

Contract Cheating in Computer Science: A Case Study

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Abstract—Contract cheating has recently become much more prevalent and threatens to render higher education grades meaningless. Online contract cheating services are not only easily accessible but, most importantly, highly affordable.

We report on a case study investigating how students use one particular online tutoring company to purchase solutions to their computer science assignments. Taking the perspective of a typical student, we uploaded several assignment questions and solicited solutions, looking at factors such as quality and time taken to procure the answers, and the tutoring company’s diligence in acting on clear violations of their own honor code.

The results show that purchasing solutions for homework questions is both easy and cheap. Solutions for questions at CS1 and CS2 levels appear to be of good quality and are delivered within short time frames. Even though the questions had clear cues to indicate that the student was trying to buy answers for a current assessed activity, the questions were neither identified nor flagged as violations of academic integrity anywhere in the process.

We discuss potential measures that might counter contract cheating and conclude that a multi-pronged approach may be necessary for effective mitigation.

Keywords—positive learning; academic dishonesty; contract cheating; student assessment; plagiarism

I. INTRODUCTION

Like many other forms of academic dishonesty [1], contract cheating has been used for a long time. However, the rapid rise in low cost online cheating services has enabled a widespread adoption of contract cheating, to the extent that the overall integrity of many conventional assessments is now under serious threat. Teaching staff now have to be mindful of contract cheating and take action to detect and mitigate it, or risk compromising their assessments.

All forms of academic cheating take effort to detect, investigate, and prosecute. Contract cheating significantly exacerbates this situation. When a large percentage of students can purchase custom solutions to their assessments, detection becomes quite difficult, if not impossible.

This paper is an experience report recounting our own experience with contract cheating. It aims to address the following three research questions:

- 1) How timely and accurate are the answers obtained from a selected online tutoring company (Chegg.com, in this case) for assessed homework problems?
- 2) Does the online tutoring company check for potential violations of academic integrity?

- 3) Which steps could possibly be taken to mitigate students obtaining answers to assessed homework problems?

Lancaster reported on a similar case study on the scale of contract cheating services sold at Fiverr.com, a popular digital services marketplace [2] using publicly available data. Private ghostwriters as well as ghostwriting companies advertise their services on Fiverr, and Lancaster reports on their pricing, location, advertising, and operational models. Lancaster also conducted a similar study of FreeLancer.com, another digital marketplace, investigating the contribution of ghostwriters from India to the contract cheating economy [3]. While a student might employ the services of such digital marketplaces for a large programming project, for small homework questions or quizzes that require fast turn-around times, these sites are expensive and slow. Our experience suggests that many of our science students now use an online tutoring company, Chegg.com, which provides solutions to small assignments or quizzes as a subscription service, using a large pool of freelance tutors who are paid per question answered. To this end, this paper examines how students are able to use the Chegg’s services to obtain solutions to their computer science assignments. It uses student-observable data (available to a subscribed student) rather than publicly available data.

Among numerous other services, Chegg provides an online question answering service based on a subscription model. Students pay a US\$20/month flat fee for this service. The fee includes the privilege to have up to 20 questions answered during the month; further questions may be submitted for a small additional fee each. This paper examines the extent to which students use Chegg to obtain solutions to their current assignments, effectively using the platform as a contract cheating service. It demonstrates the ease with which solutions may be obtained, assesses the quality and timeliness of the solutions provided, and considers how such solutions undermine the integrity of higher education. The paper then discusses a number of possible steps to mitigate such cheating.

The rest of this paper is organized as follows. Section II reviews and summarises some of the recent literature on contract cheating and its effects. Sections III and section IV describe our research methodology and our findings. Section V discusses potential mitigation mechanisms. The final section concludes this paper with a summary.

II. RELATED WORK

While paid ghostwriting, including presumably academic ghostwriting, has taken place for centuries [4], it has traditionally been more commonly associated with larger bodies of work of high prestige, such as books or theses. Use of paid ghostwriters for routine academic assessments such as assignments, essays or lab reports has most certainly happened as well, but the relatively high cost of a commissioned piece of work in comparison to the low value of the assessment have historically acted as a barrier, along with the risk of detection in smaller classes.

