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Cheating in e-exams and paper exams: The perceptions of engineering students and teachers in Norway

Aparna Chirumamilla*{0000-0001-6985-8476}

Department of Computer Science,

Norwegian University of Science and Technology

Trondheim, Norway

aparna.vegendla@ntnu.no

Guttorm Sindre{0000-0001-5739-8265}

Department of Computer Science,

Norwegian University of Science and Technology

Trondheim, Norway

guttorm.sindre@ntnu.no

Anh Nguyen-Duc {0000-0002-7063-9200}

Department of Business and IT,

University Of South-Eastern Norway,

Bø i Telemark, Norway

Anh.Nguyen.duc@usn.no

* Corresponding Author Address:

IDI, Sem Sælands vei 9, Room. 143,

Trondheim, 7034, Norway.

Tel: +47 4546 3893

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A concern that has been raised with the transition from pen and paper examinations (paper exams) to electronic examinations (e-exams) is whether this will make cheating easier. This paper investigates how teachers and students perceive the differences in ease of cheating during three types of written examination: paper exams, Bring Your Own Device e-exams (BYOD e-exams), and e-exams using the university-owned devices. It also investigates perceptions about the effectiveness of some typical countermeasures towards cheating across these examination types. A mixed-method approach was used, combining questionnaires and interviews with students and teachers in the authors' own university (NTNU). A total of 212 students and 162 teachers participated in the questionnaire survey, and then a more limited number were interviewed to get a deeper understanding of the results. Six-different cheating practices were considered – impersonation, forbidden aids, peeking, peer collaboration, outside assistance, and student-staff collusion, and seven different countermeasures were considered – proctors, biometry, mingling, shuffling, random drawing, sequencing, and broadcasting. On the one hand, both students and teachers perceived cheating as easier with e-exams, and especially with BYOD. On the other hand, they also thought some countermeasures would be easier to implement with e-exams.

Keywords: electronic examinations, pen and paper examinations, academic dishonesty, cheating on examinations, cheating prevention, mixed-method approach

Introduction

Cheating has long been an issue of concern with high stakes summative assessment in universities (Cizek 1999). In Norway, there was a recent poll by Sentio (Skaaren and Østgaard 2019) with 1000 students across the most important higher education institutions, with the simple question *How many times have you cheated in examinations?* Of the respondents, 16% admitted to cheating (12% once, 2% twice, 2% thrice or more). The number was higher than in a similar

poll five years earlier and since less than 0,1% of students in Norway actually get caught cheating in examinations, it indicates that most cheaters are not caught. When caught and convicted, penalties for examination cheating are rather strict in Norway. In addition to annulment of the examination, perpetrators will normally get 6- or 12-months quarantine from studies and examinations at any Norwegian higher education institution. However, Norwegian law obliges the university to carry the legal costs whatever the outcome of the case. Hence, universities may be reluctant to raise cheating cases unless they appear crystal clear.

Many universities are in the transition from traditional pen and paper examinations (paper exams) to electronic examinations (e-exams or digital exams) using PCs (Fluck 2019). Even with on-campus e-exams, using invigilators and other security measures, there are fears that it may be easier to cheat at e-exams. For instance, Dawson points out that e-exams have all cheating threats associated with examination in general, and some new threats of cheating associated with the usage of PCs (Dawson 2016). However, e-exams also come with additional countermeasures against cheating (Sindre and Vegendla 2015). For instance, with an e-exam, it is easier to scramble the order of questions and response alternatives, or present candidates with different, randomly drawn questions. This would mitigate peeking, whispering, or text messaging among candidates. Regardless of examination type, cheating remains problematic, as the students make use of technological devices (e.g., scientific calculators, hidden cameras, wearable technological devices such as smart glasses, smartwatches, and wireless earpieces) (Lancaster and Clarke 2017), in addition to traditional ways such as writing answers on crib-sheets, body-parts, clothes, water-bottles, etc., and whispering, signs and code languages (Madara and Namango 2016). The mentioned Sentio poll, however, made no breakdown according to various types of examinations, nor did it look at different types of cheating or the effect of countermeasures.

This paper aims at investigating the ease of cheating in on-campus examinations (i.e., examinations done in venues controlled by the university, under the supervision of invigilators). We do not consider cheating in remote examinations, coursework or term papers where the work is performed outside a controlled setting. We are particularly interested in the comparison between paper exams and e-exams. However, a quantitative risk comparison between e-exams and paper exams is a near impossible task. Although some question formats (e.g., multiple choice) enable measurement of likely cheating from automated analysis of answers (Yates, Godbey, and Fendler 2017), other question types would require that perpetrators are caught in situ for cheating to be detected.

Moreover, examination security depends on many factors beyond the choice of paper or digital, such as the moral inclinations of the students, the competence of invigilators, and the security of the specific examination infrastructure. A comparison using one specific e-exam tool would quickly become dated with the release of new and more secure tools, or with the spread of rumours among students on how certain security controls can be bypassed. Still, it is interesting to know something about the relative ease of cheating in paper and e-exams. One natural approach would be to ask the students themselves, and surveys with students are often used in research about cheating (McCabe, Trevino, and Butterfield 2001; De Lambert, Ellen, and Taylor 2006; Colnerud and Rosander 2009; Trost 2009; Owunwanne, Rustagi, and Dada 2010). Even if students may not have complete knowledge about the ease of cheating, nor of the university's countermeasures, they are likely to have some insights, either from own experience or from peers. Another possibility is to ask teachers, who may want to design tests that are hard to cheat on, and who may have caught or suspected cheating when grading answers.

This paper makes a combined study of the perceptions of university students and teachers on cheating during written on-campus examinations that cover wide variety of questions ranging from multiple-choice to essays, with a particular focus on comparing three ways of implementing such examinations: paper exams, Bring Your Own Device e-exams (hereafter called BYOD e-exams) where students use their own laptops or desktop computers for the examination, and e-exams using university-owned PCs (hereafter called university PCs). Asking about "cheating" in a completely generic way might yield vague answers because different respondents might think of different ways to cheat. To make the survey more concrete, it was chosen to focus on six specific categories of cheating:

(1) *Impersonation*: Having somebody else sit the examination for you (Apampa, Wills, and Argles 2010).
(2) *Forbidden aids*: Using documents or tools not allowed during the examination (Trost 2009; Lancaster and Clarke 2017).
(3) *Peeking* at the answers of other candidates (Trost 2009).
(4) *Peer collaboration*: Students collaborating on a test supposed to be individual (Trost 2009).
(5) *Outsider assistance*: Getting illegitimate help from an outsider during the examination (Lancaster and Clarke 2017).
(6) *Student-staff collusion*: Illegitimate help from a university employee during the examination (Trost 2009).

We chose this particular categorization rather than the more well-known taxonomy by Cizek (1999). Cizek's taxonomy has only three categories: giving/taking/receiving information

(our items 3,4,5 would fall in this category), usage of forbidden materials (our item 2), and capitalizing on the weakness of persons, procedures or processes (our items 1 and 6 would belong here). Some of Cizek's categories are quite broad, so would be too vague as questionnaire items in their own right. On the other hand, other questionnaire surveys have tended to list many different types of cheating. For instance, the survey by Trost (2009) lists 21 specific ways of cheating. This can work fine in a survey whose key objective is to ask whether students have cheated in these various ways. However, in our study, where the focus was more on checking the relative ease of cheating for paper exams and e-exams, the survey would be excessively long with so many categories of cheating. Hence, our six categories above were seen as a viable compromise between detail and length, and although it does not cover all types of cheating, it covers the most important ones for written on-campus examinations. Of course, there are more ways of cheating, such as plagiarism, time violation, or faking disease. However, plagiarism is more relevant for take-home examinations and term papers, while the focus of this study is on-campus summative examinations. Otherwise, the list above is assumed to cover the most relevant ways to cheat, as it is important not to make a questionnaire too long.

Similarly, rather than asking about any kind of countermeasures against cheating, it was decided to focus on seven specific types of countermeasures:

(1) *Proctors*: (aka invigilators) Humans overseeing the examination to prevent cheating (Apampa, Wills, and Argles 2010). In the university where the study took place, these are normally not the teachers of the course, rather administrative personnel, or persons temporarily hired for the examination season.

