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Exploring Approaches for Blended Learning in Life Sciences

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ABSTRACT

Digital tools and platforms offer new solutions to design and conduct university teaching. This case illustrates how such digital solutions may be utilized in problem-based learning programmes within life science educations. Specifically, the case evaluated the use of live-streamed and recorded lectures, the incorporation of digital formative assessment in lectures, and the use of a digital platform to support experimental project work in a research laboratory. We find that digital solutions provide flexibility for both lecturers and students, advantageous options for collecting and sharing information, and for engaging students in their learning process. However, digital tools cannot replace all aspects of traditional in-person teaching, such as social interactions. Rather, when blended with in-person teaching, digital solutions have a large potential for supporting new forms of and approaches to both theoretical and experimental university teaching.

Keywords: Blended learning, problem-based learning, formative assessment, laboratory teaching, digitalization

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INTRODUCTION

The learning outcomes in life science education programmes, such as biology and biotechnology, contain both a theoretical and a practical element. At Aalborg University (AAU), these programmes employ authentic problem-based learning (PBL) to bridge scientifically based knowledge, obtained through courses and projects, and experimental experience, obtained through laboratory training.

The PBL-based pedagogical model at AAU allocates 50% of the curriculum to courses and the other 50% to self-directed project work (Servant-Miklos 2020; Dahl et al. 2016). The courses allow equal time for lectures and theoretical exercises, based on specific problems. This supports the projects which are designed to teach the students to solve real-life problems through a combination of research and experimental work. In this way, the PBL-based courses and projects synergize to prepare students to put theoretical knowledge into practice.

The AAU model demands a combination of teaching strategies that fit with the PBL regime (Dolmans et al. 2005). Such teaching should be interactive and engaging and stimulate constructive and contextual learning (Exley and Dennick 2009; Azer 2009). Moreover, it must embrace the practical component central to project work. In life science educations, this involves laboratory experiments, which students must plan and execute on their own initiative. However, the transition from theory to practice is challenging and necessitates intense instruction and supervision by an expert to ensure correct and safe laboratory practice during the experiments.

The COVID-19 pandemic restricted the use of existing interactive teaching formats and strategies. Urged by these challenges, we formed a working group that explored different ways to incorporate digital tools in teaching. The working group met frequently to discuss experiences, provide peer feedback, and develop new teaching ideas. At the same time, students were asked to evaluate the teaching activities via oral feedback, quizzes, or questionnaires (details on the pedagogical approach can be found in the full report). Thus, this case illustrates *to what extent digital tools provide solutions that improve both theoretical and practical PBL-based university teaching and what the outlook is for incorporating these solutions in life science education programmes.*

This was evaluated in three pedagogical experiments centered around large group classroom and laboratory teaching. In our opinion, these domains have the biggest potential and highest need for digital transformation. The three pedagogical experiments explored digital approaches for structuring lectures, for formatively assessing lectures, and for supporting laboratory teaching. Here, we present each experiment and discuss our experiences and opinions, which contribute to a future teaching paradigm based on blended learning.

LECTURE STRUCTURE

In the PBL model, lectures provide a framework of theoretical and applied knowledge that is used as a steppingstone for project work. The structure of a lecture is critical to encourage student engagement, critical thinking, and interactions in the class (Exley and Dennick 2009). The potential of digital tools for increasing student learning, perception, and engagement during lecturing was explored by a series of activities concerning the lecture structure.

Live-streaming and recording of lectures has become simple with the implementation of digital platforms such as Microsoft PowerPoint, Zoom, and Google Meet. Lecture recordings allow students to revisit the lecture to recap specific topics at their own pace. Digital platforms have also facilitated the implementation of pre-recorded lectures as student preparation for a subsequent live lecture, in which the lecturer can then focus on core topics and thereby improve the overall learning outcome (Moravec et al. 2010).