In contrast, the term *contract cheating* was coined relatively recently by Clarke and Lancaster in 2006 [5]. The term clearly describes that there is cheating involved as a student submits for assessment a work that is not their own; it also describes that there is typically a contract and monetary exchange involved in the process. Moreover, the type of contract cheating seen nowadays predominantly concerns comparatively low value routine assessments.

There are many reasons why a student might engage in cheating [6]. They include pressure to perform, high-value, low frequency assignments, lack of pastoral care, and transition from a different backgrounds in terms of academic culture. Contract cheating offers yet another incentive: It is now quite easy and relatively cheap to cheat [7]. Rigby and colleagues put forward an empirical economic investigation of cheating, and indicate that students for whom English is a second language and those who exhibit risk-taking traits are more likely to engage in contract cheating than others [8].

Advertising for contract cheating is omnipresent on the web and social media. Companies employ persuasive marketing strategies to get students' custom. Rowland and colleagues document the persuasive features used by a number of contract cheating sites [9]. For instance, a number of sites offer testimonials from happy clients, provide cash discounts for instant sign-up, and more importantly claim their work to be plagiarism-free (i.e., the solutions are custom-made).

With well-advertised contract cheating within easy reach, how is it adopted among the student body? An accurate answer will always be difficult as we are only likely to see the tip of the iceberg. Research conducted thus far has generally relied on self-reporting. As at least some students are, in general, reluctant to admit to any wrong-doing, even anonymously, the numbers unearthed here are probably underestimates.

Bretag and colleagues report on a study where they look at the prevalence of contract cheating at Australian universities and non-university higher education providers [10]. Their findings, based on self-reporting and a convenience sample, show that while contract cheating is prevalent among both types of students, university students had a significantly higher likelihood to engage in contract cheating than their non-university counterparts. Curtis and Clare report that only around 4% of the students admitted to contract cheating, but 63% of those who engaged in it used it more than once [11]. Another study, by Newton, took a long-term view, reporting on the trend

in contract cheating over 25 years. The result of the study shows not only an increase in contract cheating over the years, but also an increase in overall academic misconduct [12]. Newton, like others, cautions that the numbers are possibly an underestimate and that a convenience sample was used.

The cost and quality of the solutions provided by contract cheating companies vary. Sutherland-Smith and Dullaghan explore the relationship between cost and quality [13]. They purchased 54 items of written work (lab reports, business plans, policy briefs, etc.) from 18 companies their students had used, and assessed the quality of the purchased work. They report that nearly 15% of the solutions failed to meet the assignment requirements and that a number of solutions were not delivered in time. Their most interesting finding is that the bulk of the solutions bought were assessed to be below the pass mark. Moreover, premium solutions (which cost more) were generally no better than standard ones. Of the solutions that were assessed to be worthy of a pass, just three obtained a mark of over 70%. Lines investigates two essays in history, one at undergraduate level and the other at postgraduate level, sourced from 13 companies [14]. In this case, most of the essays were found to be worthy of a pass, with one of the 26 essays receiving distinction and two receiving high distinction.

Academic honour codes can help clarify what is expected of students in maintaining integrity and honesty. A recent study by Tatum and colleagues, however, shows that the existence of an honour code does not necessarily change the cheating behaviour among students [15].

Amigud and Dawson examine if legal prohibition could counter contract cheating in a meaningful way [16]. There are currently two countries – New Zealand and the Republic of Ireland – who by law prohibit advertising and selling cheating services. The 'Education Amendment Act 2011' [17] in New Zealand declares that a "person commits an offence if they provide any service with the intention of giving a student an unfair advantage over other students" and the 'Qualifications and Quality Assurance (Education and Training) (Amendment) Act 2019' [18] in Ireland recently introduced a similar provision. In addition, advertising of any such services is also deemed an offence in both legislations. In the US, seventeen states have local legislations prohibiting contract cheating [16]. However, cheating companies operate to and/or from these jurisdictions, and have not yet been prosecuted to sentencing. The most successful prosecution to date was the *assignments4u* case in New Zealand, which was settle during the trial for NZ\$2 million¹. The company was estimated to have sold around 12,000 assignment solutions, each for an average price of NZ\$400. Prosecuting companies who operate from outside these jurisdictions and yet provide services to those inside these jurisdictions is even more challenging. Draper and Newton argue that companies could defend themselves saying that the onus is on the student who chose to submit the solution for grading [19], and we note in this context that Chegg.com's

¹Alleged 'ghost writing' business settles with police over court action, Stuff.co.nz, 27 Jun 2018.