(2) *Biometry*: Using e.g. fingerprints, keystroke dynamics, face or voice recognition to verify the identity of candidates (Apampa, Wills, and Argles 2010; Vegendla and Sindre 2019).

(3) *Mingling (or mixed seating)* of students taking different examinations (Sindre and Vegendla 2015; Topîrceanu 2017), e.g. next to a Math candidate are others taking IT, Philosophy, etc. This is to prevent close range cheating through peeking, whispering, etc.

(4) *Shuffling* of questions and answer alternatives (Thelwall 2000), e.g., to avoid that students for the same examination have the same answer pattern at multiple choice.

(5) *Random drawing* of questions from a larger base (de Sande 2015), so that students up for the same examination have different questions to answer.

(6) *Sequencing (or Blocked backtracking)*: Enforcing sequential answering of examination questions, only one task visible at any time (Sindre and Vegendla 2015; Stack 2015). This could mitigate cheating via the toilet, or by assistance from outsiders. With all questions visible from the start of the examination, the weaker candidate could first look through the entire question set and find out where help is needed, then somehow communicate to a peer or outsider which these tasks are, and later receive the answers to all these at once. Thus, needing only two trips to the toilet (drop off, collection) or two usages of a smartphone or other communication tool. With sequencing, on the other hand, communication is needed for every little task along the way, thus increasing the risk and labour associated with such cheating.

(7) *Broadcasting*: Current practice in our university is that the teacher comes to the examination room to answer questions from students, e.g., about typos or unclarities in the examination task. This might enable student-staff collusion (e.g., teacher gives extra help to some select students). If instead the teacher is only allowed to broadcast clarifications (e.g., electronically) so that all students can see them, this might mitigate such collusion.

Again, there are other countermeasures that could also be thought of, e.g., related to body searching or scanning students before the examination (to discover concealed cheat notes, phones, etc.), room layout, walls between students, camera surveillance, etc. However, the survey had to be kept at a reasonable length. Proctors was included because it is the currently dominant countermeasure, and the six others because they are countermeasures where there might be differences between paper exams and e-exams. For instance, sequencing, shuffling, and random drawing are features that are often supported by e-exam tools, while for paper exams this would be believed to require more hassle, such as dividing the examination into several sessions (sequencing) or printing several different version of the examination question set (shuffling, random drawing). A countermeasure which was not asked about in the survey is the usage of a lock-down browser (e.g., preventing students from accessing other programs and files than the allowed ones during an examination). This was omitted because it only applies to e-exams, and for e-exams it is used by default. Similarly, the usage of specific examination answer sheets (a certain type of paper, with university logo etc.) rather than plain white paper, was not asked about as a countermeasure since it is only applies to paper exams, and is rather obvious (as usage of plain paper would make it much easier for students to smuggle in pre-written sheets).

Our research questions are as follows:

RQ1: *What are student and teacher perceptions about the frequency of the six listed types of cheating during on-campus written university examinations?* This RQ makes no comparison of paper exams and e-exams, and its purpose is to get some context about the magnitude of the problem.

RQ2-3: *Is there a significant difference between paper, BYOD, and university PC when it comes to ease of cheating (in any of the six ways listed above), as perceived by students (**RQ2**) and teachers (**RQ3**)?*

RQ4-5: *Is there a significant difference between paper exams and e-exams in the effectiveness of countermeasures against cheating, as perceived by students **(RQ4)** and teachers **(RQ5)**?* Here, we only made one comparison (i.e. paper exams to e-exams) rather than three different comparisons, to avoid a too long survey.

RQ6: *Are there differences between student and teacher perceptions of ease of cheating, and the effectiveness of countermeasures?*

The remainder of the paper is structured as follows, Section 2 provides the works related to this study. Section 3 outlines the methodology for designing and analyzing the survey data. In sections 4, the results of our findings are presented. Section 5 provides the discussion of the results and section 6 concludes the paper.

Literature review

Jamil et al. (2012) made a questionnaire survey about teacher perceptions of e-exams and paper exams. Teachers were mostly positive towards e-exams but sometimes preferred paper exams. Their questionnaire was focused on affective factors, adoptability, reliability, and practicality. Most relevant to our study was whether shuffling of questions could reduce cheating, more than 60% of the teachers agreed (p.381).

Dermo (2009) investigated student perceptions of e-assessment. The aim of the survey was to identify possible risks in planning e-assessments using the six main dimensions: (1) affective factors, (2) validity, (3) practical issues, (4) reliability, (5) security, and (6) learning and teaching. Some of the questions in the categories reliability and security are related to our study.

Trost (2009) made a questionnaire survey with Swedish university students, focusing on cheating and plagiarism. The results from her study show that taking forbidden aids to examination (9%) was common, while peeking (1%) less common, and no respondents reported about impersonation or student-staff collusion.

De Lambert, Ellen, and Taylor (2006) in their survey with New Zealand institutions report that students and staff believed impersonation is rare while forbidden aids and peer collaboration appeared to be more common.

Colnerud and Rosander (2009) made a questionnaire survey with students using scenarios, investigating students attitudes towards different ways of cheating in both assignments and examinations. They reported that students considered collaboration with another student leaving a crib notes in restroom (M=1.11, SD=0.55) as one of the most obvious cheating practices during examinations.

Dawson (2016) presents five potential hacks against BYOD e-exams, reporting that bringing forbidden aids, removal of the examination paper from the venue, and outside assistance were identified as significant threats. He stated that BYOD has the vulnerabilities of paper exams and examinations using university PCs, as well as some of its own.

Sindre and Vegendla (2015) in their paper compared BYOD e-exams and paper exams on the threats, including impersonation, forbidden aids, peer collaboration, and outside assistance using attack defense trees. Their analysis shows that BYOD e-exams need not be less secure than paper exams, claiming that the level of security will depend on the actual implementation of examinations type, what countermeasures are in place, skills of proctors, and the type of questions asked.

Also, many studies investigated cheating and plagiarism in e-assessment during assignments submission (Wilkinson 2009; Owunwanne, Rustagi, and Dada 2010; Kocdar et al. 2018; Zhang, Yin, and Zheng 2018; Bretag et al. 2019), and on frequency of cheating and attitude towards cheating in examinations (De Lambert, Ellen, and Taylor 2006; Colnerud and Rosander 2009; Trost 2009; Jamil, Tariq, and Shami 2012), but only a few studies made any detailed investigation of the comparison of cheating on paper exams and e-exams during examinations (Dermo 2009; Sindre and Vegendla 2015; Dawson 2016). Hence, more research is needed to have a clear comparison of risks with paper exams and e-exams and to have useful guidelines for how to manage the transition while avoiding an increase in cheating.

Method

The research questions investigate perceptions and beliefs of students and teachers on paper exams and e-exams. The cross-sectional survey is used in quantitative research to examine the attitudes, beliefs, opinions, or practices of the participants at one point in time (Creswell 2013). There are many different forms of surveys, and two main types are questionnaires and interviews, both with their pros and cons. Interviews allow for more open questions and deeper answers but are time-consuming to conduct and analyse, thus reducing the number of respondents that can realistically be involved. Questionnaires can reach many more respondents but at the cost of shallower answers. In this study, targeting a comparison between perceived ease of cheating for paper exams and e-exams, preferably with some quantitative results, questionnaires appeared as the most feasible choice due to the larger sample size (Fraenkel, Wallen, and Hyun 2011). However, quantitative surveys have weaknesses, especially if respondents may have trouble answering the questions reliably. Some respondents would have

little or no personal experience with cheating, so answers about ease of cheating would partly be guesswork. Hence, to gain a deeper understanding, questionnaires were supplemented with semi-structured interviews with some students. Overall, the chosen research method was thus a mixed methods approach, combining a quantitative questionnaire study with qualitative interviews.

