Student-Produced Films in Laboratory Courses as Learning Incentive and Exam Option

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Abstract: An increasingly digitalized society demands that both educators and students master the use of digital tools in all teaching and learning activities. In laboratory-based courses, the practical elements of teaching are difficult to digitalize without sacrificing the important hands-on experience, leaving the remaining components such as seminars, reports or exams as possibilities where the classical concepts can be supplemented or replaced by digital solutions. In this paper we report on the use of digital film production as an alternative option for written laboratory reports and a means to intensify the learning outcome from practical experiments. Films were produced by students of the Bachelor course "Green Biotechnology and Bioenergy" on selected parts of the course. Simple and budget-friendly measures were implemented to carry out the filming. The films replaced the laboratory reports for the respective experiments. A seminar served as an interactive platform for the students to present their films to their fellow students and exchange feedback before the films were assessed by evaluators as part of the examination. The pedagogical benefits of this teaching method and its suitability as an assessment form were later analyzed to shed light on the question if student-produced films are a promising way to impart digital expertise effectively while acquiring practical skills in an informative and creative manner. Beyond advocating student-produced films as a possible exam concept for practical courses, our article demonstrates that self-executed filming was able to provide a more creative, interactive, and thus more motivating teaching atmosphere with mutually advantageous learning experiences for all parties involved.

Keywords: GoPro camera, laboratory course, student produced films

1 Introduction

Increased use of digital tools in everyday life has also shaped the teaching and learning environment we have today. The European University Association´s trend report from 2018 estimated that student-active learning and teaching methods would have a prominent role in European educational institutions, a trend that is also followed in Norway (Regjeringen.no, 2021). Suggestions are that it is digital technology that helps facilitate more student-active learning. In 2004, the Ministry of Education and Research in Norway started integrating digital competence throughout the education sector. The Norwegian Directorate for Education and Training (Udir) revised the framework for basic skills in 2012, ensuring that digital competence was included in the curriculum (Forskningsdepartementet, 2004; Regjeringen.no, 2022; udir.no, 2022).

Technology for applying digital tools in teaching and learning at the university level is available (e.g., Canvas, Slido, Zoom and Panopto). Well-documented effects of digitalization have been observed in lectures that can be rendered more interactive and inclusive for students (Tabieh et al., 2021). However, the broader implementation of digital tools and their adaptation to different learning situations lags behind in some fields. In **STEM** disciplines **(Science, Technology, Engineering and Mathematics)**, lectures conveying the theoretical frameworks are typically accompanied by practical exercises where technologies, methodologies and skills are conveyed. Some STEM courses have already experienced a high degree of digitalization with many analysis methods relying on automated and even artificial intelligence-assisted algorithms. However, there are large differences between different STEM subjects. For instance, the practical laboratory and field skills that are part of learning outcomes in biological sciences, still rely heavily on the same hands-on learning approaches that have been used over decades. Because these approaches are interactive and student-centered by default, the paucity of digital solutions has not been perceived as problematic, so far. Moreover, a recent study executed in Finland and Sweden reported that the “digital labs” and digital simulations of experimental procedures that have been developed for different courses did not support student-active learning and motivation in the same way as hands-on experience did (Cheung et al., 2023). A second area that has been surprisingly resilient to changes is the assessment of student learning through exams that have often remained in their traditional written or oral form. In this form, the theoretical rather than the practical skills are in focus, and their alignment with the courses' learning outcome may be regarded as insufficient.

Filming the execution of complex procedures has become very popular and has led to dedicated platforms for research publications (like “Journal of Visual Experiments” (JoVE)) and for education (like “Experiments on film” (https://experiments.science.cymru). Indeed, filming has increasingly been used to produce instructional resources that can be valuable tools for preparation or revision of lab exercises (Holmes, 2015; McCaslin et al., 2014; Schmidt-McCormack et al., 2017). In these cases, the films can be seen as engaging supplements to other teaching methods, but students still tend to “consume” the filmed procedures in a relatively passive manner. However, the active use of filming by students in technical projects has also gained attention (e.g., Young, 2020; Schultz and Quinn, 2014). Unfortunately, there are only few examples where this has been utilized and evaluated as an alternative form of student-active learning or for learning assessment, and our search did not reveal any published examples of this approach being integrated into the teaching of biological curricula in Norway. We therefore initiated a pilot project to test our hypotheses that (a) the active nature of filming increases the hands-on learning experience and that (b) the films are able to improve the alignment of the practical learning process and the learning assessment. Here, we present the setup of this pilot filming project and share our experiences and conclusions from it with an emphasis on the active role that students played in it and its subsequent analysis.

1.1 The Learning Environment for the Filming Approach

"BIO-2009 Green Biotechnology and Bioenergy" is a course that provides practical laboratory experience (https://en.uit.no/education/courses/course?p_document_id=842085) for second-year biotechnology and third-year biology Bachelor students at UiT The Arctic University of Norway. In the years where the experiment on student-produced filming was conducted, it was given as an intensive course where students over a few weeks were introduced to various relevant topics related to biotechnology in photosynthetic organisms. The focus of the course was on applications of genetic modifications in plants, techniques of breeding, plant tissue culture and grafting in agriculture or horticulture, the production of high-value plant-based compounds (pharmaceuticals, nutraceuticals) as well as biofuel generation from plant waste. Lectures conveying background knowledge in biotechnology and plant physiology were supplemented with seminar presentations given by the students and home assignments. In addition, 30 hours of laboratory work (5 hours of which included filming) and 10 hours of related *in silico* cloning and bioinformatics comprised the practical component. Students worked in pairs when conducting their experiments, while their exams, consisting of a collection of written laboratory reports and films, were assessed individually.