The presented case explored the potential of pre-recorded lectures to enhance student learning compared to live-streamed lectures. Further, the impact of lecture duration on student learning was investigated by comparing short 20-minutes lecture sessions with long 45-minutes sessions. Students evaluated which lecture formats (pre-recorded vs. live-streamed lecture and short vs. long lecture session) they preferred. In general, the students appreciated having lectures recorded and made available, whether being a recorded live-streamed lecture or a pre-recorded lecture. Additionally, most students found shorter, topical sessions a useful format for obtaining new knowledge, due to better subject delimitation and focus.

A good lecturer-student connection helps generate and maintain the attention and engagement of students during lectures (Steinert and Snell 1999). Under circumstances with a lack of in-person connection, such as during online or pre-recorded lectures, it is therefore critical that the lecturer reflects on alternative initiatives/strategies to engage the students.

To improve student engagement during online lecturing, this case used digital support tools for interacting with the slideshow presentation and for incorporating intermittent quizzes. In the former activity, lecturers interacted with the slideshow by using a digital laser pointer and/or by writing on the slides while communicating their content. In the latter activity, students were presented with several multiple-choice questions during the lecture, using the digital student response system Socrative. Most students found both slideshow interactions and integrated quizzes useful for improving their engagement in the lecture and their understanding of the topic covered.

LECTURE ASSESSMENT

Formative assessment of student learning and teaching quality describes the process of making sure students understand the topic being taught while it is being taught. The goal of formative assessment is to actively monitor student learning through feedback for real-time adjustment and improvement (Boston 2002).

This case used Socrative to formatively assess student learning during hybrid in-person/online lectures. In preparation for each lecture, the learning outcomes were defined, and for each learning outcome, a series of learning objectives were identified (Fig. 1A). For each learning objective, several multiple-choice questions were prepared (Fig. 1B). These questions were presented to the students *via* Socrative immediately after communicating the associated lecture content and student responses were used for real-time formative assessment. If most of the students failed to correctly answer a question, the lecturer elaborated on the topic associated with the specific learning objective before moving on to the next learning objective.

Apart from real-time assessment of student learning based on individual learning objectives, the use of a digital platform allows collection and analysis of data across learning objectives and students (Fig. 1C). Upon completion of the course, the lecturer can use the accumulated results from the multiple-choice questions to pinpoint topics for which most students fail to understand one of more learning objectives. This approach allows the lecturer to refine the content and improve the learning quality of each lecture, and eventually of the entire course. The method is especially important in lectures where learning objectives are highly inter-connected in a way that understanding of the current learning objective depends on the understanding of a previous one. Over time, this approach can also be used to refine learning materials, thereby improving the course.