Table 1. Main survey questionnaire to students

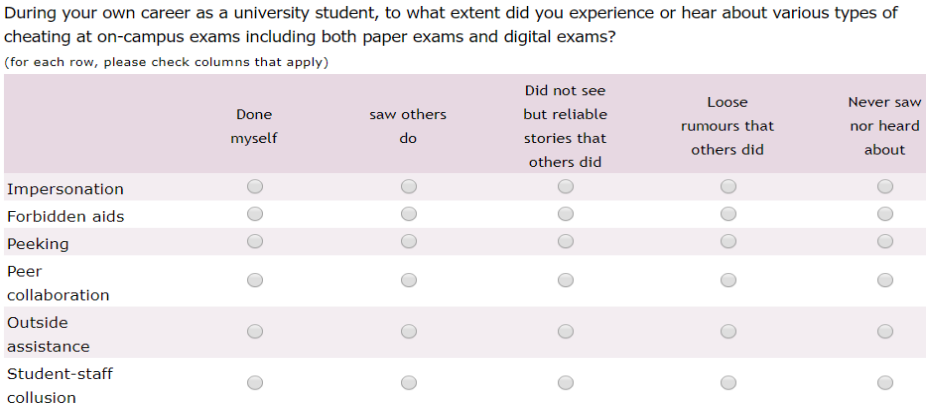
Q. No	Question
1.	During your own career as a university student, to what extent did you experience or hear about various types of cheating at on-campus exams including both paper exams and digital exams?
2.	Based on your experience as a student, do you think what percentage of the annually delivered exams (both on-campus paper exams and digital exams) in your university will have utilized various ways of cheating?
3.	If somebody cheats at written on-campus exam in your university, what is your guess for the average likelihood of getting caught?
4.	What do you think about the ease of cheating for paper exams vs. BYOD (Bring Your Own Device) digital exams, i.e. exams where students use their own laptop?
5.	What do you think about the ease of cheating for paper exams vs. digital exams done in computer labs using university-owned PCs?
6.	What do you think about the ease of cheating for BYOD digital exams vs. digital exams done in computer labs using university-owned PCs?
7.	To what extent do you think the above-mentioned countermeasures can be effective in mitigating at least some types of cheating?
8.	What do you think about the relative effectiveness of the above-mentioned countermeasures, for paper exams vs. digital exams?
9.	How costly do you think the proposed measures would be to implement, for paper exams vs. digital exams?

Table 2. Main survey questionnaire to Teachers

Q.No.	Question
1.	During your own career as a teacher, to what extent do you know about various types of cheating at on-campus exams in the courses you taught or heard about various types of cheating at on-campus exams including both paper exams and digital exams?
2.	Based on your experience as a teacher, do you think what percentage of the annually delivered exams (both on-campus paper exams and digital exams) in your university will have utilized various ways of cheating?
3.	If somebody cheats at a written on-campus exam in your university, what is your guess for the average likelihood of getting caught?
4.	What do you think about the ease of cheating for paper exams vs. BYOD (Bring Your Own Device) digital exams, i.e. exams where students use their own laptop?
5.	What do you think about the ease of cheating for paper exams vs. digital exams done in computer labs using university-owned PCs?
6.	What do you think about the ease of cheating for BYOD digital exams vs. digital exams done in computer labs using university-owned PCs?
7.	To what extent do you think the above-mentioned countermeasures can be effective in mitigating at least some types of cheating?
8.	What do you think about the relative effectiveness of the above-mentioned countermeasures, for paper exams vs. digital exams?
9.	How costly do you think the proposed measures would be to implement, for paper exams vs. digital exams?

Survey design

The questionnaire consists of four sections: (a) Background questions, including participant designation, department name, and their experience on paper exams and e-exams. (b) Questions related to the participant's cheating related experiences. (c) Questions related to the participant's perceptions about ease of cheating in paper exams and e-exams. (d) Questions related to cheating prevention in paper exams and e-exams. Table 1 and Table 2 shows the main questionnaires (Sections b, c, and d) of the surveys for students and teachers. To present questions as concisely as possible, the most used question format was Matrix – One Answer per Row. Each question is a collection of closed-ended questions on various cheating threats with Likert scale answers. To save space, only the main questions are provided in Table 1 & 2. The link to the full questionnaire can be found at, https://www.dropbox.com/sh/8h0wgzusbx1vd9e/AACnkL47EHZR4f2IgxYGFecLa?dl=0.



During your own career as a university student, to what extent did you experience or hear about various types of cheating at on-campus exams including both paper exams and digital exams?

(for each row, please check columns that apply)

	Done myself	saw others do	Did not see but reliable stories that others did	Loose rumours that others did	Never saw nor heard about
Impersonation	○	○	○	○	○
Forbidden aids	○	○	○	○	○
Peeking	○	○	○	○	○
Peer collaboration	○	○	○	○	○
Outside assistance	○	○	○	○	○
Student-staff collusion	○	○	○	○	○

Figure 1. Question No. 1 in students' online questionnaire

As an example of the matrix format, Question 1 from the survey is shown in Figure 1. To calculate the mean value, we have given scores of 1 – 5 to the answers. It could be noted that the scaling of the questions is not uniform throughout the survey. The questions that compare two alternatives (Q4-6, 8-9 in Table 1 & 2; corresponding to 10-12, 14-15 in the web page linked

above) have 3 as the neutral alternative (e.g., paper exams and e-exams are equally risky), and 1 and 5 for opinions strongly in either direction. For Q7, which asks more generally about perceived effectiveness of various countermeasures against cheating, the five alternatives were very effective / moderately effective / slightly effective / no effect / will instead make cheating easier. Here it can be said that "no effect" at position 4 could be considered neutral. Placing this at 3 might have been more consistent but did not appear sensible. The listed tactics were countermeasures against cheating, so it was considered unlikely that a lot of respondents would have the contrary opinion, and "no effect" at 3 would then give little granularity at the positive end of the spectrum. On the other hand, having "no effect" as the extreme would constrain respondents to a positive or neutral view of a countermeasure even if they thought otherwise. Hence, putting "no effect" at 4 was considered a sensible compromise. Q1-3 are different, without any neutral alternative, because they are not comparing anything. Q1, as shown in Figure 1, asks about the respondent's own experience with cheating, with qualitative alternatives that are not really on a linear scale. Q3 (likelihood of getting caught if cheating) is on a linear scale, with five intervals divided at 20, 40, 60, and 80 per cent. Q2 (percentage of delivered examinations using some kind of cheating) has quantitative options, but not on a linear scale, as intervals are divided at 1, 5, 10, 20 per cent. The rationale for these divisions, rather than the same as for Q3, was the assumption that few respondents would think more than 20% of delivered examination papers had used cheating, hence a uniform split of alternatives would give results skewed to the lower end of the spectrum, thus fail to reveal nuances between perceptions of various respondents.

For several of the questions, it might have been natural to have a "don't know" option in addition to the options going from low to high or from extreme via neutral to other extreme.

However, it was chosen not to have a "don't know" since many respondents might too easily choose that option, thus reducing the chance to have substantial findings (Krosnick et al. 2002).

The guide for the interviews was designed to follow up on the questionnaire findings, seeking more detailed explanations for the perceived ease of cheating relative to the examination type. Semi-structured interviews were chosen as the best compromise between keeping the interviews on track towards finding opinions about various ways of cheating and at the same time allow viewpoints on cheating that might not fit into the authors' predefined categorization of various types of cheating.