Within this curriculum, the topic of genetic modification of plants was identified as suitable for a pilot experiment on the use of student-produced films. This topic offered various experimental approaches that were of approximately similar complexity to allow students to learn about the principles and the technical details with one specific technique selected for active filming (see Table 1), but were yet different enough to learn about the range of options through more passive film-viewing of films produced by their fellow classmates.

1.2 Motivation and Research Questions Connected to the Study

Bachelor-level lab courses often employ parallel group work to maximize practical learning within limited timeframes. Such an approach that is focused on demonstrating a multitude of experimental protocols almost always comes at the expense of limited opportunities to revisit and repeat failed experiments, which are important in the learning process, leading to a shallower comprehension of the experimental protocols and their limitations. They also offer only very limited possibilities to provide the students with feedback on their practical performance. This tradeoff raises the important question if the acquisition of practical skills benefits more from broad but shallow or from narrow but deep/detailed teaching approaches.

The main objective of the student-produced film project was to assess the opportunities and challenges of this approach with respect to the motivation to learn and with respect to the constructive alignment between experimental tasks in the course and the performance assessment. Opinions and preferences from both students and teachers towards student-produced films and the overall execution of the course were collected through surveys and interviews, with the following questions as the basis for their evaluation:

- Did filming of individually executed experiments increase the theoretical and practical comprehension level of the students compared to conducting the experiments in a parallel supervised teaching mode?
- Did watching fellow students' films reduce the theoretical and practical comprehension level of the students compared to conducting the same experiments in a parallel supervised teaching mode?
- Did students' motivation to learn increase with the degree of autonomy and creativity compared to traditional laboratory teaching?
- Were the produced films a suitable exam component?

2 Methods

2.1 Experimental Concept and Execution

Students worked in pairs and each pair selected, conducted, and filmed one out of four alternative experiments: (1) agrobacterium-mediated transformation, (2) virus-induced gene silencing, (3) transient transformation by gene gun bombardment and (4) protoplastation of plant tissue (Table 1).

A detailed script with experimental protocols and other information pertaining to the experiments were provided to the students. The students were tasked with conveying the principle of their experiment, its execution and their results to others by filming the process, editing their raw footage and equipping it with informative narrative and subtitles. GoPro Hero 7 Black cameras (valued at 3000-4000 Norwegian Kroner (NOK)) were used for filming. The students received an introduction to using this type of camera to familiarize themselves with it. Before going to the lab, they also met with their individual supervisors for a rehearsal of the experiments up front where any questions could be asked. Technical requirements for the films were given regarding the file format (mp4 or wmv format) and the length of the films (minimum 7, maximum 12 minutes) (see Appendix A.4). Otherwise, the students were encouraged to make their own decisions regarding the approach and were given freedom to come up with creative solutions. Various editing software such as iMovie, VSDC, or Adobe Premiere Pro were accepted, depending on the computers used and the students´ prior knowledge. Every student pair presented their film to the entire class as part of the integrated seminar where these student-led contributions supplemented the other teacher-led seminar parts. Thus, students achieved the learning outcome by presenting their own experimental work to their classmates, while in return learning from them about the principles and procedures of the other three experiments (Table 1). For the assessment of the learning outcome (exam), the scientific presentation as well as the presence of evidence that the film was a team product were considered alongside the compliance with the guidelines for the films. In contrast, the scientific results did not influence the grade (pass/fail).

Table 1. *The group setup: Students in pairs of two chose which of the four alternative experiments they wanted to produce and present a documentary amateur film for (presented by 🎬📷🖵). The other alternatives were later studied by watching and commenting on the films produced by the other student pairs (presented by 👁).*

Group	Experiment: Transient gene modification of plant cells using:							
	Agro-bacterium	Agro-bacterium	Virus	Virus	Gene-gun	Gene-gun	Proto-plasts	Proto-plasts
1	🎬📷🖵	👁	👁	👁	👁	👁	👁	👁
2	👁	🎬📷🖵	👁	👁	👁	👁	👁	👁
3	👁	👁	🎬📷🖵	👁	👁	👁	👁	👁
4	👁	👁	👁	🎬📷🖵	👁	👁	👁	👁
5	👁	👁	👁	👁	🎬📷🖵	👁	👁	👁
6	👁	👁	👁	👁	👁	🎬📷🖵	👁	👁
7	👁	👁	👁	👁	👁	👁	🎬📷🖵	👁
8	👁	👁	👁	👁	👁	👁	👁	🎬📷🖵

2.2 Feedback from students

Feedback on how the filming was perceived was collected at two time-points: First, impressions and suggestions were collected from all students and teachers through an anonymous questionnaire (on paper) and group discussions immediately after the course. The questions were aimed mainly at identifying strengths and weaknesses of the set-up in order to implement improvements in the following year (see Survey 1 in Table 2 and Appendix A.1).

