these two cases are connected. Their answers for all twenty questions on the exam perfectly match. Their only mistake on the exam, which is on the same question, is where they both submitted the same incorrect answer of "125". Figure 4 shows the answers submitted by the rest of the class on this particular question, and it appears only three students submitted "125" while the rest of the class submitted a whole range of different numbers. Two of these three students are Students 1 and 2.[9] Lastly, timestamps from their Access Logs show that once Student 2 finished his exam, Student 1 started his immediately (in 2 minutes) after Student 2 finished submitting his answers. We believe the probability that these students cheated and cooperated is higher than a random statistical occurrence.

How did these students cheat? The most likely explanation is that they used online resources, where private tutors helped them solve problems with which the students were presented. In fact, we have found evidence that the answer key for the Final Exam was distributed online in a common web platform. With only a fraction of a cost, students could get access to the solution key. Once the student obtained the solution key, the only task they would need to complete would be to type in the answers for the questions they were presented in a random order.[10]

Why did these students cheat? They had a lot to gain. Had they not cheated, they were very likely to fail the class. Student 1 had 47.8 and Student 2 had 53.5 before the Final Exam, which replaced their worst Midterm result. Their only

[8] A rough estimate on the probability of "being lucky" on the Final Exam and guessing the correct answers by randomly submitting numbers is less than 1×10^{-20}. The probability of winning the lottery is around 1×10^{-7}. This rough estimate takes into account a student's potential to "guesstimate" the range for the correct answer.

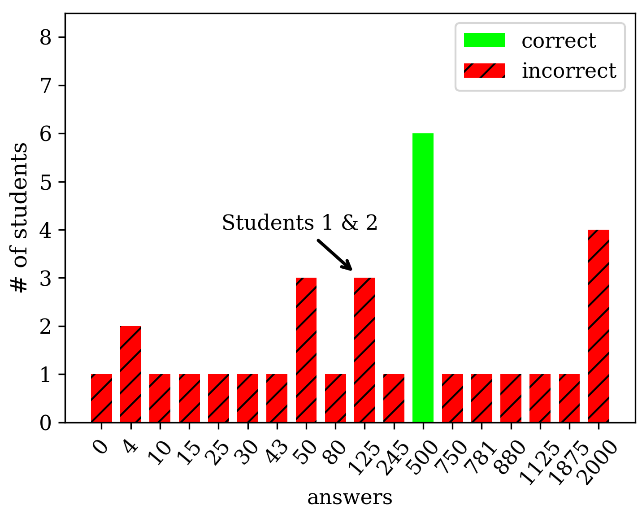
[9] This question was by far the most difficult question on the exam, with a correct response rate of only 19.3%. The third student who submitted "125" scored 18/20 on the Final Exam. His other incorrect answer was "12", and the correct answer for that question was "124". It appears he simply must have made a typo.

[10] It would potentially take 15-20 seconds to identify what question comes up on the screen and match it with the solution key they have at hand since the order of the questions is randomized for each student.

chance to pass the class, or get at least 70, was to perform extraordinarily well on the Final Exam. With the scores they received on the Final Exam, both students would have passed the class. Students' relative performances on Figures 5–7 show their extraordinary performance on the Final exam compared to their prior exams.

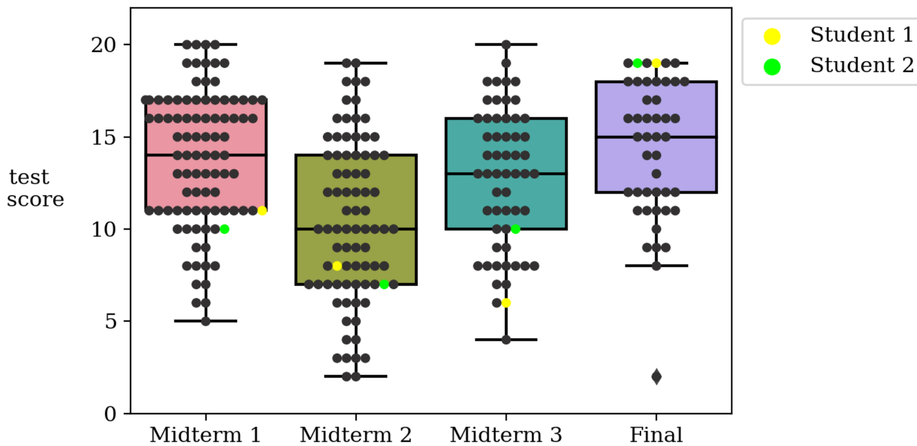
Note that there is nothing that stops students to type in their answers "slowly" which would mimic a case with no cheating. It appears these two students were not aware that their Access Logs had timestamps showing how much time they spent on each question. Had they known, they would have most likely submitted their answers in a longer time period, so that their Access Log would look perfectly "normal". Thus it is essential that any information on the "cheating-detection" tools the instructors possess be kept private.

