TAKE-HOME EXAMS IN UNIVERSITY MATHEMATICS AND SCIENCE SUBJECTS: SOME ETHICAL CONSIDERATIONS

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Abstract

This article addresses some challenging perspectives related to offering take-home exams in mathematics at university level. The challenges arose during work on a previous article where four perspectives originating from Bjerrum Nielsen's framework (2003) were used to analyze universities' assessment methods during the Covid lockdown in our country. The perspectives had some ethical considerations that were beyond the scope of the previous work. They include social, ethical but also personal aspect of the students involved. We raise a discussion and conclude that the arguments lead to new questions that need to be followed up. We finalize the article with an argument as to why the discussion is important even in a post Covid situation.

Introduction

During the Covid-19 pandemic, societies around the world were closed down for longer periods of time. Now we are turning back to normal again, but there are still a number of issues that were raised during the lockdown that retain their relevance post pandemic. One of these are the running of take-home exams in mathematics and science subjects. The arrangements in themselves may have some problematic issues, but also the preparing for them may have. The aim of the present article is to lift forward some of these issues; issues of more philosophical and ethical nature than what facts and statements illuminate. The discussion is still relevant since the growing demand for distance education and lifelong learning increases topicality of take-home exams even after the pandemic.

The issues brought forward in the this article emerged during a research project that investigated the implementation of take-home exams in mathematics during Covid in Norway (Rensaa, 2023). In this project, feedback was collected from nine anonymous university teachers in Norway, where they were asked about assessment of mathematics and science subjects in their home institutions during lockdown. This was both about the implementation of the exams and on how possible challenges with misconducts had been met. To analyse the data, a framework developed by Harriet Bjerrum Nielsen (2003) was adjusted and used. It is based on four different perspectives that proved to cover the range of challenges when implementing take-home exams well. The discussion did, however, touch on some issues of an ethical nature that were beyond the scope of the previous article (Rensaa, 2023). These forms the starting point for the present one.

The article starts with a brief review of literature that is relevant when discussing assessment issues when arranging take-home exams in mathematics. Four perspectives are then presented as an adjusted framework based on Bjerrum Nielsen's work (2003). The perspectives act as catalysts to uncover challenges with such exams. A schematic organization of the framework is offered to illuminate its perspectives. A brief description of the research project in (Rensaa, 2023) is also given, before the main part of the article is devoted to a discussion of the ethical challenges brought up by the informants in the research project. These are four in all, one within each perspective of the adjusted framework.

Background

Theoretical background in short

It has long been an established fact among researchers that assessment demands and questions included in an assessment task guide students approaches to learning (Entwistle & Entwistle, 1991). Iannone and Simpson reveal and re-reveal that among lecturers in mathematics in the UK, the favourable type of assessment is timed, written exams without access to external helping aids (Iannone & Simpson, 2011, 2021). This is by no means unique to the UK and exams in mathematics are typically held in a proctored environment (Trenholm, 2007). Trenholm and Peschke state that "Whether hand-written or completed online through a testing facility, examinations are generally proctored" (Trenholm & Peschke, 2020, p. 2). If the students do an exam at home, these researchers presume that they use a webcam and an online proctor system to carry it out. Nevertheless, such surveillance is highly problematic in a Norwegian context due to carefully maintained laws that protect privacy (Datatilsynet, 2022). One aspect is that university educations are free of charge, which means that asking students to buy video equipment may be problematic (Lovdata, 2006, § 3.1). Even more problematic, though, is that the General Data Protection Regulation (GDPR), Article 6, is interpreted strictly in our country (Lovdata, 2018). The interpretation underlines that proctoring should be voluntary. This means that if a student is uncomfortable being monitored online during a take-home exam, an alternative but similar mode of assessment should be offered. The alternative should in no way have negative consequences for the student. This hinders use of online proctoring in Norway. However, although researchers have concluded differently on whether un-proctoring evidence better grades on final exams (e.g. Schultz, Schultz and Round (2008) found no significant difference while Carstairs and Myors (2009), and Prince, Fulton and Garsombke (2009) did), the absence of proctoring during online exams increases the possibility of engaging in misconduct (Hylton, Levy, & Dringus, 2016). Hylton et al conclude that such surveillance discourages cheating. It can also be questioned whether the different exams investigated in Schulz et al were comparable (Hylton et al., 2016).