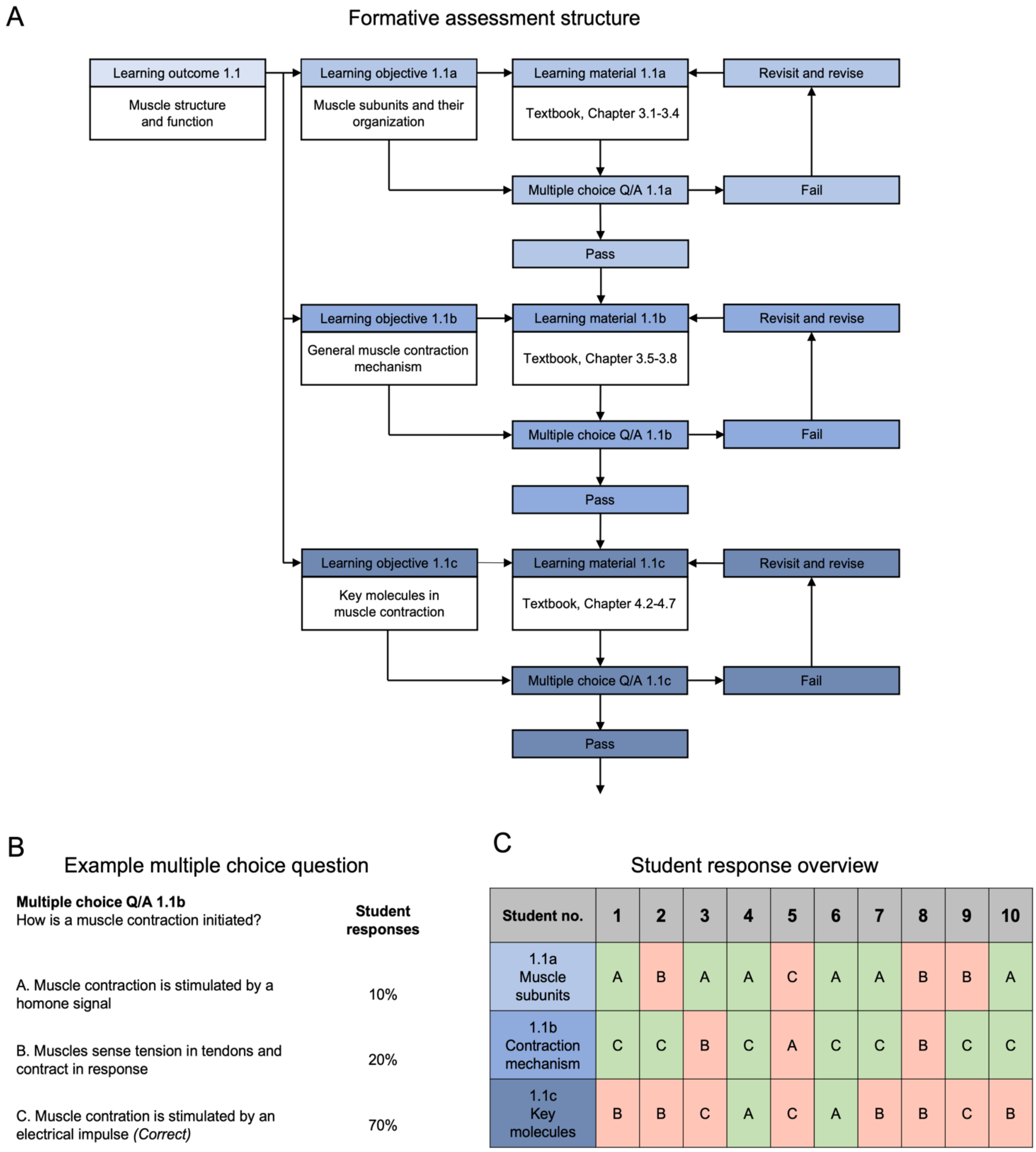

Figure 1. Continuous formative assessment of lectures was done to pinpoint topics that students failed to understand. A. Flowchart illustrating the formative assessment structure of a lecture about muscle structure and function. Each learning outcome was subdivided into specific learning objectives with associated reading material. For each learning objective, a multiple-choice quiz was used to assess whether students understood the content just presented before moving on to the next topic. B. Example multiple-choice question associated with learning objective 1.1b. C. Example table of student responses to multiple-choice questions related to each learning objective. Green: correct answer. Red: incorrect answer. Examples have been adjusted from the original experiment for simplification (see the full report for implemented assessment).

LABORATORY PRACTICE

The technological advancement of life sciences relies on continuous research progress, inevitably associated with laboratory experiments. This means that students enrolled in life science education programmes must acquire hands-on experience with laboratory practice. This is especially important in a PBL environment, where student projects are centered around experimental work.

However, students are often confused and overwhelmed by the many practical details and guidelines associated with good laboratory practice, which steal the attention from the scientific problem related to their project (Galloway, Malakpa, and Bretz 2016). Particularly in the initial learning phase and in early semesters, practical training is equally demanding for instructors who must be available almost constantly to support and instruct students.

Thus, this case evaluated the use of a digital platform for supporting laboratory practice. The online whiteboard and collaboration platform Miro was used to design an interactive guide on how to handle chemical waste generated during laboratory work (Fig. 2). The rationale for making the guide on chemical waste handling was that the ability to handle laboratory waste correctly is part of the practical curriculum of *all* students, thereby increasing applicability of the guide.

A decision-tree-based approach was used to transform an overall challenging workflow into a manageable series of decisions (Fig. 2A). The tree has a fixed starting point, from where it branches out, and the user must navigate through the branches by making decisions based on available information/knowledge (Fig. 2B). At every decision node in the tree, there is a link to a digital whiteboard that explains the practical procedures associated with the decision, via text, photo, and video instructions (Fig. 2C).