Terms of Use also suggest this approach.

Given the complexities and hurdles of the legal remedies to counter contract cheating, are there any other potential avenues available to academics? Morris reviews contract cheating behaviours and possible ways to counter them. These actions include choosing appropriate assessment types (such as oral examinations) as well as forming administrative strategies and policies [20]. Bretag and colleagues explore how well various assessment types lend themselves to contract cheating [21]. They identified 13 assessment types such as high-frequency assessments, high-value assessments, oral examinations, and individualized assessments. Staff were asked about their likelihood of using these assessment types, while students were asked about the likelihood of being able to successfully outsource these. Their paper summarizes the result of these self-reported surveys.

The quality assurance agency for higher education in the UK proposes blocking all known contract cheating sites accessed from within an academic institution’s network, and re-directing these accesses to information on academic integrity [22]. While this may increase the awareness of academic integrity among students, it cannot stop students using their own devices and network to access these sites.

Graziano et al. report on a bot which monitors cheating sites for students seeking solutions for specific assignments [23]. If the bot detects suspicious activity, it informs the instructor, who then provides a watermarked solution which the bot bids to sell to the student. If the student submits this solution, the watermark provides grounds and evidence to prosecute the student.

If a contract cheating company provides custom, plagiarism-free solutions as it promises, then it is quite difficult to detect if a student cheated. One way to address this is to look at the student’s past submissions and observe differences in style. This can be automated, and there are commercial tools, such as *Authorship* from TurnItIn, that claim to do this for essays. On the other hand, it is possible that a student employs the same academic ghostwriter every time, and in this case such a style analysis will not be fruitful. Such tools are also limited if the solutions are not written prose, e.g., if they consist of program code, or are too short to yield sufficient confidence.

III. RESEARCH METHODOLOGY

In 2019, the author’s school dealt with two large scale cheating incidents in two of our computer science courses. One occurred in a year 1 programming course and the other in a year 2 computer systems course. Both involved students using Chegg to obtain solutions for assessed work in an attempt to gain unfair advantage. The investigation of the incidents prompted us to also consider the wider issue of using Chegg for obtaining solutions. We will defer the discussion on the cheating incidents to Section IV-A and outline our research methodology towards answering our research questions: Which cheating behaviours are observable on Chegg; and how to mitigate such cheating behaviours.

TABLE I
SERVICES OFFERED BY CHEGG. SOURCE: CHEGG.COM.

Service	Description
Textbook Sol’ns	Step-by-step solutions for thousands of textbooks
Q&A Archive	Unlimited access to homework questions
Post Questions	24/7 expert answers in as little as 30 mins
Flashcards	Study with millions of cards or create your own
Practice problems	Test strengths & weaknesses with practice problems
Video solutions	View video walkthroughs for thousands of problems
Math solver	Guided equation solver with explanations
Writing Tool	Check for plagiarism and grammar mistakes

Chegg uses a subscription model for their services, costing US\$20 a month. Table I lists the services they advertise for this subscription. Our students used both the *post new questions* service and the *archive* of previously posted questions for cheating purposes. Chegg advertises the former as “Answers in a snap: snap a photo of your question and get notified when it’s answered” and the latter as “Homework made easier: get access to millions of problems solved by subject matter experts”. When one student posts an assignment question and obtains an answer for it, everyone else with a paid subscription can view this answer. Each paid subscription earns the right to post 20 questions per month. Once this limit has been reached, further questions cost an additional US\$3 each. Viewing any number of archive questions is included in the subscription.

