Moodle and Problem-Based Learning: Pedagogical Designs and Contradictions in the Activity System

Rikke Ørngreen[1], Sara Paasch Knudsen[1], Ditte Kolbæk[2] and Rune Hagel Skaarup Jensen[3]
[1]Department of Culture and Learning, Aalborg University, Denmark
[2]Independent Researcher
[3]Center for Digital Supported Learning, Aalborg University, Denmark
rior@hum.aau.dk

Abstract: This paper presents an empirical study and related activity system analysis regarding the implementation and use of Moodle specifically, and learning management systems in general, in problem-based learning. The research involved an exploration of the characteristics that defined use of Moodle at a Danish university, the reasons why Moodle was or was not used in specific contexts and the way in which Moodle use was perceived by students. Some of the obstacles and challenges identified through this study highlighted the need for a deeper analysis of the elements that characterised the activity system(s) and their contradictions in this contextual setting, leading to a consideration of possible implications for change processes. The investigation consisted of a literature review, a survey of 345 students regarding their experiences with Moodle in conjunction with a nomination for the best Moodle course, an analysis of the 178 nominated courses and interviews with four university teachers about their use of Moodle. This examination revealed that many existing Moodle activities at Aalborg University focus more on sharing information and teaching materials and less on the students' problem-based learning activities and projects. This finding is intriguing, as use of Moodle does not reflect that problem-based learning comprises the pedagogical foundation of Aalborg University's academic programme. The investigation uncovered several reasons for the lack of focus on problem-based learning in Moodle structures and content and explored them through the contradictions identified within the activity systems and between the double contextual frame surrounding the interacting activity system.

Keywords: Moodle, problem-based learning, higher education, design, literature review, empirical findings, activity system

1. Introduction

This paper rests on an empirical case study that involved a project, the objective of which was to elicit research-based insight on factors impact the use of Moodle (or similar eLearning platforms/learning management systems) for problem-based learning at the university level. We worked with a concrete level of pedagogical design factors, guided by the following two research questions: 1) What characterises the current use of Moodle at Aalborg University (AAU)? 2) How can teachers use Moodle to support problem-based learning (PBL) activities?

The case study was based on the AAU-funded PBL development project titled 'Learner-Centred Moodle Course Design: Design Factors, Differences in Perceptions and Best Practices'. In this paper, it is referred to as the Moodle Course Design (MCD) project. The project ran from January 1, 2018, to December 31, 2018, and in the early months of 2019, the first version of an online resource was finalised.

Through this work we found that the complex organisational structure, which encompasses university teaching and learning, often presents challenges to the implementation of the project's results. After the project ended, we recognised the need for more profound analytical insight and thus, we investigated the organisational implementation structures and processes through an activity system analysis to uncover the contradictions that impacted the use of Moodle for PBL within AAU. We therefore expanded our investigation with the following research questions: 1) What characterises the activity system(s) and their contradictions in this contextual setting? 2) What are the implications for change processes of this manner?

In Part 1 of this paper, we present the case study, that is, the original MCD project, its research design, the theoretical frame and the empirical investigations, as well as lessons learned from this project. This led to interesting results that provide new knowledge to this field. From the lessons learned, we developed a small online resource for the application of Moodle in problem-based and project-based learning settings like AAU. This also uncovered interesting results on an organisational note; therefore, in Part 2, we present our organisational mapping using activity theory. Here, the method applied, the activity systems analysis, and the special settings in which universities are situated that are tightly regulated by governing bodies – which we

identify as a double contextual frame – are described. Finally, we reflect on the contradictions found in the interacting activity systems and relate them to the more concrete level of the original case study. We also relate to the actions and non-actions the university took after the project's completion. We end by highlighting the challenges and potential courses of action when working with change management structures that pertain to IT-supported learning in university teaching with respect to PBL in a learning management system (LMS) such as Moodle.

PART 1

The objective of the MCD project, according to the project application, was to create 'multimedia resources demonstrating Moodle courses and activities as the best cases nominated by students across study programmes'. AAU defines itself as a PBL university. The project was intended to create materials to facilitate the professional development of AAU teachers, for example, during the university's pedagogy course for assistant professors. Next, we outline the PBL setting in which the case study lived and describe the project's research design.

2. The case study

A case study describes how participants, researchers and others perceive a phenomenon that requires 'thick descriptions' to illustrate its diversity. If the researchers examine areas within their areas of expertise, their knowledge of the case is an advantage in the case study because they have better access to data and a deeper understanding of related issues than people 'outside' the situation, so the research benefits from the researchers' conscious and subconscious knowledge. Case studies may include one or more cases but not a traditional sample (Flyvbjerg, 2006); they are often divided into two categories: extreme cases and paradigmatic cases. Extreme cases are, for example, 'black swans' that would disappear in the statistics in quantitative research, although they certainly exist and provide insights into the diversity of the swans. Paradigmatic cases show general tendencies in a specific case that cannot be generalised but may uncover new knowledge and create new understandings about the case itself (Flyvbjerg, 2006). Case studies do not intend for researchers to be neutral and objective; rather, they should know the case intimately and describe their pre-assumptions and their biases to allow others to understand their position.