A group of students tested the digital waste handling guide and compared it to a written laboratory manual covering the same content. All students preferred the digital guide over the written manual and indicated that such a tool supports laboratory work and makes it easier to navigate in the laboratory by being instructive, intuitive, and simple.

The implementation of a feedback function in the digital guide itself provides the student easy access to ask clarifying questions or point out if information is lacking. In our experience, students hesitate to ask these questions if it requires a lot of time or effort. Thus, a one-click-away feedback function facilitates and improves the learning process of the students and ensures that deficiencies in the guide can be addressed and amended by the creators to continuously improve its functionality. Finally, the students thought the concept of the digital guide would be useful in relation to other topics than waste handling, such as standard operating procedures/protocols in the laboratory or handling of advanced laboratory equipment.

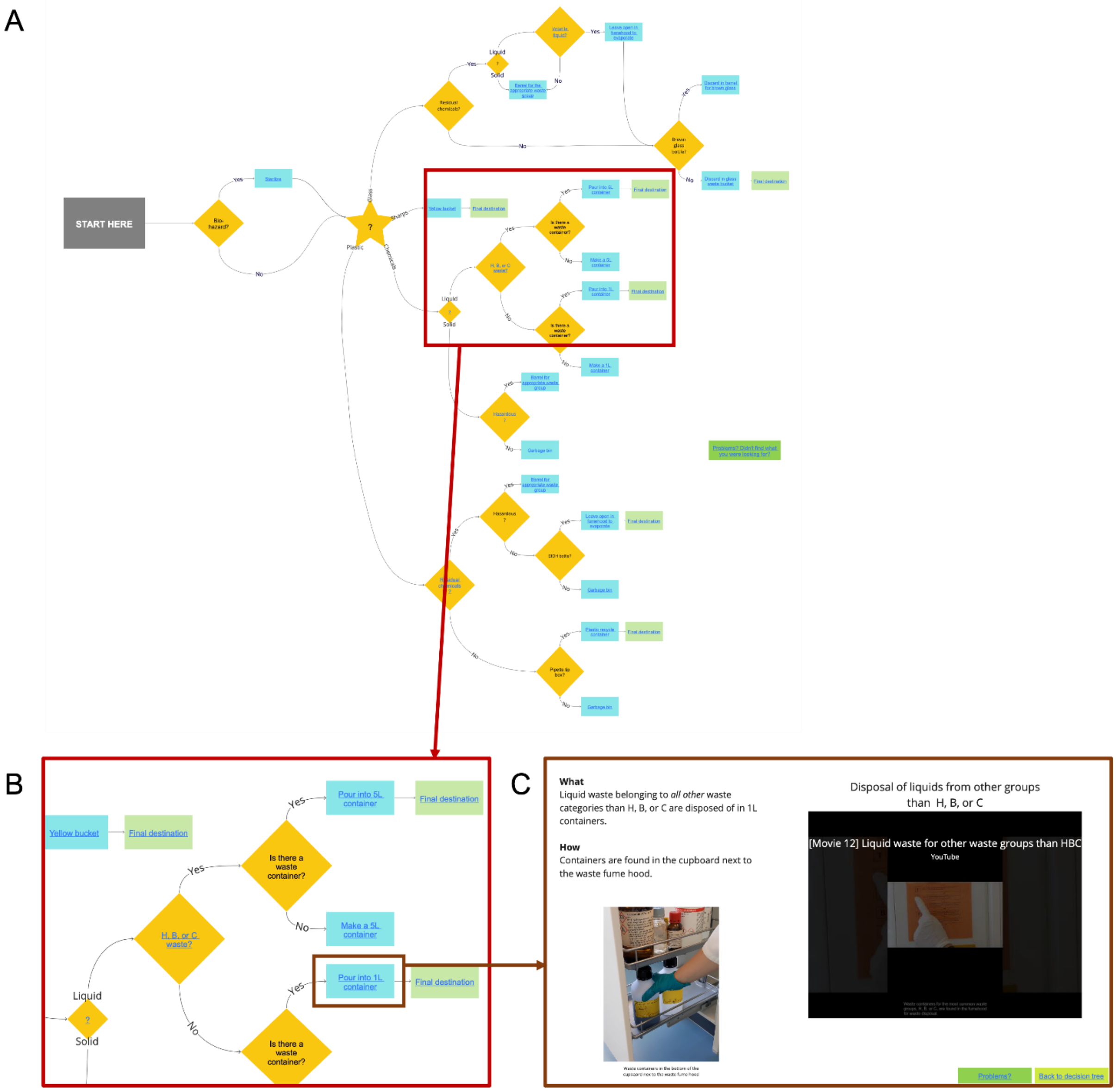

Figure 2. An interactive laboratory guide on chemical waste handling to support experimental laboratory work. A. Complete decision tree on chemical waste handling, designed in [Miro](). B. Subsection of the part of the decision tree that concerns chemical waste categories. C. Example of a whiteboard including text, photo, and video instructions, the latter with narration and subtitles. All information on the whiteboard was prepared for the specific laboratory used by the students.

LEARNINGS FROM EXPERIMENTS WITH DIGITAL TOOLS

Across the three pedagogical experiments presented above, we found that digital tools offer novel ways to design teaching and course curricula. We also found that digital tools offer useful, new ways to facilitate already existing activities in an organized, streamlined, and engaging fashion. However, one should carefully consider when and where these added benefits can be achieved, as they generally require a time-investment and compromise some types of student interaction. Here, we elaborate on some of our main experiences from working with digital tools in university teaching.

Variation in online lectures

All activities that tested ways of breaking up a lecture were perceived positively by students, in line with similar previous studies (Hsin and Cigas 2013; Wammes and Smilek 2017). Lecture variation was key to engage the students in their own learning process and to obtain and maintain their attention. We also found that a digital format offers several approaches to creating variation in lectures.

