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To cite this article: Vegard Gjerde *et al* 2021 *Phys. Educ.* **56** 055004

OPEN ACCESS PAPER

Phys. Educ. **56** (2021) 055004 (11pp) iopscience.org/ped

The Covid-19 shutdown: when studying turns digital, students want more structure

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Abstract

In March 2020, universities in Norway and many other countries shut down due to the Covid-19 pandemic. The students lost access to classrooms, libraries, study halls, and laboratories. Studying turned digital. Because it is unclear when this pandemic will cease to affect students and because we cannot know whether or when a new pandemic occurs, we need to find ways to improve digital study-life for students. An important step in this direction is to understand the students' experiences and perspectives regarding how the digitalization affected their study-life both in structured learning arenas and their self-study. Therefore, we interviewed 12 students in an introductory mechanics course at a Norwegian university in June of 2020. Through a thematic analysis, we identified four broad categories in the students' different experiences and reflections, namely that digitalization: (a) provides benefits, e.g. the flexibility inherent in online video lectures; (b) incurs learning costs, e.g. students reducing their study effort; (c) incurs social costs, e.g. missing being around other students; and (d) increases the need for structure, e.g. wanting to be arranged in digital groups to solve mandatory tasks. We also found that the 2019 students on average scored significantly better on the final exam than the 2020 students, $d = 0.31$, but we discuss why this result should be interpreted with caution. We provide suggestions for

how to adapt courses to make students' digital studying more socially stimulating and effective. Furthermore, this study is a contribution to the historical documentation of the Covid-19 pandemic.

Keywords: Covid-19, remote instruction, digitalization

Supplementary material for this article is available online

1. Introduction

In March 2020, universities in Norway and many other countries shut down due to the Covid-19 pandemic. The students lost access to classrooms, auditoriums, libraries, and study halls, and their studying turned digital overnight. Because it is unclear when this pandemic will cease to affect students and because we cannot know whether or when a new pandemic will arise, we need to find ways to improve digital study-life for students. An important step in this direction is to understand the students' experiences and perspectives on how their study-life has changed.

The increased need for social stimuli and peer interactions during adolescence (10–24 years) indicates that the Covid-19 pandemic can be highly detrimental to university students' brains and behaviour (Orben *et al* 2020). Cao *et al* (2020) found that delays in academic activities during the Covid-19 pandemic were correlated with symptoms of anxiety in Chinese college students. They also found that social support was negatively correlated with the level of anxiety, suggesting that it is the social isolation that drives anxiety. Therefore, the detrimental effects may be mitigated by social contact through digital technologies (Orben *et al* 2020).

There seems to be no reason to believe that lectures must be live and physical for maintaining the learning effects. Ried (2010) showed that the basic principles of statistics can be taught entirely online. Brockfeld *et al* (2018) found that there was no significant difference in learning effectiveness for live online lectures versus recorded video lectures for the clinical part of medical exams. However, 48% of the students preferred the live lectures while only 27% preferred video lectures. The same pattern of results was found by Paegle *et al* (1980) for traditional vs videotaped lectures and by Schreiber *et al* (2010) for live vs recorded online lectures. Ramlogan *et al* (2014) found a different pattern of results where students scored better after live lectures but preferred video lectures. They also found that 97% of the students wanted to have both live and recorded lectures in the future. It should be noted that the literature suggests that students often tend to prefer less effective teaching (Deslauriers *et al* 2019, Carpenter *et al* 2020) and learning strategies (Kornell and Son 2009, Logan *et al* 2012, Tullis *et al* 2013, Blasiman *et al* 2017). Hence, one should be cautious when interpreting students' judgments. In a meta-analysis from 2019, Pei and Wu (2019) found that medical students learned significantly more from online vs offline teaching, although they did caution that the experimental designs in the included articles varied greatly. And in a very recent meta-analysis, Noetel *et al* found that replacing existing offline methods for lectures with online videos led to small improvements in learning outcomes ($g = 0.28$) in higher education, while adding video to existing methods led to large improvements ($g = 0.80$).