Surveillance is not the only way to regulate the assessment situation. For example, the types of tasks given in a mathematics exam can be adjusted in order to require a wider range of competencies, competencies where cheating is more visible. According to Niss and Højgaard (2019), there are eight mathematical competencies albeit not disjoint but distinct. Organized in two categories, one is about presenting and answering questions in mathematics. It includes mathematical competencies in thinking, problem handling, modelling and reasoning. The other category deals with the language, constructs and tools of mathematics competency. It involves representation competency, mathematical symbols and formalism competency, communication competency and competency in using mathematical aids and tools (Niss & Højgaard, 2019). In order to design tasks for take-home exams, it may be relevant to draw on other competencies than what is done in school exams.

Butler-Henderson and Crawford (2020) underline that research on cheating so far mainly has focused on technical challenges connected to online examinations, like testing remedies that could mitigate the cheating potential (Hylton et al., 2016). What is in short supply, they stress, is discussions of ethical and social aspects of cheating, discussions both with the students and among teachers and researchers. Many academics avoid bringing up such topics, which entails that "If we don't talk about it, it doesn't exist" (Wright, 2015, p. 256). Ethical perspectives may include students' personal choices on how to act in an assessment situation and how to respond to cheating. This has been researched in depth when it comes to traditional assessment situations (e.g. Wright, 2015), but is even more relevant in online examination situations. Ultimately, though, cheating is a matter of which choices an individual student makes. Such choices are both governed by current laws and regulations and by the relation to fellow students. But it is perhaps mostly governed by the autonomy that the individual student possesses in a learning situation. Self-regulation is a key component when it comes to learning, and it is cultivated by a student's metacognition, strategy adaptability, and motivation (Panadero, 2017). There are deep theories in educational psychology about self-regulated learning (SRL) that we will not go into here, but Panadero's review (2017) includes among others the work of a Zimmerman ((1986) - one of the first SRL authors). Zimmerman's second model describes the cyclic phases of SRL, including a forethought phase where self-motivation is important, a performance phase including self-control but also a self-reflection phase where students' self-evaluation is a component (Zimmerman & Moylan, 2009). This depends on each student's autonomy and personal perspectives, which is closely related to self-efficacy. Definition of the latter is given by Bandura as "an individual's own judgement of how well one can execute courses of action required to deal with prospective situations" (Bandura, 1982, p.122). A student with high self-efficacy more often sees demanding mathematical tasks as a challenge more than a burden, a challenge worth making effort for. This promotes performance attainments (Bandura, 2012). Among the engineering students at a university in Norway, self-efficacy was shown to be closely related to task performance in mathematics (Rensaa & Tossavainen, 2022).

The framework with adjustments

Bjerrum Nielsen's framework on 'doing gender' embraces four perspectives; structural, symbolic, personal and interactional gender (2003). Structural gender is about the relation to the social structure, the environment. Adjusted to be relevant to the assessment situation, this concerns the context of take-home exams provided by society. Symbolic gender embraces symbols and symbolic dialogs, evolving over a longer period of time, indicating what is normal in a society. In the case of take-home exams, this is about established practices in these settings. When it comes to personal gender, this is about individuals' personal comprehensions of gender. Bjerrum Nielsen split this in subjectivity; the 'what you are', and identity; the 'what you have', both referring to autonomy and personal feelings. In our situation, with data from the university teachers and not the students themselves, this is about how students' behaviour or actions in a meta perspective signalize something about personal stances. Subjectivity refers to students expressed negative and positive feelings towards exams, like being nervous, stressed and frustrated or satisfied and conscientious. Identity may be about the effort each student put into a mathematics subject to gain knowledge and understanding. The fourth and final perspective in Bjerrum Nielsen's framework is interactional gender, comprising the continuously social interactions between humans, seen as something we 'do'. In an assessment situation, a dominant theme is collaboration between students. The four perspectives represent different points of view, used to interpret one and the same situation (Wedege, 2007).