Table 3. Demographic information of student interviewees

Student & date	Gender	Department	Year	Exp. in e-exams
S1, 25 Feb	Female	CS	BSc 3rd year	6
S2, 25 Feb	Female	CS	BSc 3rd year	7
S3, 26 Feb	Male	CS	BSc 3rd year	6
S4, 27 Feb	Male	CS	BSc 3rd year	6
S5, 4 Feb	Male	CS	BSc 3rd year	6
S6, 5 Mar	Male	CS	BSc 3rd year	6

Computer Science = CS; Bachelor of Science = BSc; Experience = Exp

Table 4. Demographic information of teacher interviewees

Teacher & date	Position	Teaching for	Course Subject Area	No. of students
T1, 13Sep	Professor	MSc	Visual Computing	150
T2, 23Sep	Associate Professor	BSC & MSc	Java, Python	100
T3, 23Sep	Professor	MSc	Database management system,	600
		MSc	Big data management	150
T4, 26Sep	Associate Professor	BSc	Informatics	50
T5, 27Sep	Associate Professor	BSc & MSc optional for all departments	Software Security,	150
		MSc	Advanced Software Engineering	50

Bachelor of Science = BSc; Master of Science = MSc

Data collection and analysis

The questionnaire part of the survey was carried out from Nov 2018 – Jan 2019 using the SelectSurvey online tool (Design 2008) with web-based questionnaires. Participants were

teachers and students from different departments at the NTNU: computer science, electronic systems, electric power engineering, cybernetics, information security and communication technology, mathematical science, natural sciences. Students were invited through email to various student's groups at NTNU. A total of 259 students responded to the email invitation, but 47 of these skipped the survey. Of 212 participants, 149 completed the whole survey while 63 partially completed it. Out of the 149 fully completed, 84 were computer science students who responded to the survey by direct administration in a classroom, while others responded remotely on the web. Teachers were invited to participate by emails containing a link to the web-survey. A total of 736 teachers were invited, whereof 197 responded, though 35 of these skipped the survey. 162 then participated, whereof 95 (13% of those invited) completed it fully and 67 partially. Participation in the survey was voluntary, and the participants were assured that their data would be confidential and treated anonymously. Additional demographics such as age, gender, nationality was not collected from the respondents. Partly the motivation was to keep the questionnaire short, and especially for students, it was also to avoid fear that respondents admitting to cheating might be identified in retrospect. A majority of the students surveyed were in their early twenties, Norwegians, and likely at least 2/3 would be male given the gender distribution of the study programmes involved. Thus, a somewhat older student would easily stand out in the material, especially if also being female and foreign.

Statistical Package for Social Sciences (SPSS) version 25 was used to analyse the questionnaire data. For items related to RQ1, descriptive statistics were used. As for items related to RQ2-5, comparing various types of examinations, one-sample and independent t-tests were used, with the neutral alternative 3 as test value, to check if respondent preference went significantly to one of the sides (e.g., whether one type of examination allowed for easier

cheating than another). Similarly, for RQ6 comparing student and teacher perceptions, independent t-tests were used to check if differences were significant.

The interviews were conducted with six 3rd year bachelor students in Feb and Mar 2019 and five teachers in Sep 2019 (Refer to Table 3&4). All the interviewees were from the computer science department. Participants were received invitation emails explaining the purpose of the interview, and selection was done based on their experience (e.g., no. of e-exams they had) with e-exams in different courses. All the participants were informed of their consent for the audio recording of interviews. Interviews were designed as semi-structured so that they can be prepared and competent during the interview, and an average lasted approx. 40 mins. To extract data from interviews, we used constant comparative method, an inductive coding process (Corbin and Strauss 1990) in Atlas.ti (Atlas.ti). Constant comparative is commonly used in ground theory; it makes the analysis more explicitly theoretical (Urquhart, Lehmann, and Myers 2010) and encourages the researcher to be both rigorous and theoretical. The first step in the analysis involved allocation of categories (i.e. codes) through open coding. Second, constant comparison of data and categories were made to obtain additional data from interviewees. The data collection, coding, and analysis were done together to enrich the existing category.

Results

Frequency of cheating

Both students and teachers reported little first-hand experience with cheating. In Figure 2 and 3, the alternative for no experience (dark blue) is dominant for most types of cheating. Peeking and usage of forbidden aids are considered the two most common ways of cheating both among students and teachers.

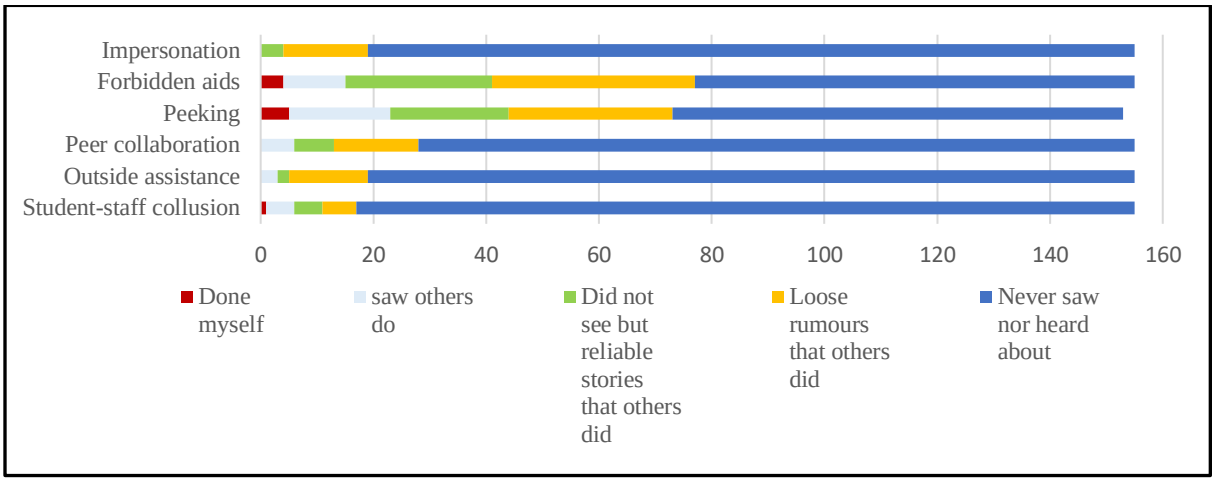


Figure 2. Students response to a question about experiences related to cheating

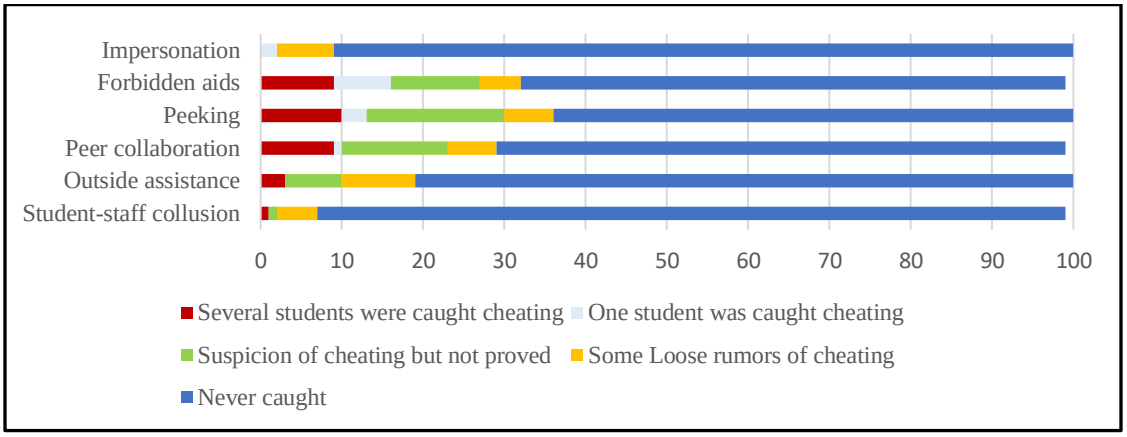


Figure 3. Teachers' response to question about experiences related to cheating

Figures 4 shows responses on questions eliciting more general beliefs of the amount of cheating, independent of personal experiences. Most respondents think frequencies are modest, a clear majority assuming <5% of delivered student examination answers utilised cheating, again with peeking and forbidden aids as the two threats that are considered most frequent.

There was also a question about likelihood of getting caught if cheating (not shown graphically). This was only asked on a generic level, without breaking the question down into

sub-questions for various types of cheating. 46% of students and 59% of teachers assumed this likelihood to be in the lowest fifth (0–20%).