The Chegg Tutors Terms of Service in their version of November 8, 2017 (the current version at the time of writing) urges tutors to “[...] at all times comply with applicable law” and, in its section on interactions with users, “urges” tutors to immediately contact the police directly if they believe that another user is violating the law or defrauding anyone. We note however that there is no request that this be brought to Chegg’s attention. The terms of service further require tutors to agree that Chegg “will not be responsible for any damage or harm resulting from your interactions [...] with [...] Users” and that, “to the fullest extent permitted by applicable law, that (i) any legal remedy or liability that you or such third party seek to obtain for actions or omissions of Tutors, Users, or other third parties will be limited to a claim against the particular Tutor, User or the third parties who caused you, or such third party, harm; and (ii) you will not to attempt to impose liability on, or seek any legal remedy from Chegg with respect to such actions or omissions”. The terms also require every tutor to grant a license that warrants that tutors must have rights to all content they post, and that the content must not violate third parties’ copyright, moral rights, intellectual property rights, or violate any law or regulation. Tutors must further agree not to conduct themselves in an unprofessional manner, help a student to cheat, complete graded assignments for students, plagiarise, and must agree to comply with all applicable laws and regulations, including foreign ones. Chegg reserves the right to investigate and prosecute any of these, but also states explicitly that it has “no obligation to monitor” the use of the site by the tutor.

In the current Terms of Use (dated July 8, 2020), Chegg

Chegg is committed to students. We want to help you learn, at every stage of the journey, at your own pace and with the tools you need to succeed. For some of you, that may mean using our step-by-step solutions to help you understand the answer in your textbook – or it may mean working with our tutors to help you master the subject. It might mean just using our tools to make sure your work is properly sourced and cited.

It should never mean that you use our services for any sort of cheating or fraud – like passing someone else’s work off as your own.

The vast majority of Chegg students use our services to help them learn and understand. We don’t tolerate abuse of our platform or services. Dishonest behavior damages your reputation as a student. It’s also unfair to other students, and it makes it difficult for your instructors to assess your learning. Misuse of Chegg’s services can have serious consequences, up to and including being banned from our platforms or having an investigation opened by your institution.

If you aren’t clear on whether you can use online platforms for the problem or assignment you’re working on, please ask your instructor to clarify. For example, one common instruction is “open book” – but while some instructors use that to mean all outside materials are fair game, others very much mean only the textbook I assigned . Just ask – it’s better to have a conversation than have a miscommunication that ends in front of your institution’s academic integrity board.

You should know that if Chegg finds out or is informed that our services have been misused, we may take any action necessary to maintain the integrity of our services and our community. This may be simply removing offending materials; it may also mean terminating the accounts of users involved with misusing our platform, or helping an institution determine the nature of the misuse and the identities of those involved in committing such fraud.

You should also understand that Chegg respects the intellectual property rights of others, and we expect our users to do the same. You should only upload content to our website that you’ve made, or that you’re otherwise authorized to post. In keeping with the Digital Millennium Copyright Act (DMCA), we will remove content that’s identified to us by the copyright owner through a valid notice of copyright infringement. We will also terminate the accounts of users who repeatedly engage in copyright infringement.

Fig. 1. Honour code for students. Source: chegg.com/honorcode. 14 Oct 2020

includes an Acceptable Use Policy, which appears to ban copying (but not plagiarism in general) under point 6 but does not mention attempts to solicit solutions for academic assessments. Outside the acceptable use policy, users must “specifically agree not to use, claim or submit as your own any portion of the help material”. Perhaps most explicitly, a section on the Chegg Honour Code near the end of the terms requires users to abide by that code, which includes not using Chegg’s “questions and answers service to complete tests or homework when instructed not to use outside help” and not “passing along any solutions [...] as your own”. It also explicitly requires users to observe their own instructor’s and school’s honour code, and promises to take “ swift

Our services are designed to support learning, not replace it. Our tutors and subject matter experts work hard to supplement your instruction with a number of different tools. We offer step by step explanations, real time tutoring, and interactive feedback. Please be as clear as possible with your students about what resources are appropriate for them to use on any given assignment. If you believe your students are using our services inappropriately, we encourage you to first have an open and honest discussion with your students.

If you cannot resolve your concerns directly with your students, please use the appropriate form below so that we can help address your concerns. While misuse of our platform represents an extremely small portion of the activity on our services, we understand how frustrating it can be in the context of the work you put into your classes. We also know how disappointing it is to confront academic dishonesty. We are constantly working to improve our abilities to detect and respond to issues around both copyright and academic integrity. We take both of these situations very seriously, and we will respond as quickly as possible.