Having pre-recorded lectures can be a valuable asset, enabling a flipped classroom and more structured, active learning and problem-solving during lectures (Talbert 2017, Strelan *et al* 2020). More student-centred, active learning may also help satisfy the students' need for relatedness (and autonomy and competence), thereby improving their motivation (Abeysekera and Dawson 2015). Moreover, when lectures are pre-recorded and uploaded, students can watch and re-watch the lectures whenever and wherever they want (McNulty *et al* 2011, Nieder *et al* 2011). They also enjoy the options to speed-up, rewind, and pause video lectures (Schreiber *et al* 2010).

Finally, being able to self-regulate one's motivation and study effort is important for academic success in normal situations (Kryshko *et al* 2020) and one may speculate that this ability

is even more important when studying suddenly turns digital.

When the pandemic broke out the authors were in the middle of a longer set of experiments on the use of various teaching methods in a basic mechanics course. As the students were already involved in the research project, it was natural to extend the research to include an investigation of how the students were affected by the shutdown. Therefore, we asked for volunteers to participate in a research interview on the students' experiences and reflections about the digitalization of the course.

2. Methods

2.1. Participants

We interviewed 12 students from an introductory mechanics course. The course had 150 students enrolled and the interviewees were volunteers. There were seven females and five males, with a mean age of 21 years and a range of 19–28 years. The final exam scores of the participants spanned from 19 to 98 percentage points. All the participants in this study provided informed consent and the study was approved by the Norwegian Centre for Research Data. The study was carried out in accordance with the ethical policy of Physics Education.

2.2. Context before the Covid-19 shutdown

All the students interviewed were enrolled in a ten ECTS (European Credit Transfer and Accumulation System) basic mechanics course. The only mandatory work during the course was a set of lab experiments with reports. Approval of the four reports was a condition for a student to be allowed to take the final written, 4 h exam. The grade was decided solely on the basis of the exam performance. Little mandatory work during a course is in line with common practice at many European universities.

Before the lock-down, the course consisted of one 1 h lecture and one 2 h lecture each week, with a mixture of traditional lecturing, peer instruction (Mazur 1997), and a 15 min retrieval practice session each week. In the retrieval practice session, the students retrieved and wrote important physics principles on a sheet of paper (see Gjerde *et al* 2020, 2021).

In addition to the lectures, the course offered a 2 h problem-solving seminar each week where a seminar leader taught the students how to structure problem solutions, how to solve problems, and what to focus on while studying worked examples, see Gjerde *et al* (2021). There were also several 2 h problem-solving workshops each week, where the students could receive individual help with problem-solving from a former student of the course. Brief solutions to all problems were available on the course site in the university's learning management system (LMS). Finally, multiple-choice reading quizzes, inspired by Mazur (1997), were available in the LMS for practice with each chapter (six to ten questions per chapter).

2.3. Context after the Covid-19 shutdown

After the Covid-19 shutdown in the middle of March, the lectures were changed into pre-recorded asynchronous videos. The format of the traditional lectures was not substantially changed but the videos were split thematically into short 10–15 min videos, as advised by the university's pedagogical support group. The videos were always uploaded within the intended week, but the day and time varied somewhat. The practice of conceptual questions from the peer instruction sessions was continued but without the digital response system and the peer discussions. The instructor presented each conceptual question and told the students to pause the video to think and answer before listening to the instructor's explanation. The retrieval practice sessions were discontinued and the students were encouraged to do retrieval practice during their self-study.

The problem-solving seminar was changed into short pre-recorded asynchronous videos for each problem. This enabled the students to select the problems they wanted help with and ignore the ones they were able to solve on their own. The problem-solving workshops were changed into digital synchronous workshops on the platform Zoom, where the students could log into an

open meeting room during regular time slots every week. The remaining three lab experiments were cancelled.