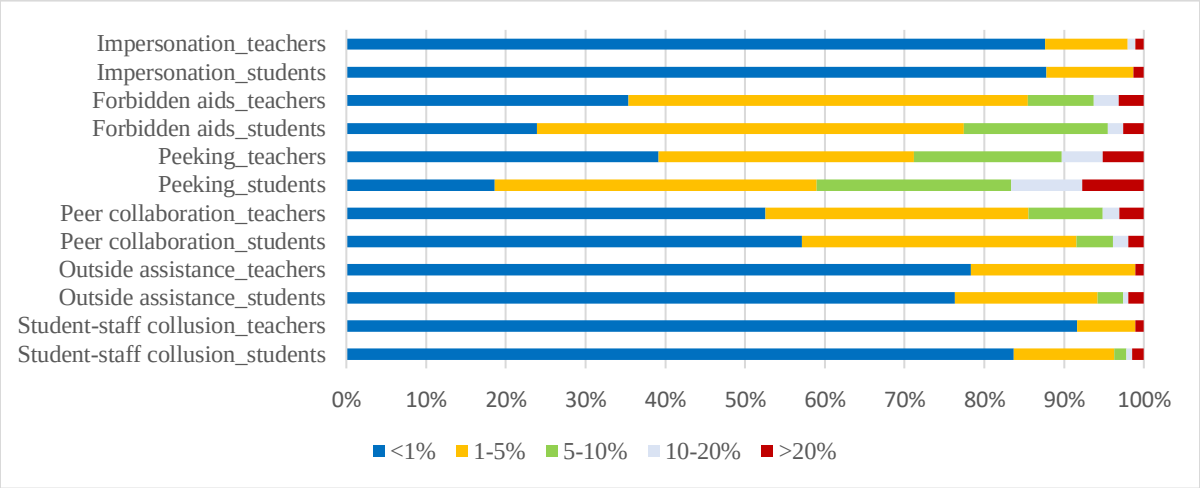


Figure 4. Students and Teachers' response to a question about their beliefs concerning percentage of delivered examinations using various ways of cheating

Table 5. Opinions on ease of cheating in paper exams and BYOD e-exams

Type of Cheating threat	Students (t-test)				Teachers (t-test)				Students and Teachers (independent t-test)	
	Mean	SD	P-value	Mean Diff.	Mean	SD	P-value	Mean Diff	Sig.	Mean Diff
Impersonation	2.94	.498	.140	-.061	3.08	.679	.230	.084	.056	-.145
Forbidden aids	3.26	1.120	.006**	.257	3.68	1.187	.000***	.684	.005**	-.427
Peeking	3.44	1.032	.000***	.439	3.07	.948	.451	.074	.005**	.366
Peer collaboration	3.35	.764	.000***	.351	3.56	.908	.000***	.558	.068	-.207
Outside assistance	3.51	.778	.000***	.507	3.77	.944	.000***	.766	.027*	-.259
Student-staff collusion	2.94	.470	.118	-.061	3.15	.699	.043*	.147	.012*	-.208

Notation: *(p< 0.05) ,** (p < 0.01), and *** (p < 0.001).

Table 6. Opinions on ease of cheating in BYOD e-exams and university PC exams

Type of Cheating threat	Students (t-test)				Teachers (t-test)				Students and Teachers (independent t-tests)	
	Mean	SD	P-value	Mean Diff	Mean	SD	P-value	Mean Diff.	Sig.	Mean Diff
Impersonation	2.89	.333	.000***	-.108	2.84	.574	.008**	-.160	.431	.051
Forbidden aids	2.20	.699	.000***	-.797	2.14	.875	.000***	-.862	.548	.064
Peeking	2.97	.501	.413	-.034	2.77	.679	.001**	-.234	.015*	.200
Peer collaboration	2.59	.626	.000***	-.405	2.37	.816	.000***	-.628	.026*	.222
Outside assistance	2.51	.685	.000***	-.486	2.37	.880	.000***	-.628	.188	.141
Student-staff collusion	2.97	.329	.319	-.027	2.81	.676	.007**	-.191	.030*	.164

Notation: *(p< 0.05) ,** (p < 0.01), and *** (p < 0.001).

Table 7. Opinions on ease of cheating in paper exams and university PC exams

Type of Cheating threat	Students (t-test)				Teachers (t-test)				Students and Teachers (independent. t-test)	
	Mean	SD	P-value	Mean Diff	Mean	SD	P-value	Mean Diff.	Sig.	Mean Diff
Impersonation	2.89	.559	.020*	-.107	2.96	.585	.482	-.043	.388	-.065
Forbidden aids	2.63	.867	.000***	-.372	2.95	.771	.503	-.054	.003**	-.318
Peeking	3.35	.982	.000***	.351	3.04	.806	.608	.043	.009**	.308
Peer collaboration	3.01	.595	.783	.014	3.02	.703	.770	.021	.927	-.008
Outside assistance	2.97	.573	.565	-.027	3.10	.704	.191	.096	.139	-.123
Student-staff collusion	2.96	.387	.202	-.041	2.99	.602	.863	-.011	.638	-.030

Notation: *(p< 0.05) ,** (p < 0.01), and *** (p < 0.001).

Ease of cheating

Questionnaire results comparing the ease of cheating for the three examination types are shown in Tables 5-7. A value smaller than 3 in the column "Mean" would indicate the first examination type (e.g. paper exams in Table 5) enables easier cheating, whereas a value larger than 3 would indicate the second type (e.g., BYOD in Table 5) enables easier cheating. Level of significance was shown in Tables 5-9 using notations *(p< 0.05) ,** (p < 0.01), and *** (p < 0.001). A quick summary of the results (more details to be found in the tables):

- BYOD e-exams are believed to allow easier cheating than paper exams (Table 5) and university PC exams (Table 6). When BYOD and paper exams were compared, there is a significant difference for four of six cheating threats both for students and teachers, of which three are common to both groups. When compared to university PC, teachers see BYOD as enabling easier cheating for all six cheating threats, while students for four of them.
- The comparison between paper and university PC (Table 7) is more mixed. Students see paper as enabling easier cheating for impersonation and forbidden aids, while university PC is easier for peeking. Teachers do not have any significant differences either way.

- As indicated by the above, there are some differences in the views of students and teachers (RQ6). This is indicated in the two rightmost columns of Tables 5-7. For instance, where students had a significant difference in peeking for paper to BYOD while teachers had not, there was a significant difference between student and teacher responses to that question. Although both groups agreed that using forbidden aids would be easier for BYOD than paper, teachers were significantly more positive to BYOD than students on that issue.

Table 8. Opinions about effectiveness of countermeasures for paper exams and e-exams

Type of Countermeasure	Students (t-test)				Teachers (t-test)				Students and Teachers (independent. t-tests)	
	Mean	SD	P-value	Mean Diff	Mean	SD	P-value	Mean Diff.	Sig.	Mean Diff
Proctors	2.78	.562	.000***	-.220	2.60	.713	.000***	-.396	.049*	.176
Biometry	3.10	.591	.047*	.100	3.13	.653	.057	.132	.701	-.032
Mingling	3.02	.741	.734	.021	2.95	.656	.426	-.055	.425	.076
Shuffling	3.13	.726	.038*	.128	3.07	.614	.306	.067	.510	.061
Random drawing	3.18	.650	.001**	.184	3.12	.650	.078	.122	.479	.062
Sequencing	3.44	.701	.000***	.440	3.33	.790	.000***	.330	.268	.110
Broadcasting	3.13	.536	.005**	.129	3.14	.625	.032*	.143	.863	-.013

Notation: *(p< 0.05) ,** (p < 0.01), and *** (p < 0.001).

Table 9. Opinions on cost of countermeasures for paper exams and e-exams

Type of Countermeasure	Students				Teachers				Students and Teachers (independent. t-tests)	
	Mean	SD	P-value	Mean Diff	Mean	SD	P-value	Mean Diff.	Sig.	Mean Diff
Proctors	2.99	.431	.696	-.014	2.98	.421	.620	-.022	.892	.008
Biometry	2.70	.765	.000***	-.305	2.80	.763	.015*	-.198	.298	-.107
Mingling	2.85	.506	.001**	-.149	2.75	.625	.000***	-.253	.186	.104
Shuffling	2.24	.804	.000***	-.757	2.18	.825	.000***	-.824	.540	.067
Random drawing	2.13	.839	.000***	-.865	2.13	.819	.000***	-.868	.979	.003
Sequencing	1.83	.929	.000***	-1.171	1.99	.876	.000***	-1.011	.191	-.160
Broadcasting	2.67	.753	.000***	-.333	2.58	.700	.000***	-.418	.393	.084

Notation: *(p< 0.05) ,** (p < 0.01), and *** (p < 0.001).