Fig. 2. Information for instructors. Source: chegg.com/honorcode 14 Oct 2020

TABLE II
ACCOUNT PRIVILEGES AT CHEGG.

Account Type	Privileges
Account with paid subscription	Post and view answers to all questions. Up-vote or down-vote an answer.
Account without subscription	View questions.
Auditing public	View questions.

action against anyone found violating this Honor Code”. In “A message to students” below the Honour Code, Chegg states that “Copying solutions or posting unexplained final answers promotes completion without comprehension, and that’s something we don’t support on the Services.”

To understand how the students might be using the site, we created two student accounts, one with a paid subscription and the other without. Table II shows the privileges available to these two accounts as well as to someone with no account.

As noted in Table II, neither an account with no subscription nor the auditing public can post questions on Chegg. They cannot view the answer archive either. While anyone can view a posted assignment question, including those in the archive, viewing the answers is important to estimate the possible extent of cheating, if there is any. Therefore, the account with the paid subscription is the only account type we used in the end. While publicly available data is useful in order to get an idea of the range of questions submitted, this data is not sufficient to determine the scale of potential cheating.

Using the paid subscription account, we posted 30 questions via Chegg’s smartphone application, snapping and uploading photos of the questions. The questions are at year 1 and year 2 levels covering computer systems (computer networks, com-

Computer Security in everyday life – COMPSCI 105

Our lectures covered the basics of various aspects of computer security. This assignment asks you to research how computer security is used in our everyday life, and relate your research to what you learned from the lectures. You then need to write a short-essay of around 400 words reflecting your research and learning.

The assignment is worth $X\%$ of your final grade and is due [on a date in the very near future].

Fig. 3. A sample question with due date and weight

puter security, and computer architecture and organization), algorithms and data structures, and computer programming.

Each of the questions had an explicit due date in the near future and clearly mentioned how much the assignment was worth in terms of the final grade. It had to be clear to any observer, including anyone providing an answer, that the question was part of a current assessed homework. Figure 3 illustrates a sample question. Nazerian reported that Chegg uses a machine learning approach to check if students violate the honour code [24], so our questions presented 30 opportunities for Chegg’s algorithm to demonstrate its abilities.

The next section looks at what may be gleaned from our experience posting these questions and the solutions and responses obtained. We look at factors such as the quality of answers, how promptly each answer was delivered, and follow-ups to incorrect answers.

IV. RESULTS

None of our 30 questions were flagged as violating academic integrity even though the questions had clear indications that they were going to be graded and were still current. Almost all of the questions were answered – most of them correctly – and on time.

Tables III–V summarise the results. They note the time (in minutes) it took to obtain the solution for each assignment and also show our mark for the solution. The mark is an indication of the quality of the solution provided. The authors formulated the questions and graded the solutions obtained from Chegg.

TABLE III

SUMMARIZED RESULTS OF THE QUESTIONS IN *Computer Systems*. TIME IS THE NUMBER OF MINUTES IT TOOK FOR GETTING THE SOLUTION.

Assignment	Marks	Time	Notes
S1 (Cryptanalysis)	80%	420	Followup unanswered
S2 (Crypto essay)	0%	17	Plagiarised
S3 (Assembly 1–3)	100%	60	Followup unanswered
S4 (Assembly 2–3)	–	–	No answer
S5 (Assembly macro)	–	–	No answer
S6 (Web security)	20%	120	
S7 (Two’s complement)	100%	10	Good explanation

Question S1 (see Table III) was an easy question on elementary encryption, but it took 7 hours to obtain an answer. It would have required the answerer to carefully verify if Chegg’s automated transcript of the uploaded image was correct and make manual adjustments before an answer could

be obtained. The answers were reasonably correct, but the only explanation that was provided was incorrect, making us believe that the answerer may have arrived at the answer with one of the readily available tools without actually understanding the subject. The errors in the answer might be due to poor transcription.

Question S2 was to write a 300-word essay about the prevalence of cryptography in products and services around us. The answer came very quickly (17 minutes). It was a 700-word essay which simply had factual statements on cryptography – this was not the supplied topic, and therefore did not meet the requirements of the question. Besides, the essay was plagiarised. The first paragraph was taken from a solution supplied at one of the contract cheating sites. The second paragraph was available at more than one Internet source.