After two years of conducting the filming experiment with two different student groups, all the students and teachers who participated were asked to answer a net-based "hindsight-survey" developed by a participating student from the first year together with the course responsible (see Survey 2 in Table 2 and Appendix A.2). This second survey aimed at assessing the students' prior knowledge and the perceived benefits or disadvantages that the students associated with this method of teaching and learning (Table 2). The online survey (see Appendix A.2) was handled via Nettskjema (www.nettskjema.no) with approval from the Norwegian Center for Research Data (NSD).

Table 2. *Focal points of the two surveys.*

Focal points in the immediate feedback questionnaire (survey 1)	Focal points in the "hindsight questionnaire" (survey 2)
• Level of novelty of filming and editing • Learning outcome from filming, editing and presenting the experiment to peers • Learning outcome from viewed films of the other groups • Depth of learning as compensation for reduced hands-on lab time • Opinion on films as written lab report replacement	• Prior experience with film editing • Value (in learning outcome) for added time investment • Level of engagement in self-produced films • Filming as a possible general teaching concept in practical courses • Opinion on films as written lab report replacement • Benefit of feedback during film viewing • Level of preparedness for the course • Suitability of filming at Bachelor level

2.3 Interviews with students and teachers

Interviews were conducted with students and teachers who wished to provide more detailed feedback, allowing them to elaborate further on their experiences with the filmmaking process, including pre-production and post-production aspects, and its impact on their learning. A set of questions were prepared beforehand as a guide for the interview (see Appendix A.3), and interviewees were asked to elaborate on their experience around and beyond these prepared questions. All interviews were conducted individually and, whenever possible, physically. Transcripts of the interview notes were made immediately afterwards and analyzed later for trends/commonalities.

3 Results

The incorporation of filming as a teaching method resulted in a total of 14 films over two years. 26 anonymous written feedback responses from students (of total 27 participants, equaling a feedback response rate of 96%), as well as oral feedback from all students and 4 teachers were obtained and evaluated as part of survey 1. In addition, 15 responses (from 12 students and 3 teachers) were obtained in the second online survey. They formed the basis of the following presentation of the results.

3.1 Prior knowledge and experiences

Given the widespread popularity of GoPro cameras in documenting leisure activities, it was reasonable to assume varying levels of prior experience, impacting both the time required to master the task and novelty of this documentation method. To provide a framework for interpreting the overall feedback from both surveys in relation to the pre-existing experience with GoPro filming, we asked about students´ familiarity with film processing software (see Survey 1 in Appendix A.1) and GoPro cameras (see Appendix A.2, Survey 2). While Survey 1 showed that some students even used semi-professional film processing software (e.g. Lightroom and other Adobe Suite products) indicating their familiarity with processing and editing of films, Survey 2 revealed that a significant portion of the students did not have any prior experience with GoPro cameras as such (see Figure 1). The same applied for the teachers.

In the personal interviews, the interviewees also stated that they had not heard of student-produced films as teaching method before, but that they had encountered filming in other courses as prefabricated instruction material similar to a script or textbook. Students who were tasked with writing laboratory reports based on pre-recorded films reported that it was a very passive approach, and they would have preferred to be involved in the filming or the execution of the experiment.

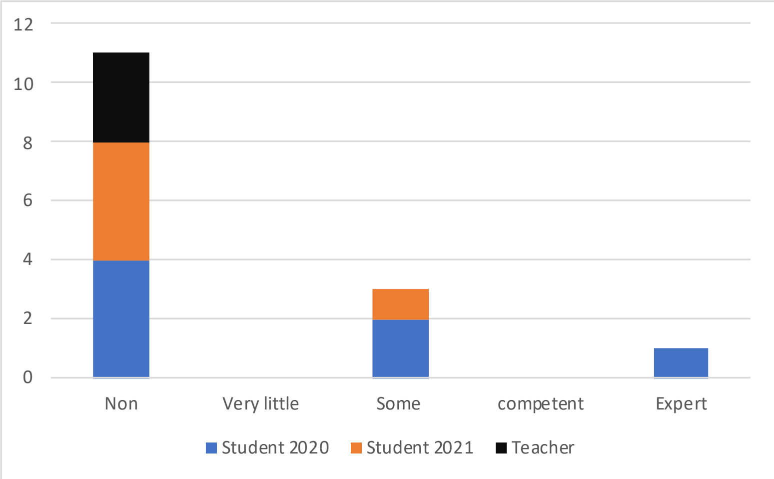

Figure 1. *Self reported experience level regarding GoPro Filming. The poll shows the self-assessment of students from the 2020 class (blue), students from the 2021 class (orange), and teachers (black) regarding their prior knowledge of GoPro filming using a scale from non-existent (non) to well-versed (expert). The y-axis shows the number of answers per category.*

3.2 Can students learn better through the filming process?

It was our hypothesis that the filming would be an engaging activity that also facilitates learning through the repetition of the experimental context in the various stages of film production (planning, executing, editing, presenting), and several questions were directed at testing this hypothesis (see Appendix A.2, Survey 2, and Appendix A.3, interview questions 3, 4, 6,). All the interviewees stated that alternative teaching methods such as filming are more engaging and inclusive compared to standardized classroom teaching, owing most certainly in part to their novelty. Raising curiosity and interest for an experimental procedure was predicted to be tightly connected to a better preparation beforehand and, as a result, should yield a greater learning outcome of each experiment. Based on the feedback from the students in Survey 2, the filming exercise was successful in achieving both (see Figures 2 and 3). As filming requires a conceptual understanding already while the experiment is being performed, the various steps are carried out more consciously. One student framed it in the following way: “I gained a greater learning outcome in the end, and it stuck with me.” An additional motivation factor was that student pairs were competing with each other to make their films interesting and fun to watch, bringing an outreach component into their work. Most student groups chose to create a script outlining the steps and actions to be filmed and framing their narrative. The majority of students indicated in the executed surveys that detailed planning in connection with filming helped them indeed to gain a better understanding compared to courses where such digital tools were not used. In summary, filming was perceived as more motivating as students had a lot of freedom (Figure 2). In addition, it succeeded in getting the students acquainted with laboratory techniques (Figure 3).