Effectiveness of countermeasures

For effectiveness of countermeasures (Table 8), proctors are considered more effective with paper exams than e-exams. On the other hand, sequencing and broadcasting are considered more

effective for e-exams, and students also consider biometry, shuffling, and random drawing as more effective for e-exams. For cost (Table 9), both students and teachers consider all countermeasures except proctors to be more costly for paper exams.

Findings from interviews

As few university computers were available for examinations, interviewees had mainly experienced BYOD e-exams. All the students experienced BYOD e-exams in the same venue, so there was no bias in their response related to examination setting and furniture used during e-exams.

Ease of cheating

Most interviewees considered peeking easier in e-exams, as vertical screens can be easier to read from a distance, especially if font size and brightness are deliberately adjusted for this purpose. However, some respondents noted that it depends on the seating pattern and that the seating in the e-exam hall had been arranged to mitigate peeking:

> "I have a kind of closed desk. I don't sit right next to someone like in a paper exam where we usually sit behind each other on a row but in the digital, we sit like back-to-back and we have a wall in front of us. To see the other's screen, we would have to turn around. There is not a wall behind. If we would turn around, we would see someone else's back."

Some students thought that cheat sheets would be easier in paper exams than e-exams: on a desk anyway full of paper, one extra sheet is less conspicuous. BYOD e-exams were believed to be quite secure due to the usage of a lock-down browser, e.g., Safe Exam Browser (SEB) (Schneider March, 2014). Interview respondents had no personal knowledge whether it was possible to circumvent the lock-down during examination, but assuming no system is 100%

secure, they believed loopholes would be easier to exploit in the BYOD than university PC setting since university PC could have functionality limited to the legitimate needs of the examination. S5 said having examination in university PC has an advantage:

> "…nothing on the computer except the Inspera and Writing program and Python. I think once you have Python available, you can of course do quite a lot, but if someone removes Python then university PC will be safer because you cannot install programs or Skype for screen sharing."

T2 said that having BYOD is also feasible:

> "cheating is easier when you have wireless network connection in BYOD devices. If university can bear the cost of ethernet cables for BYOD devices, it could be more feasible in detecting cheating (e.g. by jamming the network coming from forbidden aids). Then problem is that of course many modern students' owned devices don't have ethernet ports, you need dongle in order to connect it. Many of these things are problematic because of large exams but I guess if university PCs are used you likely to end up with the same cheating problems that you have for paper-based exams."

Even given a workaround to access forbidden material on the PC during an e-exam, students thought this might carry a high risk of getting caught, as any screen image different from the e-exam UI would look suspicious to proctors from afar. Hence, although the computer might give access to more material than a traditional cheat sheet, the paper sheet would be less risky. Indeed, some students and teachers thought that the PC (whether BYOD or university PC) would not be the preferred device of most cheaters for reading forbidden material or messages, as smaller devices (phones, watches, hidden earpiece) would have better chance of going unnoticed. S6 said:

> "Generally, we should not bring cell phones, gadgets to the exams but once I wore Fitbit watch that could read SMS coming from my mobile and no one notices it. Proctors knew about some specific smartwatches, e.g., Apple watch, in order to be more vigilant, they should be trained more about upcoming technologies."

Some teachers thought that accessing forbidden material is more common in assignments than summative examinations and they also thought that to make the e-exams less vulnerable, it is very important to have them administered in a better way. T5 said:

> "In one of the exams, I forgot to remove a link to the code that is not related to the exam, which is unfortunately not detected by administration before the exam. It further made some of the students jump out from the SEB to that code, but they could not jump back, so they needed technical assistance to move back to exam in SEB"

T2 said that one of the reasons for cheating is getting easier in e-exams is due to less integrity between the examination system (i.e. Inspera Assessment system), and the LMS (i.e. Blackboard):

> "Once the systems broke down, it made students unable to deliver their answers in exam duration. But some students were able to read key solutions published by their teacher in Blackboard, which was supposed to be available after the exam, so they submitted them as their original answers."

Some students held paper and e-exam as equally risky for peer collaboration. Given a reasonably secure lock-down browser, the examination PC would not be the weakest link. Most of the teachers and students thought that most ways students cheat are basically the same (e.g., whispering, signs and code languages) regardless of paper exams or e-exams. Students and teachers thought it is hard to get peer collaboration and outside assistance through the

examination PC since the lock-down browser would also detect a virtual machine (VM). T2 thought that it's possible to fake even when examination runs in the VM:

> "When student use modern virus, it will behave as if it's running in normal safe environment and even anti-virus fails to detect it if it doesn't have that virus signature in its checks. So, any system can be cheated. It's just a matter of resources, one is capable of and willing to put effort."

However, it was considered more likely that one could bypass lock-down with BYOD than with university PC. To use shared screen, remote access, Skype or similar and yet go under the radar of the lock-down browser, would require some up-front preparations that would be hard to achieve on a PC that the cheater did not have regular access to. S1 said:

> "tricks like modifying the lock-down browser software and submitting the exam through a less secure browser, might be possible in BYOD but not with university PC."

Effectiveness of countermeasures

Some students thought proctors are quite effective in ensuring the integrity of examinations, though some might lack comprehensive knowledge of cheating threats, especially for e-exams (as proctors are often retired elders, doing this as a seasonal side job):

> "Proctors are more effective than biometrics. As students might actually switch seats, when biometrics authentication is implemented, it would need to be continuous and not only at the start and the end of exam. As it is not possible always, proctors are effective comparatively."

Some students and teachers thought biometrics might be more effective against impersonation than proctors, especially if there are high-quality fake ID cards that the proctors do not spot. T1 said:

> "There was a student who came to take the paper-based exam impersonating someone else having totally different hair colour and it was just too risky"

However, they were concerned about privacy issues of biometry, as well as negative effects on the students' concentration during the examination. On the other hand, some teachers thought about the necessity of having biometric authentication implemented in examinations. T1 said:

> "The problem with biometrics is if that's not implemented nationally. When you have biometrics on your card then it's out of the line for rest of the countries, and they cannot implement it. For e.g., you can't say taking an exam is more important than driving a car because you might kill someone there because you can also use someone else's driving license there for that purpose, and even that is not biometrically verified. Also voting for someone else, is it more important to have biometric verification implemented in exams than voting? So the whole idea of biometrics, I don't think it's practically implementable in the university setting if it's not a nationally implemented"

Mingling was considered effective against peeking and peer collaboration regardless of examination type. Students explained that it is easier to implement for small-scale paper exams in a supervised environment whereas for high-stakes digital assessments, mingling together with biometrics were considered more effective because e-exams do not require submission of answer sheets to proctors.

Some students and teachers held shuffling as effective against peeking, peer collaboration, and forbidden aids and especially when shuffling is used in answers of multiple-choice questions. When paper and e-exams were compared, effectiveness of shuffling would depend on the type of questions. For instance, shuffling of multiple-choice questions might be more secure against cheating in e-exams, because only one question per page is displayed usually in e-exam whereas all questions are available at a time in paper exams. In the latter case,

it is considered more effective in paper exams, because coming back and forth to the questions is easier on e-exams. However, some students and teachers thought that shuffling would not be usable for interdependent questions. For random drawing, both students and teachers were concerned with fairness issues and uncertain whether this would add much security beyond shuffling.

Several students pointed out that sequencing might be effective against peer collaboration and outside assistance, but impossible to implement on paper exams because of a too high distribution and collection effort on the proctors.

As for broadcasting, interviewees did not expect added security, since they had never experienced student-teacher collusion. However, they did consider it an advantage for fairness (everybody gets a clarification at the same time, rather than sequentially by face-to-face messages). T3 said that broadcasting in e-exam would be effective compared to paper exams where students hear the corrections from instructors directly:

> "Inspera assessment has a broadcasting feature that would help a lot since we are sure that everybody hears it because some students might sit with earplugs to avoid noise, so they don't hear us, and we don't notice that."

Though the answer from T3 is not related to cheating, in this case, if student is pretending as if he has earplug to avoid noise when he uses hidden earpiece to cheat, it would go unnoticed by retired elder proctors.