Question S3 contained three parts, two requiring short assembly programs, and the third requiring a critical comparison of the two answers of the first two parts. The answerer answered part 1 correctly, but did not answer parts 2 and 3. Our follow-up with the answerer went unanswered. We eventually re-posted the question as S4 indicating that we required answers for just parts 2 and 3. The question went unanswered and, after three days, we were notified that the question had expired and therefore had been refunded. The notification said that they were “unable to find a Chegg Expert” to answer the question. The refund meant that the unanswered question was not deducted from the monthly allowance of 20 questions.

Question S5 required the student to study a short macro implementation, critically discuss its shortcomings, and provide a better implementation. This too went unanswered, and eventually “refunded”.

According to one of the answers on Chegg, a question may go unanswered if it is too difficult or if a matching “expert”, who could solve the question, could not be found. It also goes on to say that if a question does not get answers in 2–3 days, the student will get a refund, and could try re-posting the question.

Question S6 was another short essay based on critical analysis of concepts. The answer provided mostly consisted of statements of facts but lacked critical analysis. Therefore, it did not attract a mark worthy of a pass.

S7 was an easy question on two’s complements. The answerer provided workings, and explained them quite well.

TABLE IV

SUMMARISED RESULTS OF THE QUESTIONS IN *Algorithms*.

Assignment	Marks	Time	Notes
A1 (Time complexity)	100%	44	
A2 (Dijkstra)	100%	60	
A3 (DFS/BFS)	100%	26	Partial solution
A4 (BFS)	100%	12	
A5 (MST 1)	100%	180	
A6 (MST 2)	100%	45	
A7 (Tree traversals)	100%	3	

Question A3 (see Table IV) had two parts requiring the application of two search algorithms on a given graph. The

answerer provided the correct answer for the first algorithm, but requested that the second algorithm be posted as a separate question. A4 is the re-post of A3 requesting answer for the second algorithm. A different answerer picked this question, and provided the correct answer.

A7 is a trivial question on in-order, post-order, and pre-order tree traversals. This resulted in a very quick solution.

TABLE V
SUMMARIZED RESULTS OF THE QUESTIONS IN *Computer Programming*.

Assignment	Marks	Time	Notes
P1-P11	100%	Time taken: 14, 8, 8, 7, 7, 8, 6, 50, 6, 69, 8	
P12	70%	8	Some test cases fail
P13	90%	27	Minor mistake. Follow-up unanswered
P14	0%	60	Follow-up unanswered
P15	–	–	No answer
P16	100%	39	Excellent solution

All programming questions were pitched at CS1 level and required short python functions to be written. The programming question P14 (see Table V) attracted an incorrect solution and our follow-up went unanswered. We eventually downvoted the answer. At this point we were asked to indicate the reason so that Chegg could ‘fix’ it, but no ‘fix’ ever materialised. Question P16 was a reformulation of question P14. This was answered correctly and the solution provided was excellent, complete with comments explaining the steps. This showed that the quality of the solution depends on who picks up the question for answering.

In cases where there were issues with the solution (questions S1, P13, and P14), we tried to engage with the answerers, but none of them responded.

A. Cheating Incidents

As discussed in the previous section, the main motivating factor for this work were the cheating incidents we uncovered in a year 1 programming course and a year 2 computer systems course.

In the programming course, nearly 10% of its 296 students were found colluding during an online test, with one of the students posting test questions to Chegg and successfully obtaining answers during the test.

The year 2 course was more interesting as it used small weekly assignments that were individualised. The 216 students in the class were given 11 assignments over the course of twelve weeks. There were 32 confirmed postings of 7 out of the 11 assignments on Chegg. Our search on Chegg was quite rudimentary and may not have spotted all postings², depending on how the student posted the assignments. Since the assignments were individualised, we were able to trace the postings to individual students. Six students were then successfully prosecuted.

²A cursory analysis of the information available on the site shows that the site might be receiving between 10,000 and 40,000 questions on an average day. This is a large number to sift through.

B. Analysis

Without judgement, we would like to re-iterate our key observations based on the crafted assignment questions we posted on Chegg and the answers we obtained.