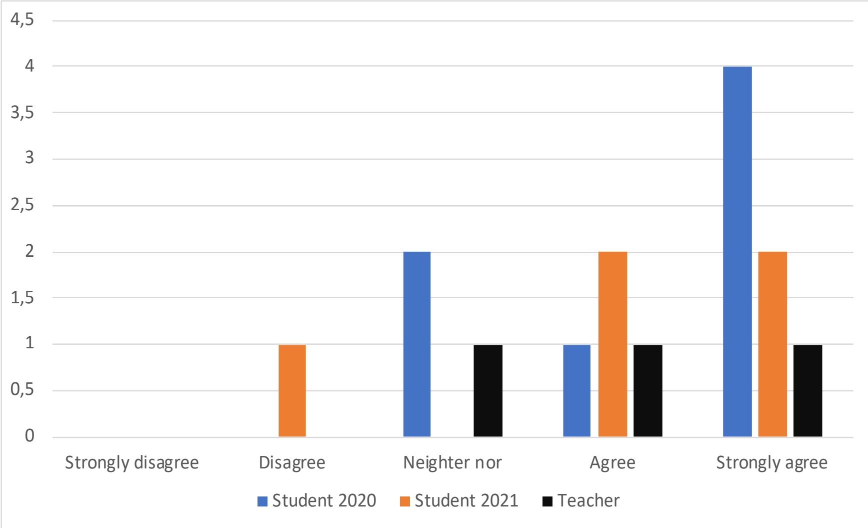

Figure 2. *Answers to the question whether students were more motivated to read before-hand and to come into the laboratory more prepared when tasked with filming the experiment (Question 7 in Appendix A.2). The bar plot shows the responses to this question in survey 2. Bars represent counts for the corresponding answers with colors indicating students from 2020 (blue), 2021 (orange) and teachers (black, same set for both years). The number of answers (y-axis) per category is shown.*

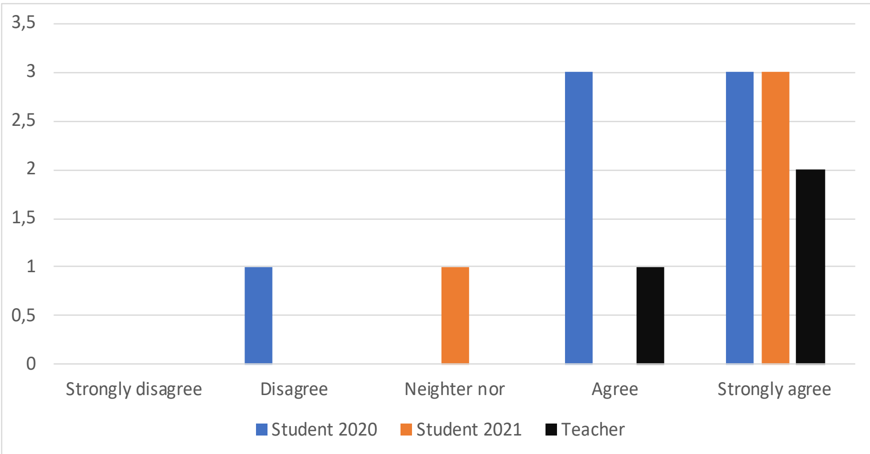

Figure 3. *Answers to the question whether filming was a good approach to learn laboratory techniques. The bar plot shows the responses to this question in survey 2. Bars represent counts for the correspond-ding answers with colors indicating students from 2020 (blue), 2021 (orange) and teachers (black, same set for both years). The number of answers (y-axis) per category is shown.*

Working in pairs has helped to reduce the issues and uncertainties that students often face with laboratory work at this stage in their studies. When asked if they preferred to work in groups or alone when facing new tasks (Survey 2, question 2 and interviews), all interviewees unanimously answered that they prefer group work, but they also emphasized that, under time constraints, “the group follows the one who learns the fastest,” yet generally, “it´s good to have someone to ask and help each other.”

3.3 Can students learn by watching films?

Students were provided with scripts and detailed protocols for all filmed experiments, and it was expected that the students read this information before the film viewing sessions to be theoretically prepared for discussing the alternative approaches to genetic modification of plants presented in the other films. Nevertheless, a few students stated that it was difficult to understand the experiments conducted by other students just by watching the films. On the other hand, other students stated that “they enjoyed watching the films of other groups” and that they “understood what the other groups had done.” In the study it was not assessed how well the students had actually prepared themselves for the film viewing sessions and if the reported occasional lack of comprehension was perhaps related to insufficient preparation.