The research project

The research project (Rensaa, 2023) discusses assessment issues in mathematics courses at universities in Norway during the Covid lockdown. In this period, exams had to be accomplished as take-home exams, handed out digitally without knowing whether the students received help to solve the tasks. Data in the project included retrospective feedback from nine university teachers about assessment implementations at their home university during lockdown. The research questions ask which considerations had influenced the choice of assessment methods, but also if and which particular actions had been implemented due to the possibility of cheating. The results show how the perspectives in Bjerrum Nielsen framework can act as a catalyst for the analyses of data, and how the different components (themes) shed light on the possibilities of cheating in take-home exams.

A schematic illustration of the adjusted research perspectives is given in Figure 1. Included in this figure are the ethical considerations that appeared in the analysis of data in (Rensaa, 2023), but which were out of scope there. Each of these is brought up for discussion in the next section.

	Regulations on general level	Regulations on individual level
Decree/rules by society	1. Structural environment: Privacy laws	3. Symbolic: What to assess in exams
Decree/rules by individuals	2. Interactional: Degree of collaboration	4. Personal: Actions on an exam

Figure 1: Perspectives on take-home exams including ethical considerations

In Figure 1, cell 1 is about the structural environment of take-home exams. That is, what society decides to allow in general by providing regulations on the topic. In case of home exams, the issue of proctoring touches upon students' privacy. Cell 2 is about interactions at take-home exams; generally provided by whether and what type of collaboration is permitted in home exams. At the same time, it is up to the individual student to decide whether she or he wants to act accordingly. Cell 3 on the symbolic perspective is about what society decides that the students should learn academically, which the individual student interprets the meaning of in terms of types of exam tasks. The final cell in Figure 1, cell 4, is about the decisions made by each individual students about how they should act when accomplishing a take-home exam.

Ethical perspectives on take-home exams in mathematics

As explained in the above sections, analyses in the research project encountered some ethical issues that were beyond the scope of the discussion in (Rensaa, 2023). These issues happened to be four in number and appropriately distributed between the four analysis perspectives in the previous article. Each challenge is introduced by a quote from one or two of the university teachers informing the study (Rensaa, 2023) and a question raised in wake of these statements.

The perspective of context of take-home exams

Quotes:

> T1: It is a general problem that no matter how you set up an individual home exam, you cannot be sure that you are testing the individual student's skills when there are no possibilities for surveillance.
>
> T3: We have done nothing but make the students responsible and emphasize that we have a trust-based system. We have little faith in video surveillance.

Question:

Since it can be difficult to carry out a plagiarism check on mathematics arguments, what ethical considerations are there around monitoring students in a take-home exam situation?

From the two quotes, from the literature, but also from public debates in Norway, there are conflicting views on this question. An important issue when discussing the context of a take-home exam is the use of student monitoring. If this is not done, there will be a concern whether the students may have taken advantages of the situation and cheated. A dominant motivation for examinations of students is to authenticate learning (Butler-Henderson & Crawford, 2020). Students may use illegal tools or collaborate when this is not permitted. They may even have someone else take the exam for them (Hylton et al., 2016). Then you cannot evaluate the student taking the exam. In such cases, students may achieve an exam result that is better than what their knowledge suggest. However, Teacher T3 conveys a trust-based system; the benefit of the doubt. This is in line with Norwegian laws where privacy is strict (Lovdata, 2018). During the pandemic, this was also publicly debated in Norway. Some academics advocated use of online proctoring, while university leaders explained why this was not possible (Mikkelsen, 2022). Still, a majority of our universities looked at the possibilities of monitoring students at take-home-exams when there was a lockdown (Bye, 2022). Keeping the technical challenges aside, it is also interesting to note the gap between the strong proctoring typically used for school exams and a trust-based system for take-home exams, as suggested by Teacher T3. If trust was a viable option, why is this not used more in school exams? Do we really trust our students, or do we use trust as an argument when we have no other option?