2.4. Interview procedures

The last author conducted the semi-structured research interview digitally using an interview guide, as he had no connection to the students and has substantial experience with interviewing. The interview guide consisted of questions that probed students' experiences and reflections related to the Covid-19 shutdown. Intelligent verbatim transcription of the interviews was done by an authorized company (Totaltekst). The full interview transcripts (in Norwegian) and interview guide (in Norwegian and English) are openly available at Gjerde (2021).

2.5. Data analysis

We used thematic analysis (Braun and Clarke 2006) to analyse the interviews, using the software NVivo (QSR International 2018). The first step of the analysis was to get familiar with the data, listening through the interviews and reading through the transcripts several times. The second step was to generate a lot of simple codes for the data, coding inclusively and including the surrounding context. The third step was to combine codes into themes, creating a thematic map, and playing with the hierarchical levels of the themes. The fourth step was reviewing and refining the themes, reading through the themes and the entire dataset, searching for lacks in internal homogeneity (coherence) or external heterogeneity (distinguishability). The fifth step was defining and refining the themes and the sixth and final step was to produce the report (Braun and Clarke 2006).

3. Cohort comparison 2019 vs 2020

A two-tailed t-test was performed to determine whether there was a difference in the average grade (1–6, i.e. F to A, where A: 90%–100%, B: 78%–89%, C: 62%–77%, D: 50%–61%, E: 40%–49%, F: 0%–39%) between the 2019 and 2020 cohorts of the same course. The t-test showed a significant difference between the 2019 cohort ($M = 4.5$, SD $= 1.2$, $N = 83$) compared to the 2020 cohort ($M = 4.1$, SD $= 1.4$, $N = 96$), $t(176.2) = 2.35$, $p = .02$, $d = 0.31$, a small effect.

The largest difference between the 2019 and 2020 courses was, of course, the Covid-19 shutdown in March of 2020. The structure and instructional methods in the two courses were highly similar (before the shutdown). However, one must be careful when interpreting this result. Although cohorts from different years are usually similar, we cannot guarantee that there were no pre-existing systematic differences. We were limited to analysing the grades of the students who had provided written consent. Differences in recruitment between the two cohorts may have introduced systematic differences. To check for this, we did a t-test of the students' prior Calculus grade. The t-test showed no significant differences between the 2019 cohort ($M = 3.8$, SD $= 1.4$, $N = 83$) compared to the 2020 cohort ($M = 3.9$, SD $= 1.3$, $N = 96$) for their Calculus grades, $t(169.5) = 0.54$, $p = .59$, $d = 0.02$, which suggest that the student cohorts were similar. However, there may have been unintentional differences in the difficulty between the 2018 and 2019 Calculus exams (taken one semester earlier) and between the 2019 and 2020 physics exams.

4. Findings and discussion

We identified four broad thematic categories in the students' experiences and reflections, namely that digitalization: (a) provides benefits, (b) incurs social costs, (c) incurs learning costs, and (d) increases the need for structure. See supplemental material at (URL will be inserted by publisher) for the original quotes in Norwegian (available online at stacks.iop.org/PED/56/055004/mmedia).

4.1. Digitalization provides benefits

4.1.1. Taking responsibility and solving more problems. Four students (C, C, B, A on the final exam) reported that they had to take more responsibility for their learning than before the shutdown and that they succeeded in doing so. They became more structured and spent more time on problem-solving. However, two of these students indicated that they were already used to doing most of their study individually, e.g. (grade B) '[…] I think it is

just fine to work on your own. I do not typically depend on getting help.'

4.1.2. Pre-recorded videos are flexible tools. Ten students indicated that they liked the flexibility in having pre-recorded video-lectures (although some stated that they would also like to have live digital lectures). They liked that they could watch the videos when they wanted and needed to (e.g. while solving problems), that they could pause and think, that they could speed up the videos, and that they could rewind the parts they failed to understand.