Figure 4: All responses for the question both Students 1 & 2 made their only mistake on



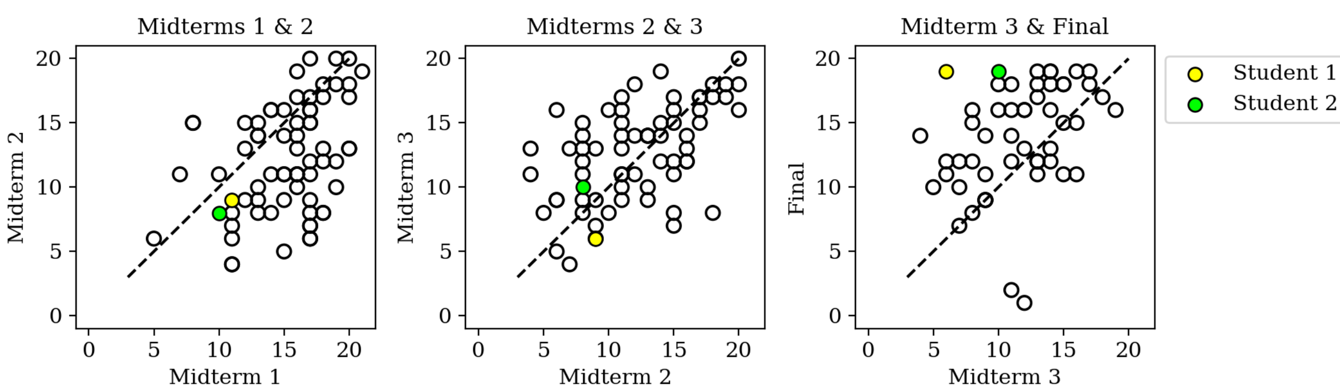
Note: Both Students 1 & 2 gave the same incorrect answer of "125". This question was by far the most difficult question on the exam, with a correct response rate of only 19.3%. The third student who submitted "125" scored 18/20 on the exam. His other incorrect answer was "12", and the correct answer for that question was "124". It appears he simply must have made a typo.

Figure 5: Student 1 & 2's performance relative to the rest of the class



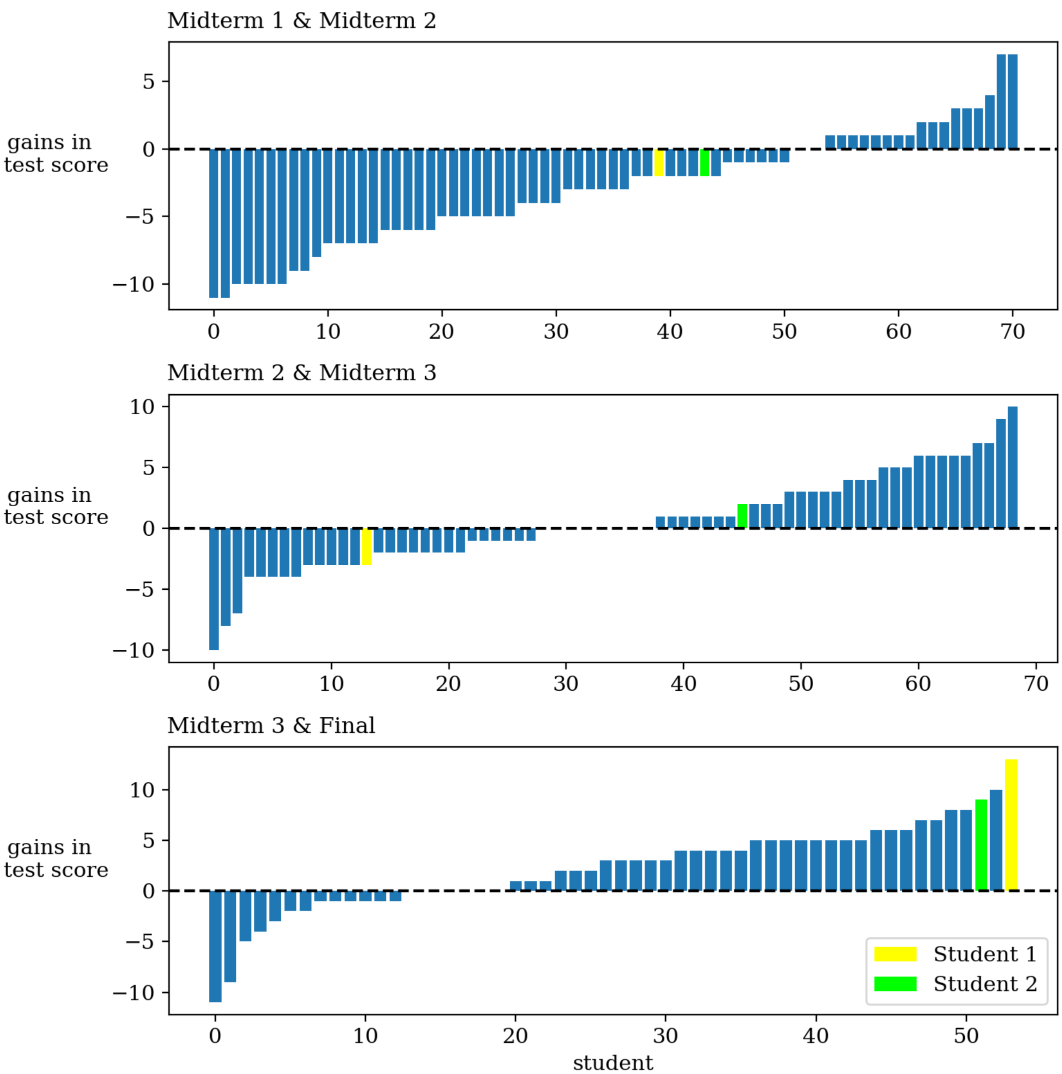
Note: Midterms 1 and 2 were held face-to-face with proctoring; Midterm 3 and the Final Exam were held online asynchronously without proctoring following COVID-19 related campus closures. Each dot represents a student's test score.