Monitoring students at home is a challenging issue with neither definite yes nor definite no to carrying out such activities. Our stance is that the parity principle makes the support for such actions weightier than the arguments against surveillance. Some of the arguments that focus on student well-being, thus rejecting surveillance, may also be countered. Butler-Henderson and Crawford point to students' anxiety in online examinations as a problem, something that can hinder optimal performance on the exam (Butler-Henderson & Crawford, 2020). Their review, however, shows inconsistencies in the anxiety effect without any definite conclusion about increased anxiety. Norway has a very strict policy when it comes to surveillance; it is

sacred to keep the privacy of each individual citizen (Datatilsynet, 2022). However, monitoring a student in a home atmosphere is something else. Then the student has put up the camera herself, she decides what is to be filmed and she is fully aware of when she is being filmed and when the camera is switched off. It resembles a school exam situation; the students are being watched while they solve tasks. This is also supported by literature. Among other things, Rois and Liu (2017) compared the test-taking behaviour of students in proctored and non-proctored online exams and found no difference between the two environments. Another objection is that surveillance situations may be recorded with an appurtenant possibility to store and use the recordings in other contexts. This can be prevented by not permitting recording of the activities. The Government in Norway provide strict law regulations on monitoring possibilities and can similarly prepare strict regulations about illegal recording of surveillance. From academics' point of view, we find issues other than recording more problematic: Students may set up the camera in such a way that the teacher that watches and control that illegal aids are not used cannot see areas in the room that may contain information, e.g., notes, calculations etc. If students have to go to the toilet while the exam is taking place, should this be allowed? Such practical problems must be solved by having some rules for the take-home exams. However, making notes is not in itself problematic as this can have a learning potential. For instance, note-taking during lectures is strongly evidenced to imply better performance among students (Einstein, Morris, & Smith, 1985). Students who make notes to use in an exam will probably put a lot of effort into this so that the notes are relevant and helpful, and this process has a learning potential. The students may then realize that they do not need notes and that it is unnecessary to risk looking at notes that are not allowed. More problematic is the principle that equivalent alternative examination arrangements must be offered for student who do not want to be monitored online during the completion of the exam (Lovdata, 2018). This is not easy to meet during a pandemic, but also not in distance educations. However, we question this privilege. Why should students have this option when doing exams at home when this is not a rule for school exams?

The two teacher quotes, T1 and T3, above also underline a central issue: do we examine the students or their results? In a standard school exam setting with physical surveillance and anonymous evaluation, we are examining the students results anonymously. This is possible since we have a well-established system to ensure the link between the student and the result. The strength of this link depends on how certain we are that the actual student is the one who has produced the result. In a traditional (physical) exam setting where the students are monitored continuously, we have a strong link, and can be sure that the results reflect the skills of the students. Hence, evaluating the result corresponds to evaluating the student. This link is generally lost when having individual take-home exams, unless we impose it by some type of surveillance (strong link), as suggested by Teacher T1. The other case, as proposed by Teacher T3, is to establish a system of trust (i.e., a weak link). The goal for both cases is to ensure that exam results reflect the skills of the individual student, but the proctoring approach represents a significantly stronger link than relying on trust only. If proctoring is the goal, it would be beneficial to find a middle ground, like searching for assessment methods where proctoring is an integral part of the assessment. However, an intriguing alternative would be to find assessment methods where we evaluate the students directly without anonymity, and thereby remove the need for proctoring.

The established practices of take-home exams

Quote:

> T5: What we did to some extent was to have more reasoning types of tasks rather than pure arithmetic tasks, since copying reasoning is more visible than copying correct answers. Many of those I reported for cheating I reported because they had identical WRONG answers. Identical correct answers are more difficult to get people for
>
> ['difficult to get people for' refers to a Norwegian expression which means that it is difficult to prove that people are cheating].

Question:

How "new" can the tasks on an exam be compared to previous years' exams and to what extent should students be prepared for such a new format in advance?