Each experiment was carried out and filmed by two different groups, resulting in two independent films on each topic. We hypothesized that this moderate redundancy during the film viewing would have a positive effect on students’ comprehension. However, during the student interviews, it was revealed that students had mixed reflections on the learning outcome from seeing the same film twice (see Appendix A.3, question 4). Some students enjoyed seeing how the same task was performed in different ways, while others were indifferent and did not think about whether this was an advantage or not.

Last but not least, we had also expected that films produced by their classmates would be perceived as more entertaining than films made by professionals or teachers. This was generally confirmed in both Survey 2 and in the interviews (question 1) where all students agreed that they preferred self-produced films over other instructional films. Nevertheless, the active performance of the exercises in a laboratory was still the most favorable option for all students.

3.4 Can films replace other teaching and assessment methods?

When initiating the filming experiment the teachers hoped that it would surpass traditional teaching methods by increasing the students’ attention during the laboratory work. With a film potentially serving the same purpose as a lab report, students’ reflections on these two alternatives as deliverables for the exam were moreover supposed to be captured. Both surveys, supported by various oral feedback, revealed that a clear majority (67%) of the students of Bio-2009 found that filming gave an equal or superior learning outcome due to the depth that it offered on one representative technique and would prefer this to the broader but more shallow execution of several similar experiments in parallel laboratory groups if having to choose (Figure 4A). However, they tended towards the opinion that both together would be the best. Most students that favored the traditional set up were from the first year (2020) (Figure 4A).

Even though film-producing took the students longer than writing regular laboratory reports, a large majority of students found that films could replace some of the written laboratory reports that constituted the exam (Figure 4B). Again, this tendency was stronger in 2021 than in 2020. Writing laboratory reports is an activity that many students, especially at the Bachelor level, struggle with. Only a few students felt that written documentation should be completely replaced with film-based documentation while most students acknowledged that they need the writing skills but that alternative reporting skills can make the task of reporting more varied, interesting and relevant, so a combination of both was widely favored (Figure 4B).

Figure 4. *Student opinions on filming as a teaching method (A) and as an exam form (B) based on the immediate feedback (survey 1) from students in 2020 and 2021. (A) Students had the choice between two alternative answers (represented in green and purple respectively in the legend) as response to the question whether they felt they benefitted from the deeper preparation of one experiment more than if they would have done all four experiments in the same time frame. The number of answers (y-axis) is shown for both years separate and in total (sum of both years). (B) Students were asked to indicate their preferences when comparing either filming or laboratory report writing or a combination of both.*

3.5 Are student-produced films appropriate for a Bachelor course?

The current experiment was performed in a Bachelor course where the participating students had very little laboratory experience, making the laboratory work challenging. Yet, most students thought that student-produced films were useful and suitable as a teaching concept at Bachelor level, with only one skeptical vote (Figure 5). This was further elaborated on in the interviews where all the students stated it worked great for a Bachelor course. One student emphasized that "due to Corona I personally did not have so much lab experience which made the tasks a bit difficult", but added that "it was fine to do the filming in the Bachelor course." In summary, it would have been interesting to have a comparison to the perception of this teaching concept in more advanced courses, but it appears that filming can be used with success as a teaching variation in laboratory courses, at least at Bachelor level.

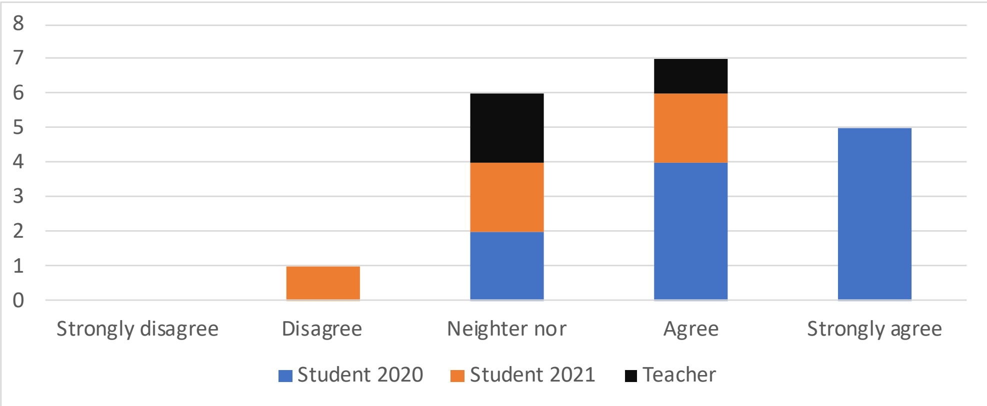

Figure 5. *"Can student produced films be a suitable teaching approach for Bachelor students?". The poll results from survey 2 to this question are reproduced as a bar plot, showing the opinion of students from 2020 (blue) and 2021 (orange) as well as teachers on a scale from "Strongly disagree" to "Strongly agree". The y-axis represents the number of answers per category.*

4 Discussion

One of the main goals in our teaching of practical courses is to increase the comprehension of the scientific method or, in other words, convey scientific literacy to students by incorporating classical as well as modern approaches (McComas, 2020; Tai et al., 2018). A few factors are crucial in order to succeed with this. One of them is the students' motivation to learn, and another is their curiosity. Both, students and teachers have certain expectations for teaching, where students often prefer engaging and sometimes creative teaching methods (Netland et al., 2019) while the teacher´s role is to convey relevant content in an understandable and memorable way. The aim is to strike a balance so that the teaching is neither too simplified and passive nor overwhelming, allowing students to feel a sense of accomplishment (Hjukse et al., 2020).