- 1) All our questions had explicit due dates in the near future and stated what they were worth in terms of the students’ final grade. Any observer, including the answerer, should have been able to see that the “student” was trying to “buy” the solutions and that these questions were clear violations of any reasonable honour code. Yet, none of our questions was flagged or removed.
- 2) Easy questions attracted correct answers.
- 3) Questions that required higher-level thinking attracted substandard answers or no answers.
- 4) Answers, when provided, were prompt, and well within the due dates of the assignments.
- 5) Students could “buy” answers without having to learn the concepts required to arrive at the answers themselves.

Note that our study is limited in that our investigation was based on a small set of assignments we crafted at year 1 and year 2 levels. We did not look at assignments at year 3 or higher. However, based on our observations above, we hypothesise that these assignments are not likely to attract high quality or prompt answers.

We also note that students are buying answers on Chegg, as our cheating incidents reveal. When contacted, Chegg took down the questions we flagged and assisted us in prosecution.

V. MITIGATION

There are two classes of approaches to mitigate students buying answers to assessed homework – one implemented and enforced by the tutoring company, and the other implemented and enforced by the instructor or the academic institution.

A. Tutor-initiated Approaches

A strict enforcement of Chegg’s honour code would mitigate cheating to a considerable extent. Chegg’s terms of service place responsibility for adherence (and any legal consequences) squarely on users and tutors. While silence on proactive policing of their own honour code does not imply that there is no such policing, we found no evidence of it in our small study.

Chegg assists users and tutors to report inappropriate content by providing a trigger for registered users to report questions, but it is only available in the online version and not in their smartphone version. The current reporting defaults are *inappropriate* and *spam*. An inclusion of *suspected cheating* to the list would clarify that such questions should be flagged. Even though the chance of a student reporting *suspected cheating* may be low (especially when the student also uses the site for cheating), it creates a risk for the student.

In order to tackle cheating, Chegg (and other such companies) could also implement some of the following positive approaches:

- 1) Since each question is read by an expert answerer before answering, the answerer should be required to assess at this point if the student's question violates the honour code; and if it does, they should be required to direct the student to the honour code rather than answering the question. A machine learning approach in this case seems unnecessary since the questions are answered by humans – not by machines.
- 2) Require students identify themselves as well their institution so that violations to honour codes can be investigated. Anonymity breeds cheating.
- 3) Request a statement of compliance with the honour codes of the tutoring company and their own institution each time they post a question. While this does not prevent a student from posting questions that do not comply, it increases their awareness of the honour codes.
- 4) Provide free access to institutions to monitor violations of academic integrity and be proactive in informing institutions about suspected cheating cases. While Chegg does cooperate with institutions in academic integrity investigations and supply data to assist with these investigations, academics will have to spend time looking for questions posted on Chegg to request assistance.
- 5) Education tools such as Piazza plug into learning management systems and obtain students' credentials. This means that students are not anonymous, and instructors are able to monitor students' activities in these application plugins (for teaching purposes as well as for maintaining academic integrity). Tutoring companies could have a business model that facilitates such a plugin. This will then enable instructors to easily monitor non-compliant uses (e.g., an abusive post, cheating, etc.).

B. Institution-initiated Approaches

An institution must have an honour code that every student clearly understands, and / or have a compulsory course in academic integrity that every student must complete. This educational approach to combat cheating is quite important as it removes any defence citing ignorance.

Assessment designs should take into account the possibility that a student might employ a contract cheating company. Scaffolded assignments where progress is discussed with the instructor at each step along the way is one design approach. An oral examination where the student is expected to explain their work is another approach. Unfortunately, neither of these two approaches scale to large classes.

Another approach could be an automated authorship analysis where each student's submission is compared to their historical submissions to see if there is any substantial style deviation. However, this will not be effective if a student uses the same ghostwriter for all of their assignments. In the case of Chegg, their question answering facility puts the student's question into a public pool in the subject area, and the tutors pick the questions from the pool to solve. This means that the same tutor is unlikely to pick the next question from the student. Therefore, an authorship analysis is likely to work so

Assignment – HTTP Latencies

This assignment helps you familiarize with latencies in the HTTP protocol. The latencies are incurred when a web client requests information from a server `www.kensamolet.com`. You will be using the simplified latency model described in the text book.