Figure 6: Comparison of gains in scores for students across exams



Note: Midterms 1 and 2 were held face-to-face with proctoring; Midterm 3 and the Final Exam were held online asynchronously without proctoring following COVID-19 related campus closures. Each dot represents a student's performance in corresponding exams. The dashed line is the 45 degree line.

Figure 7: Comparison of gains in scores for students between exams



Note: Midterms 1 and 2 were held face-to-face with proctoring; Midterm 3 and the Final Exam were held online asynchronously without proctoring following COVID-19 related campus closures. Each bar represents a student's test score gains between corresponding exams. Each exam is worth 20 points.

6. Conclusion

Like doping, cheating cannot be completely eliminated. There always was, is, and will be cheating in face-to-face and online examinations. However, we can (try to) keep it at an “expected equilibrium” level. In this paper, we first looked at two simple models of face-to-face and online examinations. The theory suggests that cheating should be expected online. Then, we presented evidence of cheating that took place in an online examination in Spring 2020 under COVID-19 lockdowns and made suggestions on how to do mitigate cheating based on the experience accumulated by online chess communities in the last two decades.

COVID-19 made online chess much more popular since March 2020, and there is a growing number of online chess tournaments with substantial monetary prizes. This online chess experience is very similar to the experience of many academic instructors. Arkady Dvorkovich, the President of International Chess Federation, FIDE, summarized this experience:

> *"I am talking about cheating. Unfortunately, no one can be trusted, except maybe for the top players for whom their reputation is the key asset."*
>
> –Arkady Dvorkovich,
> FIDE President,
> April 2020.

> *(In response) "Wow. So sad. The biggest insult ever to all chess players just surfaced online."*
>
> –Jovan Retronic,
> International Chess Master,
> April 2020.

The recent evidence suggests that the problem is still there. In the intermediate Section B (1401-1700) of the recent European Online Chess Championship, 5 out of the top 6 players have been banned for cheating. The comment of International Gradmaster, Nigel Short, FIDE Vice-President, on May 25, 2020 is revealing: *"This scourge will not stop until people are criminally prosecuted for fraud."* Whether people indeed be prosecuted or not, one thing is clear: there is no chance to win a prize in an online chess event without proctoring if you do not cheat because you expect that everybody else will cheat and this belief is fulfilled in a bad equilibrium where everybody cheats. Of course, some people are disqualified, but not all.

What does this mean for online exams? If an instructor curves their grades, then they create a competition among students, similar to what is seen in the chess tournaments. Now, each student has more incentive to cheat because if they believe that the rest of the group is cheating, then they must show better than at least the average class performance in order to pass the class. Thus, a student's chance to pass the class without cheating would be very slim. Of course, now their cost to cheat would be very small because the alternative of cheating is failing the class. Therefore, we suggest that curving should not be used for online teaching.

Of course, the problem is much bigger, as was noted by Peter Heine Nielsen, Coach of World Chess Champion Magnus Carlsen, on May 25, 2020: *"The same could be said about corruption, pre-arranged games, buying of votes, jobs going to friends or political allies instead of an open recruitment procedure based on merits etc. These are big issues for the chess world, not a 1400-1700 online event."*

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