What was distinctive about the first year of the filming project, was that many decisions had to be made on the fly with relatively little preparation time due to the Covid pandemic and limited possibilities to discuss its implementation with the larger teaching community. Making films was relatively new to both students and teachers. Also, the limited access to the necessary laboratory infrastructure minimized possibilities to test practical aspects. This led to increased student involvement and intense dialogue with the teachers throughout the course. By delegating some of the responsibility to the students, their self-confidence arguably increased, having a positive effect on their motivation. It was the students´ responsibility to manage their time, plan the script, engage in necessary self-study, and create and present their self-produced films in a seminar that contained a higher proportion of student-led activities. That the seminars were co-led by the students helped to eliminate the barrier for asking questions and engaged students in discussions, showing their curiosity. However, there is consensus that student-produced films cannot fully replace the laboratory experience that students gain from conducting the experiments themselves. This was evident from the questionnaires, where several students pointed out that they had a deeper understanding of their own experiment compared to experiments they only saw in films. This is not surprising, considering that watching films naturally is a more passive approach, making it more challenging to evaluate and critically assess new information

(Jonassen, 2003; Jonassen et al., 1999; Schultz & Quinn, 2014). Thus, student-produced films alone may not be sufficient to convey the wider perspective, but they can be one element in the quest to reach this goal. On another positive account, students responded positively to the introduction of films as an alternative to written reports and exams. This supports existing theories that state that varying teaching methods can reach more students and be perceived as more inclusive and engaging for those who face challenges with written reports and exams (Harrison-Pitaniello, 2013).

In teaching, especially in conveying practical skills, repetition is a common approach. We assumed that filming would combine "learning by repetition" with "learning by reflection" by increasing the necessity for understanding all the critical details of the experiment in its entirety, including all the sub-steps to plan a film script. Thus, the time in the laboratory can be better utilized, and students can focus on the critical steps of the work. This would imply that laboratory teaching, contrary to general opinions, can benefit from the use of digital tools to convey practical skills and enhance students´ learning outcomes in a creative way. The surveys did not completely support the teachers' perception as students, particularly from the 2020 class, expressed an eagerness in the interviews to keep the proportion of hands-on laboratory experience as high as possible, (see Figure 4). However, it is impossible to know if this was a result of the extensive social distancing during the first months of the Covid pandemic and reflected that students were just overanxious to spend time at the university, or whether the filming approach was a better developed and thus a more convincing experience for the students in 2021 after some improvements were implemented in the second year of our project.

Students also reported a somewhat higher tendency to actively help each other and share information rather than passively and uncritically relying on information from the teachers, while teachers on the other hand found themselves learning partially from and with the students. The mutual benefit of this was a noticeable and positive side-effect and made all participants more receptive to giving and receiving feedback in a learning-enhancing and constructive manner in line with general good teaching practices (Topping, 1998). The analysis of the results of this study was essentially done in collaboration between the course responsible and one of the course's students. This in itself and the high feedback response rates prove that the course was successful in capturing the students' interest. The success of the course showcases undeniably that student-produced films can be implemented in teaching with some advantageous impact on students' learning outcome. However, it also needs to be stressed that this approach demands a higher time investment by teachers and students alike. Ultimately, the investment by universities into an adequate number of cameras and in standardized software also needs to be considered. In Bachelor courses that are typically characterized by higher student numbers, the initial investment into the necessary equipment and software and the perpetual investment into teaching time might preclude taking this approach on a regular basis. This leaves advanced courses with a narrower focus at Master or even PhD level, which have not been targeted in this paper, as tentatively more suitable candidates for establishing and developing this kind of teaching further. Still, also at Bachelor level, there are scenarios where filming can be envisioned as an alternative option to written reports and exams, such as, for example, for dyslectic students. This was not a topic of the reported pilot study but deserves investigation in the future.

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References

Cheung, L., Strauss, L., Antonsen, P., Soini, S., Kirkham, M. & Fisher, R. M. (2023). Digital labs as a complement to practical laboratory training for Bachelor and Master Biomedicine students. Proceedings of the Technology-Enhanced Learning in Laboratories Workshop In Elmoazen, R., López-Pernas, S., Misiejuk, K., Khalil, M., Wasson, B & Saqr, M., eds, *Proceedings of the Technology-Enhanced Learning in Laboratories Workshop (TELL 2023), Virtual Event organized by University of Eastern Finland, Joensuu, Finland & University of Bergen, Norway, April 26, 2023*. Volume 3393 of *CEUR Workshop Proceedings*, pages 5-15. https://ceur-ws.org/Vol-3393/TELL23_paper_9410_1.pdf

Utdannings- og Forskningsdepartementet (2004). *Program for digital kompetanse 2004-2008*. https://www.regjeringen.no/globalassets/upload/kd/vedlegg/grunnskole/strategiplaner/program_for_digital_kompetanse_liten.pdf

Harrison-Pitaniello, M. (2013). Using student-produced time-lapse plant movies to communicate concepts in plant biology. *Journal of Microbiology & Biology Education*, *14*(1), 101-102. https://doi.org/10.1128/jmbe.v14i1.436

Hjukse, H., Aagaard, T., Bueie, A. A., Moser, T., & Vika, K. S. (2020). Digitalisering i grunnskolelærerutdanningen: Om faglige forskjeller i arbeidet med profesjonsfaglig digital kompetanse. *Acta Didactica Norden*, *14*, 1-27. https://doi.org/10.5617/adno.8023

Holmes, J. (2015, 28.08.15). How Methods Videoes are Making Science Smarter. *The New Yorker*. https://www.newyorker.com/tech/annals-of-technology/how-methods-videos-are-making-science-smarter

Jonassen, D. H. (2003). *Learning to solve problems with technology: A constructivist perspective*. Prentice Hall.