In this case, the researchers' pre-assumptions included a positive attitude about IT in general and LMS systems as supportive for teaching and learning. The researchers of this specific case were employed at AAU and, therefore, were committed to PBL, preferring this pedagogy over more traditional methods of university instruction. Hence, the researchers were biased regarding the case, as they were personally involved in the university as well as in the specific pedagogy of this university. To create distance in the study to the LMS in their workplace, the researchers excluded their own instruction and materials from consideration and based the study on mixed methods to enhance ambiguity.

The authors considered ethical issues, such as their role in interviewing colleagues, formulation of the questionnaire items and the implications of asking students to participate. As interviewers, it was important to involve colleagues with whom they did not normally collaborate in the work of the university and clarify for colleagues that they were free to decline participation. The researchers ensured informed consent to use the anonymised interviews for publication and were highly aware of the interviewees' vulnerability, which allowed the interviewers to ask about ways of teaching and utilising Moodle (Kvale, 1997; Brinkmann and Tanggaard, 2010).

2.1 Problem-based learning

AAU was established in 1974 in the rural city of Aalborg, Denmark, and now has two additional campuses in Esbjerg and in Copenhagen. The university employs approximately 2,500 academics who conduct research and teach over 20,000 students. AAU faculty represent the humanities, social sciences, engineering/science, medicine, information technology (IT) and design. Like most universities, AAU collaborates with external organisations, both private and public. However, AAU's pedagogical approach to problem- and project-based learning, known as the 'Aalborg PBL Model' (Barge, 2010), extends collaborative relationships to also involve external organisations and students when the students are working on their PBL-projects. AAU employs Moodle as their LMS.

The Aalborg PBL Model requires student learning to be based in real-life situations, often within external organisations, comparable to what Sipes (2017) called 'authentic problems'. Students formulate a question (i.e. problem definition) that addresses a practical situation and perceive the problem through the lens of their curriculum. They approach the question through relevant theories and select appropriate methods to gather empirical data. Their analyses and conclusions should answer the initial question/problem definition by providing solutions, which are often presented to the external organisation.

Problem-based learning encompasses numerous types of problems and practices. Sipes (2017) provided an overview of various PBL practices as an analytical framework and showed that a wide variety of PBL types exist, ranging from the presentation of small case examples in lectures, to assigning students to work on an entire problem case and engage in free inquiry in attempting to solve the problem for example on a given design or policy problem (Sipes, 2017, p.4). Jonassen and Hung (2015) demonstrated that varying complexity levels require multiple levels of knowledge; they argued for more attention to the problem difficulty level when designing PBL activities, asserting that PBL requires students to possess or gain insights into subject matter theories and methods through the PBL process.

Semesters at AAU are predominantly divided into traditional modules that focus on subject matter supplemented by a semester-project module that works across modules. PBL activities may take place in both modules. For example, during a software development module, students may be required to solve predefined and relatively small programme dilemmas using a few lines of code, whereas in the semester-project, they may have to contact a company, define an area of potential development and develop and theoretically address the chosen solution in the project report. During traditional modules, full-time students typically attend lectures and classes about 20+ hours/week, while during the semester-project, they take responsibility for their learning by working on their problems in groups, attending few to no lectures and instead attending supervision meetings and sometimes plenary Q&A and peer-feedback sessions.

2.2 Research design

The research design for analysing the MCD project comprised seven activities, carried out sequentially but also with overlaps, particularly between the literature review and more empirically grounded activities. The systematic literature review (Hart, 2018), conducted first, identified challenges to, potential benefits of and useful guidance for using Moodle in PBL teaching. Two types of searches were performed for the literature review: a library database search using ProQuest and a Google Scholar search using Harzing's Publish or Perish software. To ensure the review would be useful for AAU teachers, only papers containing up-to-date research that investigated the most recent versions of Moodle were included. The systematic searches were, therefore, restricted to papers published in the six years spanning 2013 through 2018 that included the words: 'Moodle' and 'problem-based learning' (plus variations) in the titles and/or subtitles. The search produced only a few research papers with concrete examples of the relationship between Moodle and PBL; several papers investigated Moodle as a technologically enhanced educational tool, but almost none specifically investigated PBL use in Moodle. Similarly, numerous studies investigated PBL and university teaching, but few explored the practical level of design and implementation of PBL in Moodle. These findings, which we carried into the ongoing project, reflected the issues of organisational technology implementation and acceptance discussed in the second part of the current paper.