The approach suggested by Teacher T5 is based on the idea that pure arithmetic tasks are easier to copy than tasks that require reasoning. A practical advantage of reasoning tasks is that answers to such tasks are easier to run plagiarism control on since they usually ask for more textual elaborations. Moreover, replacing some arithmetic tasks with tasks that require reasoning competency invites the assessment of more competencies than students' ability to use procedures and methods. According to Niss and Højgaard (2019), mathematical reasoning competency is the ability "to analyse or produce arguments (i.e., chains of statements linked by inferences) put forward in oral or written form to justify mathematical claims" (Niss & Højgaard, 2019, p. 16). By replacing some arithmetic tasks with more reasoning type of tasks, the exam will cover a broader aspect of competencies. It is worth noting that this requires assessment of the reasoning process more than the final arithmetic result that comes out of it. This supports the argument given in the context perspective: We need to evaluate the students and not their produced results.

Earlier year's exam tasks often work as guidelines for students since they tend to interpret these as normative to what will be the assessment requests (Entwistle & Entwistle, 1991). Thus, previous exam tasks represent a type of deal between teachers and students about what is expected of a student in an examination. Teacher T5 describes a situation where the guidelines are changed, introducing more reasoning type of tasks. When doing such a change, students should be well prepared. However, there are some weighty arguments in favour of such changes: Solving earlier exams is a learning activity that often takes place late in a mathematics course, and usually in the weeks prior to the exam. It might provide a means for the students to train for reproduction rather than understanding. Another argument is that it puts constraints on in which ways and how fast a mathematics course content can evolve over time. If the goal is to provide the students with an understanding of what is expected of them in a final exam, a better option may be to develop actual guidelines. Such guidelines will complement the learning outcome descriptions required for all subjects at Norwegian universities (UFD, 2014). This means that in addition to presenting the students with expected learning outcomes in terms of knowledge, skills and competence (UFD, 2014), we should provide them with examples of how their achievement of learning outcomes will be assessed. This is similar to what we do when providing them with earlier exams but allows for connecting assessment examples to specific learning outcomes. These guidelines could replace the ones that earlier exams represents (Entwistle & Entwistle, 1991). Also, they may serve as a tool that the students can use for self-regulated learning and self-evaluation during the course (Panadero, 2017; Zimmerman & Moylan, 2009).

Personal perspectives

Quote:

> T4: The experience is that these students work very independently, almost too much. If I say that a project work can take place in groups they create groups, otherwise they automatically work individually. Sometimes I miss the informal discussions where we can find answers together. But the positive thing about this is that they work 100% individually, also during tests.

Question:

To what extent should the way of arranging an exam be adjusted according to student types?

'Student types' here is meant as Gee's definition of identity "being recognized as a certain 'kind of person,' in a given context" (Gee, 2000, p.99). The students that teacher T4 refers to are particularly independent and individualistic – which signals high self-efficacy (Bandura, 1982). During the Covid-19 pandemic, the possibilities for group work were naturally limited to online collaboration. This made it more difficult for students to interact naturally, provided a more formal framework for collaboration, and also made it more difficult to meet other students whom they were not familiar with beforehand. It is reasonable to assume that students with a higher degree of individuality, thus possible higher self-efficacy, probably coped with this better than students who thrive in group interactions. This presumes that the students know which requirements apply to solving problems in mathematics, as explained by Bandura: "However, when individuals are informed about the nature of the activity, the stronger their self-efficacy the more effort they enlist and the higher their performance attainments" (Bandura, 2012, p. 27). Regardless of the pandemic, however, different student types will prefer different settings, and this should be taken into consideration when the exam format is decided. Individual exams (home or school) have the advantage of possible proctoring and easier assessment of the individual skills of the students. But this type of exam disables assessment of collaboration skills and plenary problem-solving which group exams could reveal. Group exams may also give weaker students the chance to hide behind the stronger ones. An intermediate solution could be to split the assessment in parts, with an initial group session of problem solving and reasoning, followed by an individual assessment session, where each student must provide their results as well as the reasoning behind them. The initial problem-solving session can also be optional, allowing students to decide themselves which format to use. In any case, the assessment itself should be individual, in support of our earlier argument about evaluating the students and not their result. However, we assert that group work and collaboration during mathematics courses is a prerequisite for collaboration during exams, to familiarize students with their own preferences.