Jonassen, D. H., Peck, K. L., & Wilson, B. G. (1999). *Learning with technology: a constructivist perspective. Upper Saddle River, NJ: Merrill*. Prentice Hall.

McCaslin, S., Young, M., & Kesireddy, A. (2014). Using GoPro Hero cameras in a laboratory setting. ASEE-GSW Conference 2014 Proceedings. https://www.researchgate.net/publication/264861328_USING_GOPRO_HERO_CAMERAS_IN_A_LABORATORY_SETTING#fullTextFileContent

McComas, W. F. (2020). *Nature of science in science instruction: Rationales and strategies*. *Springer Nature*, pp. 35-65. https://link.springer.com/book/10.1007/978-3-030-57239-6

Netland, K. Ø., Sivertsen, A., & Olufsen, M. (2019). Innføring av studentaktive arbeidsformer i seminarundervisningen. Hvilken betydning har dette på læringsutbyttet og klassemiljøet? *Nordic Journal of STEM Education*, *2*, 1-15. https://doi.org/10.5324/njsteme.v2i1.2346

Regjeringen.no. (2021). *4. Studentaktive lærings - og undervisningsformer*. https://www.regjeringen.no/no/dokumenter/meld.-st.-16-20202021/id2838171/?ch=4

Regjeringen.no. (2022). *Kunnskapsdeparementet*. https://www.regjeringen.no/no/dep/kd/id586/

Schmidt-McCormack, J. A., Muniz, M. N., Keuter, E. C., Shaw, S. K., & Cole, R. S. (2017). Design and implementation of instructional videos for upper-division undergraduate laboratory courses. *Chemistry Education Research and Practice*, *18*, 749-762. https://doi.org/10.1039/C7RP00078B

Schultz, P. L., & Quinn, A. S. (2014). Lights, camera, action! Learning about management with student-produced video assignments. *Journal of Management Education*, *38*(2), 234-258.

https://doi.org/10.1177/10525629134883
Tabieh, A.S., Al-Hileh, M.M., Abu Afifa, H.M.J., Abuzagha, H.Y. (2021). The effect of using digital storytelling on developing active listening and creative thinking skills. European Journal of Educational Research, 10. 13-21.
http://www.eu-jer.com/
Tai, J. H.-M., Ajjawi, R., Boud, D., Dawson, P., & Panadero, E. (2018). Developing evaluative judgement: enabling students to make decisions about the quality of work. *Higher Education*, *76*, 467-481. https://doi.org/10.1007/s10734-017-0220-3
Topping, K. (1998). Peer assessment between students in colleges and universities. *Review of Educational Research*, *68*(3), 249-276. https://doi.org/10.2307/1170598
udir.no. (2022). *Rammeverk for lærerens profesjonsfaglige digitale kompetanse (PfDK)*. https://www.udir.no/kvalitet-og-kompetanse/profesjonsfaglig-digital-kompetanse/rammeverk-larerens-profesjonsfaglige-digitale-komp/innledning/#Om-pfdk
Young, P. W. (2020). Student-produced video of role-plays on topics in cell biology and biochemistry: A novel undergraduate group work exercise. *Frontiers in Education*, *5*. https://www.frontiersin.org/articles/10.3389/feduc.2020.00115/full

5 Appendix

A.1: Survey 1 questionnaire. The questionnaire was designed with the purpose to record general feedback from the students immediately after the course on six different aspects of the course. Part E relating to the filming process is shown here. Questionnaires were handed out in paper form and were filled out by students anonymously after the course.

A.2: Survey 2 questionnaire. The Nettskjema- based questionnaire was designed with the purpose to record students' and teachers' reflections on the filming approach in hindsight (approximately one year later). Questions (Q) with answer possibilities (A) are shown. The questionaire was set up in a way that granted all responders anonymity.

A.3: Interview guide. The questions were supposed to document reflections by students and teachers beyond the information provided in the written questionnaires.

A.4: Guidelines for film production. The guidelines were provided to the students and the examiners of the course.

A.1 Survey 1 questionnaire

E. The filmed exercise

1. The variety of experiments on genetic modification in plants was this year replaced by one experiment that you had to prepare and understand well and that you were asked to film in an informative way that would give the other groups enough information to understand what your experiment was about.

Do you feel you benefitted from the in depth preparation of one experiment more than if you would have done 3 experiments in a compact second week? (Highlight one option and/or comment):

Prefer detailed but somewhat more narrow insight

Prefer shallower but wider insight

2. How difficult was the filming and film presentation:

	Fun, would like to repeat	Boring	Challenging, will not try it again
GoPro handling and taking the footage			
Film processing with software			
Presenting the film at the seminar			
Watching films made by the others			

3. If you did NOT use iMovie, please indicate which software you used:

Any other comments:

4. Both lab reports and movies are ways to document your set up and results but with different target groups. How do you evaluate these two when compared? (Highlight one option and/or comment):

Prefer writing

Recommend keeping the filming in future courses

Neither one/undecided

A combination of both is best

Any comments:

A.2 Survey 2 questionnaire

Questionnaire about Student Produced Films of Laboratory Experiments as a Teaching Technique in BIO 2009

Student produced laboratory films served as an alternative teaching method during the pandemic years (2020-2021). This questionnaire includes questions which will be used to map the possibilities and challenges with this method. All answers will be **annonymous**.