Most online platforms and recording/presentation software (e.g. Microsoft PowerPoint, Zoom, Google Meet) offer digital tools that allow the lecturer to animate and/or interact with a presentation. Slideshow animations are easily implemented in PowerPoint and have the potential to increase the scaffolding effect, by providing information bit by bit thereby breaking up the learning into chunks and reducing information overflow. Another important tool in presentation software is the digital pen. This allows the lecturer to use the slideshow presentation as a whiteboard, which naturally reduces the pace of presentation, thereby allowing more time for the students to absorb the presented content and acquire the associated knowledge. Both approaches have the added benefit of guiding the students' awareness to specific areas of the presentation to enhance their focus and attention. The interaction with a presentation is especially important when using pre-recorded lectures in which the lecturer cannot engage the students in real-time.

Digital tools also provide solutions for implementing student response systems as an element of variation in real-time lectures (online or in person). This kind of lecture variation makes the students actively participate in and reflect on their own learning process. In addition to engaging and activating the students, the implementation of quizzes, questions, or group discussions throughout the lecture facilitates the assessment of student learning and teaching quality. Online platforms such as Padlet, Socrative, and Kahoot! are easily accessible and allow the lecturer to follow student responses in the form of quiz answers or discussions in real-time. They can serve as a fun and entertaining break of rhythm and tracking of responses may motivate competitive students even further.

Flow of information

Since digital tools provide a unique opportunity to collect, share, and re-use information (Ahshan 2021), our experiments revealed many benefits from incorporating these tools in teaching activities. Not only will most digital platforms save information for later use or analysis, but they remain accessible and can be continuously updated to refine teaching material, notes, or instructions.

Lecture recordings or instruction videos can be uploaded to an intranet platform, such as Moodle or Blackboard, or to open access platforms on the internet such as YouTube. Some digital platforms offer to store information privately or publicly, thereby enabling the lecturer to selectively make information available to specific students at a specific time. An important point to note is that if lecture recordings are given as curriculum in preparation for a subsequent in-person lecture, they should replace a corresponding part of the reading material. Otherwise, the curriculum becomes too comprehensive as the students need to spend more time for course preparation than the time allocated. One may argue whether it is worthwhile to make topical videos in-house, as many high-quality teaching videos are available online, e.g., by Cousera or edX. We do, however, find that videos tailored for a specific course curriculum, exam exercises, or for practical work in in-house laboratory facilities do add value for the students. Moreover, the learning process of some students may benefit from the comfort of knowing their teacher rather than being faced with a stranger on the internet from an on-demand course.