Three students also reported that they preferred having pre-recorded videos of the problem-solving seminar to having live physical seminars. In addition to the benefits cited above for video-lectures, the largest benefit seemed to be that they could limit themselves to videos of the problems where they actually needed help and could skip the others.

4.2. Digitalization incurs learning costs

4.2.1. Reduced study effort. Ten students reported that their study effort had been reduced after the shutdown, citing reasons such as increased problems with concentration, the lack of structure, reduced motivation, personal problems, and increased workload in other courses. One student (grade E) said:

> My study effort has probably been reduced severely. Usually, I would get up early and go to school. I could study early if there was not a lecture. Afterward I would be in a lecture. During the breaks, I would study or sit and discuss with people who had the same course. Then there were more lectures. I could have lectures for almost eight hours. Then I would go home and eat, and then I'd go back to school and sit there until quite late. After the university shut down—and since all of the libraries and reading places have also been closed … If I get five hours of study a day, it's very good. There has been a really big difference. I lived in a shared flat with other students, and everyone suddenly sat in the small living room and had to work on school—with completely different subjects.

However, the reduced study effort was only temporary for some students as they gradually figured out how to structure their self-study. Three students also reported that their study effectiveness had been reduced due to the lack of interactions with peers or with the instructors. Six students reported that they studied the conceptual problems from the lectures, using the same structure as during the Peer Instruction sessions (individual thinking and answering—peer discussion—answering—instructor explanation and solution), but without the actual peer discussions. Although it is positive that they mentally engaged with the problems instead of merely listening to the instructor's explanation, skipping the peer discussions was probably detrimental to their learning as this is an essential element in peer instruction (Mazur 1997, Turpen and Finkelstein 2010, Vickrey *et al* 2015). Two students (grade C and A) reported that they actually met with others digitally to discuss the conceptual problems, trying to stick with the structure from the Peer Instruction sessions from before the shutdown.

4.2.2. Poorer attention, preparation, and learning with video lectures. The students reported some problems specific to digital lectures. Four students reported that they had attentional problems when watching the lectures, finding them less engaging than physical lectures. Four students said that being in a physical lecture with other students who paid attention helped force them to pay attention. Some prepared less for the digital lectures and were more passive while watching. Two students said that digital lectures consumed more time because they spent so much time writing notes. Four students felt that they learned less from digital lectures than from physical lectures.

4.2.3. Unnatural digital social situation during problem-solving workshops. Finally, five students reported that the social situation was too unnatural in the digital problem-solving workshops and, therefore, stopped attending. They felt exposed to the other students and to the workshop leader, and found it awkward to ask questions.

4.3. Digitalization incurs social costs

4.3.1. Missing discussions of physics and being around other students. The students reported that the reduced social contact was detrimental to their motivation and that they missed discussing physics with their peers. They also missed having other students around while studying, even though some said they were used to studying individually. About half the students reported having used digital tools for social contact and discussion. However, the amount of social contact they had from using these tools varied and, in most cases, seemed limited. One student (A on the final exam) said:

> I think the social aspect of studying is so important. It is important to meet those you study with when you have the opportunity to do so. Since we may not be so good at arranging things or meeting outside the study in our class, it [social contact] will be very limited.

4.4. Digitalization increases the need for structure

4.4.1. Wanting structuring support for time management and overview. Seven students reported that they struggled without the structure of going to the university and attending lectures. They began to struggle with getting started with studying, organizing their studying, and knowing what to study. One student (D on the final exam) said:

> The problem for me is that I did not have the structure, I did not have to get up every day to go to school, although I should have. It was often easier to drift away from a study routine to a more everyday summer routine, for me. I thought it was difficult, at least. Because I feel that I already struggled with keeping the structure in my studying before the shutdown.