The bandwidth between the client and server is deemed to be 220 Mb/s and the round-trip time (RTT) is estimated to be 70 ms. Note that the RTT is the time it takes for a small packet to travel from client to server and then back to the client. Note also that a kilobyte (kB) is 1000 bytes, and a megabyte (MB) is 1000 kilobytes.

Please write down your answers to the following questions in milliseconds. Do not write the units however.

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Fig. 4. Assignment fingerprinting – A sample (partial) assignment with a unique non-existing word: `kensamolet`. The bandwidth and RTT are individualised for each student, as are other values that appear in the questions (that are not shown).

long as the answers are long enough. Like any other similarity detection methods, authorship analysis may indicate a possible violation of academic integrity, and the instructors are required to take further steps to gather sufficient evidence to prove that a violation has indeed taken place.

Individualising assignments is an effective way to detect cheating. As noted in section IV-A, individualisation can lead to successfully tracing the students who use online contract cheating services. Taking disciplinary actions on these students deters others from cheating, effectively mitigating further cheating. Instructors can use frameworks that help to programmatically generate individualised assignments as well as auto-grade them [25], [26], [27]. These frameworks can work well in the science and engineering context.

Finding out where the students might have obtained the solutions from can be difficult. An Internet search for an assignment may yield thousands of hits, which an instructor would find difficult to sift through. Assignment fingerprinting, where the assignment text includes a unique non-existing word (e.g., `kensamolet`), can help to guide and filter the search results. See Figure 4. Assignment fingerprinting, along with individualization, is a powerful way to detect, and therefore deter, contract cheating.

Individualisation can also assist in assessments such as tests, especially where no physical invigilation is practicable (as seen frequently during the 2020 Covid-19 pandemic) and the assessment is online. One critical component to success here is that the time period for the assessment must be strictly limited. Another is that all questions must be answered in the order in which they appear, and the next question must never be visible before the current question has been answered. While students can still post questions on sites such as Chegg in such cases, any time spent waiting for an answer via contract cheating increases the time pressure for the remaining questions. The individualisation makes trawling through similar answers from past assessments or from classmates a time-consuming approach as well. Last but not least, in cases where

multiple students from the class seek help on the same forum, the individualised versions of each question increase the load on the answerers, and are therefore likely to increase response times. Those students who manage to obtain an answer can still be traced, but this is now more of a backstop than an ambulance-at-the-bottom-of-the-cliff approach.

For tutoring companies unwilling to engage in proactive policing of contract cheating, institutions could also implement DNS redirects that take students to their own honour code rather than the contract cheating site. This would only work for students accessing the site from within an institution's network, but could nevertheless send a strong message against contract cheating.

VI. SUMMARY AND CONCLUSIONS

Contract cheating is relatively cheap and readily available. Thus students can be tempted to buy their solutions rather than working them out themselves. This can lead to a poor learning experience and a low-value education, while simultaneously disadvantaging honest students.

In this paper we studied the wider problem through an extensive literature survey on various aspects of contract cheating. We then focussed on a case study looking at how easy it is to contract cheat. We used Chegg.com as an example where students can de-facto "purchase" solutions to their assignments. In our case study, we posted several assignments from a cross-section of CS1 and CS2 subjects with clear indication of due dates and weights, and were able to "purchase" solutions. None of these assignments were flagged as violating academic integrity. Most of them attracted high-quality solutions well within the posted due dates. Some of the questions that demanded higher-level thinking attracted substandard answers or no answers, but this was not a surprise given how cheap the service is. For as little as \$20 a month, a student can buy up to twenty solutions.

We discussed approaches to mitigate contract cheating that could be implemented and enforced by the online tutoring company, and approaches that can be taken by the academic side. Given the complex nature of contract cheating and the fact that no single approach is foolproof, we believe that a multi-pronged approach combining many of the potential solutions may be the best way to tackle contract cheating. One promising two-pronged approach in the science and engineering domain is to use individualised assignments with assignment fingerprinting. This approach allows instructors to uncover, prosecute, and therefore deter, contract cheating.

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