Other issues

E-exams were perceived as better for avoiding muscular fatigue, and easier writing and editing of answers. BYOD was considered somewhat better than university PC due to familiarity with

the keyboard, but this was not seen as a big issue. Some studies (Starovoytova and Arimi 2017; Zhang, Yin, and Zheng 2018) also investigated on moral attitude towards cheating and they found that female participants held significantly more negative attitude towards cheating. During the interviews, we inquired whether the students' moral inhibitions against cheating would be different in paper and e-exams. The majority did not see any difference, finding cheating equally unethical for both types of exam. When asked about the likelihood of getting caught, students and teachers thought peeking would carry extremely low risk, forbidden aids also low, peer collaboration somewhat higher. S5 said:

> ".. it is very easy to get caught with some forbidden aids because just if you use it at the wrong time, the proctor will notice it. At the same time, maybe collaboration is fairly easy to get caught. If cheated, likelihood of getting caught for peeking is maybe as low as 0 to 20, forbidden aids in 20 to 40, and peer collaboration in 40 to 60."

This contrasts teacher views from the survey, perceiving considerable risk of getting caught even for peeking. Concerning the penalties at NTNU, students and teachers reported that it varies based on severity. T4 said:

> "There are study programs like in health and stuff like that well you can't really cheat even when nurse or doctor cheats that can have fatal consequences for their future patients then they will be expelled and considered unfit for their profession but in computer science it isn't really fatal so consequences might vary based on severity. If it's minor, you would fail the student and let take the exam the next year, but if you have to lift it to the department head then they would be expelled for a year."

Discussion

Interpretation of Findings

Frequency of cheating. Our survey had just 3% of students admitting to cheating, much less than in the poll by Sentio Research (16%). Sentio polled a broader student population and with a broader definition of cheating (any exam, not just written on-campus examinations). Nevertheless, under-reporting in our investigation may be a cause for the discrepancy. Perhaps, students have stronger inhibitions towards admitting cheating in a survey by university personnel (ours) than with an external company (Sentio).

As for the frequency of various types of cheating (RQ1), impersonation, outside assistance, and student-staff collusion were considered rare, while forbidden aids, peeking, and peer collaboration came out as more common during on-campus examinations. Student interviews revealed that the more common ones are believed to carry lesser risk for being caught. This corresponds well to earlier studies. For instance, impersonation appears rare in studies by Trost (2009), Sheard et al. (2002), Norton et al. (2001), De Lambert, Ellen, and Taylor (2006) and Bjorklund and Wenestam (1999), and student-staff collusion also appears rare in studies by Trost (2009) and Norton et al. (2001). Peeking, forbidden aids, and peer collaboration have been found to be considerably more frequent (De Lambert, Ellen, and Taylor 2006) .

Ease of cheating with different exam types. Both students (RQ2) and teachers (RQ3) perceived BYOD to enable easier cheating than paper and university PC. This is intuitively understandable. A PC may enable new forms of communication, thus new ways of cheating. With BYOD the candidate may have stored documents on the PC and installed special software (or for the tech-savvy: even hardware) to facilitate cheating, while with university PC, device functionality can

be limited to what is allowed for the exam. Hence, responses are consistent with the analytical claim made by Dawson (2016). The e-exam tool at the university in question runs on top of a lock-down browser to prevent cheating via the PC, but as interviews revealed, many students assumed this is less than 100% secure.

Peeking was considered easier for e-exams than for paper exams. Near vertical screens were thought easier to read from a distance than paper with handwriting lying horizontally on a desk. Otherwise, comparison of paper to university PC exams gave mixed results. Students considered it easier to use forbidden aids with paper than with university PC, as cheat sheets could easily be concealed among other paper. For a university PC exam, desks are more likely to be clean except for the keyboard, so a cheat sheet would be more easily spotted from afar by an invigilator. When it comes to the effectiveness of countermeasures, some have discussed shuffling (Thelwall 2000) and random drawing (Dermo 2009; Jamil, Tariq, and Shami 2012). Dermo (2009) had similar findings that students were concerned about fairness of random drawing, but did not investigate whether it was perceived as effective as a countermeasure. Our respondents indicate that random drawing can be effective in mitigating some types of cheating, though to some extent shuffling can fill similar needs.

Cost and efficiency of countermeasures. Both students (RQ4) and teachers (RQ5) thought that proctors might be somewhat more effective with paper exams than e-exams, the main explanation apparently that the elderly persons who tend to fill these jobs may not be familiar with approaches to e-cheating. However, for all other countermeasures mentioned (biometry, mingling, shuffling, random drawing, sequencing, broadcasting), both students and teachers thought these would be cheaper to implement with e-exams.

Comparing the perceptions of students and teachers (RQ6), these generally go in the same direction, though there are some significant differences for specific cheating types or countermeasures, as shown in Tables 5-9.

Threats to validity

Self-reporting bias. Especially if reported acts are morally questionable, such as exam cheating, there is a danger that many respondents might under-report, especially considering questions whether they themselves cheated. The survey was anonymous, and it was made clear to the students that findings would in no way have an impact on grades. Yet, self-reporting bias cannot be excluded, and as reflected above, the fact that our survey was conducted by university employees may have increased the self-reporting bias compared to external researchers.

Limited respondent knowledge. Many questions were such that respondents were unlikely to know the precise answers and had to guess (e.g., percentage of delivered exams used cheating?). Moreover, at the university where the questionnaire study was performed (NTNU), the teacher is not directly involved in cheating prevention in the exam venue, which is done by administrative employees and invigilators hired short-term for the exam period. The teacher's involvement in cheating mitigation would thus be by designing tasks to make cheating more difficult, or during the grading process if particular answers contain evidence of cheating. Teachers do however visit the venue during the exam, to respond to clarification issues or corrections to exam questions, so they will be familiar with the typical seating arrangements and density of invigilators per student, which was relevant knowledge for a question in the teacher survey. In retrospect, it must be acknowledged that this may also threaten validity due to limited respondent knowledge. Especially if some of the responding teachers were recently hired, e.g., from abroad where there

might be different standards concerning exam proctoring, they would not have a clear idea about the typical density of invigilators per student.

Sloppy responding. A threat somewhat related to limited respondent knowledge would be sloppy responding, i.e., respondents just answering questions quickly to get it done, without reading the text carefully enough. Especially in combination with some variation in question design (e.g., some questions having 3 as the neutral mid-point, while others were on a low to high scale), this could have led to unreliable responses, for instance if the respondent answered a question according to a wrong assumption about its content or scaling. The typical way to control for sloppy responses is to have many questions for the same variables, to be able to check whether respondents have answered consistently. This will however cause questionnaires to be much longer, thus we chose not to do this, as it might dramatically have reduced the number of respondents.

Varied question scaling. Related to the previous issue, the scaling of questions may have caused our results to miss nuances. As mentioned in the survey design section, Q3 (likelihood of getting caught cheating) was designed with a uniform 5-step scale divided at 20-40-60-80%, whereas Q2 (percentage of delivered exams that used cheating) had another division: 1-5-10-20%. In retrospect, it was good that Q2 did not choose the same uniform scale as Q3, since the uniform scale would have placed almost all responses at 1, cf. Figure 4. Indeed, it might have been better if Q3 had been more similar to Q2, since its current uniform scale yielded results strongly skewed towards the low end, with hardly anybody choosing alternatives 3-5 – thus losing granularity.

Hypothetical questions. Some questions were hypothetical, thus hard for respondents to answer

accurately. For instance, concerning effectiveness of countermeasures, if a student has not sat any exam where a certain countermeasure was used (e.g., mingling of candidates), and a teacher has never given such an exam, answers would reflect qualified guesses by the respondents rather than experiences. However, the paper only makes claims to have findings of respondents' beliefs about the amount of cheating, ease of cheating, and effectiveness of countermeasures, not about the real amount and ease of cheating, nor about the real effectiveness of countermeasures.

External validity. The study only surveyed students from one university (NTNU), and mostly in STEM subjects. Hence, findings may not be transferable to other countries, universities, or disciplines. Yet, there is no specific reason to assume that Norwegian students are more or less honest than other students, and higher education is increasingly global, so the findings should have relevance for research related to cheating in other countries, too.