The students wanted more structure imposed on them to help organize their studying. Five students wanted more mandatory work because it helped force them to concentrate. Four students (grades E, D, D, A) said they preferred live digital lectures to pre-recorded videos. Two students (grade E and C) said they struggled to keep track of when live lectures, seminars, and workshops took place, which is a well-known challenge that has long been recognized in the literature on online learning (McVay 2001, Smith *et al* 2003). Relatedly, they felt that a well-organized online LMS was more important after the shutdown. Four students (grade E, E, D, B) also said that they would like regular advice on what to study and a summary of what was going to happen the coming week, for example through weekly Sunday e-mails.

4.4.2. Wanting structuring support through arenas for discussions. The students wanted more support for social learning. Three students said they wanted communication during the digital lectures, both with peers and with the instructor. They also wanted more structure for discussions outside of class. Seven students wanted to be arranged in groups and be given tasks to solve or discuss. One student (grade D) said:

> I think a good plan would be to create groups and then give tasks they have to solve each week, or every other week or something. [..] And in order for you to do that, you have to work together, because it is a group assignment. [..] And when you do, you learn the curriculum at the same time as you get structure, and you are forced to work with others.

4.4.3. Appreciating structuring support from learning resources. As previously reported in Gjerde *et al* (2021), some of the students found

retrieval practice of the Hierarchical Principle Structure for Mechanics (Gjerde *et al* 2020) to be an effective way to kickstart studying after the Covid-19 shutdown. One student (grade E) said,

> When you sit at home in a little room all day you can struggle with your concentration. It is hard to get started because you know you have to sit for a long time. So, I have often used it [retrieval practice] as a 'this only takes 15 min, so you start with that' and then I often notice that it is easier to start things. Then I can already put a checkmark that I have done something that day.

The students viewed access to solutions to the weekly problems as equally or more important after the shutdown. This may be related to the social barrier that seems to be associated with visiting the open meeting room in the Zoom-based problem-solving workshops, see sections 2.3 and 4.2.3.

5. Discussion and conclusions

The general pattern was that most of the students were detrimentally impacted by the shutdown and the digitalization of the course, with a few students continuing to thrive. The exam grades and statements during the interviews suggest that the thriving students were already highly self-regulated students who preferred to study individually. Most of the students felt that the shutdown and digitalization of the course incurred costs for the learning and/or their social life in university and that their need for imposed structure increased.

Our main conclusion is that structure is particularly important when courses have to be digital. Students already struggle with effective structuring of their studying in regular circumstances (Kornell and Bjork 2007, Blasiman *et al* 2017), and digitalization seems to make it more difficult because the everyday routine of going to the university is taken away. Based on the students' experiences and reflections, we have several suggestions for how instructors can help students structure their digital study-life.

5.1. Structuring support for time management and overview

First, instructors should keep all resources, like the LMS course site and digital lectures, well organized. Secondly, we suggest that instructors send short weekly Sunday/Monday emails or announcements with structuring info, such as an agenda for working through the materials and activities for the week, and recommendations to help the students organize their study week. The email can contain summaries of concepts covered in the preceding week and the coming week, information on when lectures (and similar events) are taking place, where to find learning resources, some suggestions of what to do when in their studying, and a few statements of what is expected of them. This would also give the instructors a valuable opportunity for advising students on effective (vs ineffective) learning strategies. For example, they can tell their students that the learning effectiveness of writing notes is highly limited and that re-reading and copying notes is especially ineffective (Dunlosky *et al* 2013, Blasiman *et al* 2017), as some students seem to struggle with limiting their note-taking activity when watching prerecorded online videos.