Collection of information from students can be achieved with online digital platforms, such as Socrative. The collected data can subsequently be analyzed in detail, thereby allowing the lecturer to identify knowledge gaps. This contrasts an oral feedback approach which can only function to give a snapshot of the students' learning process. An added benefit of implementing an online digital response system compared to asking for plenary feedback is the possibility to anonymize participants, thereby removing the social barrier and ultimately increasing the amount of applicable feedback.

We also found that laboratory teaching can benefit from incorporating digital tools. Platforms like Miro and Padlet provide means to share, organize and streamline information, and can be designed for a specific purpose. They can thus contain a level of information that better resembles the nature of practical work, i.e., in the form of instruction videos, flowcharts, and notes. They also provide design options that can ease the learning process of students through a stepwise process. For example, the decision tree-based design of the digital guide presented in this case allows the condensation of comprehensive information to keep focus on necessary knowledge and off distractions. Moreover, the information can be used by the instructor again and again in future semesters with no or little requirement for revision.

Finally, digital tools including Miro, Padlet, Microsoft Teams, Google Docs, OneNote, and Overleaf facilitate group work as they provide an easy solution for students to share information and interact with a task together from different computers. These platforms have much of the same flexibility as drawing on a piece of paper or a whiteboard has and can readily be used for brainstorm-type exercises. Importantly, these platforms save the content and can be used to "immortalize" notes or to share them with other students or teachers.

Meeting students in the digital space

The use of digital platforms in teaching creates a hub and meeting point for lecturers and students, which can be accessed at the convenience of all. This increases the flexibility for lecturers and students – online lectures, documents, and other resources can be accessed anywhere and from any device and gives students the possibility to work from home. In PBL projects, digital platforms provide valuable tools for students to share, discuss, and organize information with each other or with their instructor, who is just "one click away".

On the other hand, as digital platforms constitute an extra link between the lecturer and the student, they may also increase the perceived distance. It is our experience that online lectures impair the lecturer's sense of student attention and interest. Teaching through a digital platform decreased our ability to evaluate if the students were interested in the topic, understood the content, or paid attention. We also found that the students were reluctant to ask questions or participate in plenary tasks. These obstacles were enhanced by the option to turn off cameras, which most students did. With cameras off, the lecturer cannot know whether students are even present. These challenges are particularly problematic during exercises, discussions, and question time. We speculate whether the option to turn off the camera decreased the students' attention on the lecture, as they could be distracted by other activities without disturbing the other participants.

The increased student-lecturer distance created by implementing digital teaching platforms may be a hindrance especially for early semester students. Both in responses from students and in our own experience, students in early semesters are more dependent on scheduled lectures, face-to-face interactions with the lecturer, and a social network with other students for an optimal learning process. In contrast, students in later semesters are more experienced in study techniques and in managing their tasks and time and are independent enough for online self-studies. It is therefore important to consider, at which stage in an education programme it is appropriate to replace in-person lecturing with online elements, and when it is better to use these elements as a complement. Ultimately, this points towards blended learning as the optimal method of teaching rather than methods that exclusively use in-person or online teaching elements. The ratio between the elements, however, should be carefully considered and adjusted based on the academic level of the students and on the curriculum.

Regardless of whether digital tools are used to supplement or replace in-person teaching or teaching material, one should keep in mind that it is a time-consuming task to implement these. The time investment however often pays off if the prepared material can be reused with no or minor revisions. This applies to both lectures and laboratory teaching. The digital guide used to support laboratory practice has the potential to save valuable instructor time by removing the need for instructing students in real-time and by avoiding tedious repetition of the same instructions as new students enter the laboratory each semester. Together, this can transform laboratory teaching into blended learning.