I understand and accept that my answers will be used as a part of the result of this research project.

- ☐ I accept

What was your role in the course? Were you a teacher or a student?

Please write which year/years you participated in the course.

- ☐ Teacher
- ☐ Student
- ☐ 2020
- ☐ 2021
- ☐ 2022

Please state what your experience with Go pro cameras were before you started the BIO 2009 course (0=none, 5= expert).

1 2 3 4 5

Value

Please write on a scale from 1-5 (1:disagree, 3: neither nor 5: fully agrees) how much you agree to the following statements:

"I find group work to be an ideal approach when learning new things"?

1 2 3 4 5

Value

"I think it can be great to learn from my peers when presented with new topics"?

1 2 3 4 5

Value

The 4 experiments which were presented in the course were Agrobacterium infiltration, Virus induced gene silencing, Gene gun transformation and Protoplast isolation.

"I find filming to be a good approach to learn laboratory techniques"?

1 2 3 4 5

Value

"I would wish that other courses included students produced films as a part of their teaching"?

1 2 3 4 5

Value

"I find student produced films to be more engaging and inclusive than standard class room teaching"?

1 2 3 4 5

Value

"I feel more motivated to do research beforehand and to come prepared into the lab when I know we are going to film the project"?

1 2 3 4 5

Value

"I consider the filming process to be worth the effort, even though it might require more work"?

1 2 3 4 5

Value

"I find that watching student produced films can replace hands on experience in the lab for Bachelor students"?

1 2 3 4 5

Value

"I find student produced films to be a teaching approach suitable for Bachelor students"?

1 2 3 4 5

Value

"I find student produced films to be a good substitute for written laboratory reports"?

1 2 3 4 5

Value

A.3 Interview guide

1) Have you experienced any other courses that used filming approaches? Were these student produced films (active learning) or teacher produced films (passive learning)?

2) Green Biotechnology and Bioenergy (BIO 2009) is a Bachelor course where the students are exposed to different laboratory experiences. These may already be a lot of new tasks and skills to take in. Give that background, would you think that a filming approach is more suitable for a master course that has less focus on technical execution?

3) Filming gives the opportunity to learn together with and from your peers/ colleagues. When presented with new topics this can be a great way to learn. Do you agree or have you experienced other approaches? If yes, what do you prefer?

4) Two groups were given the same topic, where they performed and filmed their experiment. Was it useful to see how another group solved the same task?

5) Simultaneously you had to watch films from the other three experiments. In a setting where time, space or resources can be constrained, is this an acceptable compromise?

6) Would you agree that alternative teaching techniques such as filming can be more engaging and inclusive compared to standard classroom teaching?

7) Films serve as an alternative reporting form in science (e.g., in publications). But do you think this is an also a good alternative for teaching?

A.4 Guidelines for film production

Technical
Films must be submitted in a format compatible with MediaSite so that they can be uploaded into Canvas for review by examiners, teachers and fellow students. Formats that have been tested and that work are **mp4 and wmv**. (It is likely that other formats will work too.)

The original filmed footage will in all probability require processing. Software that can do the most important basic steps in video editing will be needed. The software should be able to do the following editing steps:

- Cut out unwanted parts of the footage
- Merge parts that were filmed separately (for example when having breaks in the protocol or when moving between labs)
- Add audio effects (lets you add spoken comments afterwards instead of commenting while filming)
- Optional functions could include adding titles or transitions between scenes, but are not as important as the above functions.

Software suggestions:
For Mac: iMovie
iMovie should be automatically installed on Macs purchased after 2014. This is an intuitive software that lets you perform all the above editing steps.

For Windows PCs: VSDC (free online download), but there is a range of other free programs available, too. (GoPro offers also software, but I have not been able to find all the necessary functions there.)
http://www.videosoftdev.com/free-video-editor/download

Length
The final movie should ideally be in the range of **7 to 10 minutes, and no longer than 12 minutes.** It should focus on the practical steps of the experiment (what equipment, material etc. is needed, how the experiment is performed, which steps are critical, etc.) but should also provide an introduction and a summary of the results and their discussion.

1. Pre-fix:
   - State who is filming and which experiment you are filming in which connection. This can be part of the film (e.g. a scene in the lab or of a plant) or it can be a still image added afterwards.
2. Aim of the work
   - Describe the purpose of the experiment and how this will be tested.
3. Materials and methods
   - **Unlike the lab reports, your main focus in the film will be to visualize the contents of the script regarding the methods and the material needed.**
     This requires very detailed understanding of what will be done. Be prepared by reading the script, discussing the steps with your supervising teacher and make a plan (or film manuscript) for which shots to take, what to say, where to use still images and where to use live footage.
4. Results and discussion
   - This is not the focus of the film, but it is important to relay your results in order to bring across the purpose of the experiment. Include a troubleshooting discussion or a take-home message in the movie.