The interactional perspective

Quote:

> T9: ...the good and the average students seem to benefit from working together in a home exam. The good ones learn a lot from explaining solutions to the average ones, and the average ones are able to understand the explanations. The losers are the low achieving students. They believe that studying is not necessary since they can ask for help from the good students on the exam, but then their limited knowledge prevent

them from understanding the explanations during the exam. Thus, they solve the tasks in such a way that it is revealed that they have not understood what they are doing.

Question:

How may the use of take-home exams in mathematics work out differently between weak and strong students, and are there any biases involved?

There is a value in collaboration between students when doing mathematics, which many researchers have emphasized. Students engage with the content in a different way when having to communicate the mathematics to others, and as Silvey states: "While it is clear that presenting and defending a prediction to a student's peers will better that student's own mathematical reasoning capabilities, it should also be acknowledged that the collaborative process can be very fruitful for students who serve as the audience to that prediction" (Silvey, 2019, p. 6).

The interactional perspective is naturally linked to the personal perspective, where students with different personalities will have different preferences for interaction. If students are allowed to collaborate during a take-home exam, it is reasonable to believe that weaker students will have an advantage from collaborating with stronger students. But as Teacher T9 states, this is often not the case, since collaboration with stronger students requires a certain understanding of the material to enable further understanding. This is in line with the cognitive learning approach which focuses on "making knowledge meaningful and helping learners organize and relate new information to prior knowledge in memory" (Yilmaz, 2011). However, it is important to distinguish between collaboration as a learning process and an assessment method. If a group exam is considered to include both learning and assessment, students at different levels will respond differently. If the purpose is only assessment, then a combination of group work with problem solving activities and individual assessment is a viable choice. If the view of Teacher T9 holds true, i.e., that low achieving students "believe that studying is not necessary since they can ask for help from the good students on the exam", then this viewpoint is not really something to consider. If a student does not work on their studies and only appears for exams, we should expect them to get low grades. This will be reflected in an individual assessment where students can not only give answers but also have to explain their reasoning.

Epilogue

All in all, no matter which perspective we have on take-home exams, it all brings down to the questions; do we trust students or not, and if we trust them - are take-home-exams fair?

Of course, the answers to these questions are not yes or no, these questions are versatile. This is reflected in the discussion above, where the arguments depend on which perspective is used when considering take-home examination in mathematics.

But is there any point in raising this discussion now – when societies around the world are 'back to normal' and have abandoned any concerns about lockdowns due to Covid infections? New variants of the virus occur, but politicians are eager to stress that closing society in a similar way to the early Covid situation is not relevant. The costs were too big, both economically and individually. Thus, is there any point in discussing assessment settings due to lockdowns like in the present paper? We would say 'yes', loud and clear. The educational scene is changing, and the demographic profile of university students is changing. Many

students are still students in traditional terms, leaving their homes and moving to a city where a university offers teaching and assessment on campus. However, some students need the opportunity to study from home. They are tied up for different reasons, but still want to get an education. Some may have completed an education many years ago and want to complement this with new courses due to new demands in the labour market. These are students who find it difficult to leave home. They want and need to be offered distance educations where they live. The lockdown situation showed that such distance education is possible, hence students may even expect that such an offer exists. It will then be valuable to have reflected on the challenges this presents, both in teaching and remote assessment of students. Moreover, education and teaching practices are also changing with increased availability of digital tools and methods. The change was accelerated through the pandemic when everything had to be online, but this change will increase in the years to come. This should entail new assessment methods, more tailored to new teaching practices and in line with changes in work requirements in the digital era. It might therefore be argued that instead of focusing on how we can develop methods for proctoring, we should design assessment methods so that we evaluate students directly and individually, rather than their produced results. In addition, we should ensure that the assessment includes all parts of the expected learning outcomes (UFD, 2014); knowledge of the mathematics content, ability to choose appropriate methods , skills in problem solving as well as competency in reasoning. For academics, this will come at a cost of higher workload and more time on assessment, but will enable a proper evaluation of students.

Accordingly, discussions should continue, also raising provocative arguments, to increase the awareness of problems that need solutions. At the end, we may be able to offer distance educations and evaluation methods that are on par with to the ones given at university campuses. This is an idealistic thought, but is a desired and necessary development.

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