CONCLUSIONS

Digital tools offer new and alternative means to conduct PBL-based university teaching. We found that these tools should be used as supplements rather than replacements for in-person teaching, as in-person interactions between students and teachers are important. Digital tools offer ways to share information, including recorded lectures, notes, information charts, and guides. This has a large potential in PBL-based projects, where students can organize and share information with each other or their instructor. The opportunity to access and revisit learning material throughout the course and during exam preparations was popular among students. Moreover, digital tools allow information logging and saving for reusing, evaluating, and revising the curriculum in the following years. Streamed lectures are challenged by the lack of lecturer-student interaction. Therefore, it is particularly important to create variation to the speed, dynamics, and focus. We found that this could be achieved by breaking down the lecture into shorter sessions, and by using slideshow animations, digital pens, and quizzes. Taking these aspects into account, several of the investigated digital tools may be valuable additions in a teaching design for blended learning.

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References

Ahshan, Razzaqul. 2021. “A Framework of Implementing Strategies for Active Student Engagement in Remote/Online Teaching and Learning during the COVID-19 Pandemic.” *Education Sciences* 11 (9): 483. https://doi.org/10.3390/educsci11090483.

Azer, Samy A. 2009. “What Makes a Great Lecture? Use of Lectures in a Hybrid PBL Curriculum.” *The Kaohsiung Journal of Medical Sciences* 25 (3): 109–15. https://doi.org/10.1016/S1607-551X(09)70049-X.

Boston, Carol. 2002. “The Concept of Formative Assessment.” *Practical Assessment, Research, and Evaluation* 8 (November). https://doi.org/10.7275/kmcq-dj31.

Dahl, Bettina, Jette Egelund Holgaard, Hans Hüttel, and Anette Kolmos. 2016. “Students’ Experiences of Change in a PBL Curriculum.” *International Journal of Engineering Education* 32 (1(B)): 384–95.

Dolmans, Diana H J M, Willem De Grave, Ineke H A P Wolfhagen, and Cees P M van der Vleuten. 2005. “Problem-Based Learning: Future Challenges for Educational Practice and Research.” *Medical Education* 39 (7): 732–41. https://doi.org/10.1111/j.1365-2929.2005.02205.x

Exley, Kate, and Reg Dennick. 2009. *Giving a Lecture*. 2nd ed. Routledge. https://doi.org/10.4324/9780203879924.

Galloway, Kelli R., Zoebedeh Malakpa, and Stacey Lowery Bretz. 2016. “Investigating Affective Experiences in the Undergraduate Chemistry Laboratory: Students’ Perceptions of Control and Responsibility.” *Journal of Chemical Education* 93 (2): 227–38. https://doi.org/10.1021/acs.jchemed.5b00737.

Hsin, Wen-Jung, and John Cigas. 2013. “Short Videos Improve Student Learning in Online Education.” *Journal of Computing Sciences in Colleges* 28 (5): 253–59.

Moravec, Marin, Adrienne Williams, Nancy Aguilar-Roca, and Diane K. O’Dowd. 2010. “Learn before Lecture: A Strategy That Improves Learning Outcomes in a Large Introductory Biology Class.” Edited by Barbara Wakimoto. *CBE—Life Sciences Education* 9 (4): 473–81. https://doi.org/10.1187/cbe.10-04-0063.

Servant-Miklos, Virginie. 2020. “Problem-Oriented Project Work and Problem-Based Learning.” *Interdisciplinary Journal of Problem-Based Learning* 14 (1): 1–17. https://doi.org/10.14434/ijpbl.v14i1.28596.

Steinert, Yvonne, and Linda S. Snell. 1999. “Interactive Lecturing: Strategies for Increasing Participation in Large Group Presentations.” *Medical Teacher* 21 (1): 37–42. https://doi.org/10.1080/01421599980011

Wammes, Jeffrey D., and Daniel Smilek. 2017. "Examining the Influence of Lecture Format on Degree of Mind Wandering." *Journal of Applied Research in Memory and Cognition* 6 (2): 174-84. https://doi.org/10.1016/j.jarmac.2017.01.015