5.2. Structuring support with learning resources

Telling the students which learning strategies to use may help some students, but is probably not enough for most (Blasiman *et al* 2017, Foerst *et al* 2017). They must also be given support through easy-to-use instructional resources and ample opportunity to practice (Biwer *et al* 2020, Endres *et al* 2020). The students in the 2021 cohort of the course in this study have been forced to study digitally from the start of the semester. To help the students use the learning strategy retrieval practice, their instructor (the second author) provides them with the Hierarchical Principle Structure for Mechanics and retrieval sheets for retrieval practice of physics principles (Gjerde *et al* 2020), and sets aside time in the digital lectures for structured retrieval practice. It might also be a good idea to recommend that students use retrieval practice as a kick starter for their daily

study, making it easier to start their daily studying, see comment from student in section 4.4.3. In addition to being highly effective for improving memory of important relationships (Karpicke and Grimaldi 2012, Rowland 2014, Gjerde *et al* 2020), the literature also suggest that retrieval practice can make subsequent study more effective, i.e. the forward effect of testing (Wissman *et al* 2011, Pastotter and Bauml 2014, Chan *et al* 2018, Lee and Ahn 2018).

We also believe that it is important to supply the students with worked solutions to the problems they are expected to solve, both because the students have less opportunity to discuss problems with peers and because trying to understand examples is an essential way for humans to learn how to solve problems (Chi *et al* 1989, Anderson *et al* 1997, van Gog *et al* 2019).

Pre-recorded problem-solving videos are, like written solutions, valuable learning resources. The students in this study also seem to prefer video-based problem-solving seminars to traditional blackboard seminars.

5.3. Keep the flexibility of videos but impose structure

For both online and hybrid courses, we suggest that instructors keep the flexibility of pre-recorded videos while also providing structure and engagement in the form of active learning. We suggest that this is done by pre-recording lectures, which are then used for flipping the classroom (Talbert 2017, Strelan *et al* 2020). In a flipped classroom, students are expected to watch the pre-recorded lectures beforehand while the scheduled lectures are used for active learning methods, such as Peer Instruction (Mazur 1997, Crouch and Mazur 2001). Moreover, pre-recorded lectures have the added benefits of potentially being of higher quality because they are more focused, often better planned, and because they tend to be in shorter segments. They also bypass the privacy issues related to the recording of students and can, therefore, be re-used in future semesters.

As with any other instructional method and resource, the pre-recorded videos must offer high quality content with competent production values. They should also align with and serve to enable the instructional content during the active learning in the scheduled lectures, which also creates a motivation for watching the videos beforehand.

5.4. Help students feel less exposed during digital problem-solving workshops

We suggest that digital problem-solving workshops using Zoom or similar software are arranged so that students feel less exposed. For example, by making break-out rooms available, which the instructor then visits in turn. This is more in line with the normal teaching situation, where students sit in self-selected groups at different tables and the instructor moves between the tables.

5.5. Provide structure that satisfies both learning and social goals

Our final suggestion is to provide structure that satisfies the students' learning goals and social goals simultaneously. A flipped classroom with peer instruction, as mentioned above, is one way of targeting both types of goals.

One may also introduce mandatory discussion tasks with pre-made groups of, e.g. three to five students. We suggest that these groups are regularly changed to facilitate social interactions across study programs and help them meet and interact with more students. We also caution that these discussion tasks need to be of high quality, i.e. tasks that stimulate effective learning processes for important knowledge, as some students may become antagonistic if they do not feel they are also learning from it. An example task could be translation between multiple representations of physics principles, e.g. between physical situations, diagrams, and mathematical equations. One should also limit the workload imposed by these mandatory discussion tasks, for example by only requiring that the students upload a video or audio file documenting their discussion. The point of providing structure is not to provide students with more work in their studies, but rather better, more purposeful work.

Data availability statement

The data that support the findings of this study are openly available at the following URL/DOI: https://doi.org/doi:10.18710/BEYEQR.

Acknowledgments

This work was supported by the University of Bergen. The first author did the analysis and wrote the manuscript. The other authors contributed to the research ideas and with comments on the manuscript. The last author performed the interviews. A special thanks goes to Oddrunn Samdal for making this article possible.

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Received 13 April 2021
Accepted for publication 19 May 2021
https://doi.org/10.1088/1361-6552/ac031e

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