Conclusion

The study has looked at both students' and teachers' perceptions about ease of cheating in paper exams to e-exams. Other factors being equal, both groups believe that cheating is easier in e-exams, particularly the Bring Your Own Device (BYOD) variety. On the other hand, both students and teachers think that specific countermeasures against cheating would be more effective, and cheaper to implement, with e-exams. If these perceptions are right, e-exams may afford more sophisticated countermeasures against cheating than paper exams (given equal funds), and some of these countermeasures do not only target cheating through the exam PC, but also traditional types of cheating like peeking, whispering, and usage of concealed phones or other communication equipment. Thus, in the end, if utilising the countermeasures especially enabled by digitalization, it is by no means obvious that e-exams will be less secure than paper in

the years to come.

Uncategorized References

Apampa, K. M., G. Wills, and D. Argles. 2010. "User security issues in summative e-assessment security." *International Journal of Digital Society (IJDS)* 1 (2):1-13.

Atlas.ti. 2019. "Atlas.ti for Windows, version 8.4." https://atlasti.com/product/v8-windows/.

Bjorklund, M., and C.-G. Wenestam. 1999. "Academic cheating: frequency, methods, and causes." In *European Conference on Education Research* Lahti, Finland.

Bretag, T., R. Harper, M. Burton, C. Ellis, P. Newton, K. van Haeringen, S. Saddiqui, and P. Rozenberg. 2019. "Contract cheating and assessment design: exploring the relationship." *Assessment & Evaluation in Higher Education* 44 (5):676-91. doi: 10.1080/02602938.2018.1527892.

Cizek, G. J. 1999. *Cheating on tests: How to do it, detect it, and prevent it, Cheating on tests: How to do it, detect it, and prevent it.* Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers.

Colnerud, G., and M. Rosander. 2009. "Academic dishonesty, ethical norms and learning." *Assessment & Evaluation in Higher Education* 34 (5):505-17.

Corbin, J. M., and A. Strauss. 1990. "Grounded theory research: Procedures, canons, and evaluative criteria." *Qualitative Sociology* 13 (1):3-21. doi: 10.1007/BF00988593.

Creswell, J. W. 2013. *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. 4th ed. Harlow, United Kingdom: Pearson Education Limited.

Dawson, P. 2016. "Five ways to hack and cheat with bring-your-own-device electronic examinations." *British Journal of Educational Technology* 47 (4):592-600.

De Lambert, K., N. Ellen, and L. Taylor. 2006. "Chalkface challenges: a study of academic dishonesty amongst students in New Zealand tertiary institutions." *Assessment & Evaluation in Higher Education* 31 (5):485-503.

de Sande, J. C. G. 2015. "Calculated questions and e-cheating: A case study." *Education Applications & Developments Advances in Education and Educational Trends Series* 2 (3):91-9.

Dermo, J. 2009. "e-Assessment and the student learning experience: A survey of student perceptions of e-assessment." *British Journal of Educational Technology* 40 (2):203-14. doi: 10.1111/j.1467-8535.2008.00915.x.

Design, A. "SelectSurvey .NET." http://selectsurvey.net/.

Fluck, A. E. 2019. "An international review of eExam technologies and impact." *Computers & Education* 132:1-15. doi: https://doi.org/10.1016/j.compedu.2018.12.008.

Fraenkel, J. R., N. E. Wallen, and H. H. Hyun. 2011. *How to design and evaluate research in education*: New York: McGraw-Hill Humanities/Social Sciences/Languages.

Jamil, M., R. Tariq, and P. Shami. 2012. "Computer-Based vs Paper-Based Examinations: Perceptions of University Teachers." *Turkish Online Journal of Educational Technology-TOJET* 11 (4):371-81.

Kocdar, S., A. Karadeniz, R. Peytcheva-Forsyth, and V. Stoeva. 2018. "Cheating and Plagiarism in E-Assessment: Students' Perspectives." *Open Praxis* 10 (3):221-35.

Krosnick, J. A., A. L. Holbrook, M. K. Berent, R. T. Carson, W. Michael Hanemann, R. J. Kopp, R. Cameron Mitchell, S. Presser, P. A. Ruud, and V. Kerry Smith. 2002. "The impact of" no opinion" response options on data quality: non-attitude reduction or an invitation to satisfice?" *Public Opinion Quarterly* 66 (3):371-403.

Lancaster, T., and R. Clarke. 2017. "Rethinking assessment by examination in the age of contract cheating." In *Plagiarism Across Europe and Beyond Conference*, 215-28. Brno, Czech Republic.

Madara, D. S., and S. S. Namango. 2016. "Faculty Perceptions on Cheating in Exams in Undergraduate Engineering." *Journal of Education and Practice* 7 (30):70-86.

McCabe, D. L., L. K. Trevino, and K. D. Butterfield. 2001. "Cheating in academic institutions: A decade of research." *Ethics &Behavior* 11 (3):219-32.

Norton, L. S., A. J. Tilley, S. E. Newstead, and A. Franklyn-Stokes. 2001. "The pressures of assessment in undergraduate courses and their effect on student behaviours." *Assessment & Evaluation in Higher Education* 26 (3):269-84.

Owunwanne, D., N. Rustagi, and R. Dada. 2010. "Students' perceptions of cheating and plagiarism in higher institutions." *Journal of College Teaching and Learning* 7 (11):59-68.

Schneider, D. 2014. "Safe Exam Browser 2.0 How To (install, configure, deploy and use SEB 2.0)." http://safeexambrowser.org/presentations/HowTo_SEB2.0.pdf.

Sheard, J., M. Dick, S. Markham, I. Macdonald, and M. Walsh. 2002. "Cheating and plagiarism: perceptions and practices of first year IT students." *In proceedings of the 7th annual conference on Innovation and technology in computer science education*:183-7.

Sindre, G., and A. Vegendla. 2015. E-exams versus paper exams: a comparative analysis of cheating-related security threats and countermeasures. Paper presented at the Norwegian Information Security Conference (NISK) 8(1): 34-45.

Skaaren, T. G., and A. Østgaard. 2019. *Juks på eksamen*: Sentio Research Norge.

SPSS, I. 2017. "IBM SPSS statistics for Windows, version 25.0." http://www-01.ibm.com/support/docview.wss?uid=swg27049428#en.

Stack, S. 2015. "The impact of exam environments on student test scores in online courses." *Journal of Criminal Justice Education* 26 (3):273-82.

Starovoytova, D., and M. Arimi. 2017. "Witnessing of Cheating-in-Exams Behavior and Factors Sustaining Integrity." *Journal of Education and Practice* 8 (10):127-41.

Thelwall, M. 2000. "Computer-based assessment: a versatile educational tool." *Computers & Education* 34 (1):37-49.

Topîrceanu, A. 2017. "Breaking up friendships in exams: A case study for minimizing student cheating in higher education using social network analysis." *Computers & Education* 115:171-87.

Trost, K. 2009. "Psst, have you ever cheated? A study of academic dishonesty in Sweden." *Assessment & Evaluation in Higher Education* 34 (4):367-76.

Urquhart, C., H. Lehmann, and M. D. Myers. 2010. "Putting the 'theory'back into grounded theory: guidelines for grounded theory studies in information systems." *Information Systems Journal* 20 (4):357-81.

Vegendla, A., and G. Sindre. 2019. "Mitigation of Cheating in Online Exams: Strengths and Limitations of Biometric Authentication." In *Biometric Authentication in Online Learning Environments*, edited by A.V. Senthil Kumar, 47-68. Hershey, PA, USA. IGI Global.

Wilkinson, J. 2009. "Staff and student perceptions of plagiarism and cheating." *International Journal of Teaching and Learning in Higher Education* 20 (2):98-105.

Yates, M. C., J. Godbey, and R. Fendler. 2017. "Observed Cheating and the Effects of Random Seat Assignment." In *SoTL Commons Conference.*

Zhang, Y., H. Yin, and L. Zheng. 2018. "Investigating academic dishonesty among Chinese undergraduate students: does gender matter?" *Assessment & Evaluation in Higher Education* 43 (5):812-26.