As the second activity for this research, the project team held four in-depth interviews (Kvale, 1997; Brinkmann and Tanggaard, 2010) with AAU faculty. Burden, Topping and O'Halloran (2015) revealed (through a literature review and empirical investigation) that artefacts can aid in comprehensive retrospective examination of decision-making, and Akama et al. (2007) reported that artefacts in a show-and-tell format '*enabled each participant to communicate an individual understanding of complex interactions with others from within, and reflexively display their understanding of those interactions to others'* (Akama et al., 2007, p.180). During the interviews, the project members, in collaboration with the teachers, investigated the Moodle design and use strategies employed by the teachers interviewed, applying the platform as an investigative artefact. Another option available for data collection was to survey the broad teacher faculty population, but we believed the interviews extended data gathering beyond that approach. Selecting the interview strategy stemmed from our case design (Flyvbjerg, 2006), for which collecting rich and thick descriptions of everyday practices and insights into the argumentations behind actions was viewed as an important research step. Thus, to obtain a broader picture, as our third research activity we incorporated a student survey into the research design. For this survey, conducted using SurveyXact, 345 students nominated their best Moodle course and identified their motivation

for their choice. The nomination survey did not represent a traditional survey style, involving several questions to be analysed. Though the survey gleaned many responses, semi-statistical analysis was only performed to determine which course(s) received the most nominations.

Based on these results, we investigated the structure and content of the most nominated courses and the wording students used to justify these nominations. (Students had the option to nominate a course without providing qualitative details to the explain the reasons for their choice, but many did provide such details.) Therefore, an analysis (Brandi and Sprogøe, 2019) of the nominated Moodle courses and students' answers that investigated how the courses were designed in Moodle, why the students liked them and whether the students had any negative aspects to convey constituted our fourth research activity.

In addition to these pre-planned activities, the project members, during the project lifecycle, recognised a need to include experiences and materials from other sources rather than exclusively relying on knowledge from journals and similar academic research publications. Therefore, for our fifth activity, the team searched for existing practical materials at AAU and online that could support AAU teachers when using Moodle for PBL activities. As the sixth activity, the team visited Delft University of Technology (TU Delft) in the Netherlands and conducted and edited (audio-recorded) interview with a project manager for the collaborative learning environment to inspire strategies for implementing and supporting faculty in their use of Moodle. The seventh and final activity consisted of developing the concrete pedagogical findings into teaching and learning materials of various formats. These materials were posted in an online resource in Moodle.

Generally, these investigations and the analyses that followed provided new knowledge about the use of Moodle relative to PBL teaching and, more specifically, about the implementation strategies of AAU teachers and coordinators and how these strategies were perceived by AAU students.

3. Literature review

The findings of the literature review are presented according to three categories: challenges, potential benefits and useful pointers for utilising Moodle for PBL.

3.1 The challenges of utilising Moodle for PBL

Mbuva (2015) identified the following challenges associated with online teaching: hidden costs, lack of computer literacy, lack of self-discipline, not suitable for all learning styles, minimal social interaction, difficulties in staying motivated, difficulties in improving oral communication, technical problems and lack of adequate training for faculty. In general, more faculty training is needed on the use of Moodle, while onsite support and reliable Internet connections are important for both students and teachers (Mbuva, 2015).

Students are generally not pleased with their initial experiences with using Moodle, but their level of satisfaction with the platform frequently changes as they become more familiar with its functions and structures. Research shows that the more experienced students are with using the Internet, the faster they can familiarise themselves with Moodle (Mbuva, 2015; Orfanou, Tselios and Katsanos, 2015).

Most LMSs, including Moodle and even those that do not support dialogue, are designed with traditional lecture-based instruction in mind. Thus, they are not intrinsically conducive to a PBL approach (Ali, Dous and Samaka, 2015). When teaching is conducted exclusively online, non-verbal and informal communication are often missing (Stockleben et al., 2017), and with no physical presence in a classroom and communication occurring as a one-way communication system (i.e. from the teacher to the students), students find it challenging to collaborate; to ask teachers for help, guidance and supervision; and to receive meaningful feedback from teachers and fellow students (O'Sullivan and Krewer, 2015; Yu and Lee, 2016). Combining synchronised and asynchronous teaching can be difficult, but several studies show that synchronised teaching is important, as it reduces the rate of dropouts and has a positive impact on exam results (Moreillon, 2015).

Regarding the focus of this study, it appears that teachers find it difficult to define, design and structure the specifications of project and problem-solving online activities, which then makes it difficult for students to understand the goal or purpose of the project and/or activities. This situation can hinder teachers' ability to engage students in the associated online activities, which creates obstacles for the teacher in terms of following the students' progress and offering relevant feedback (Agüera et al., 2015; O'Sullivan and Krewer, 2015). Moodle

is an open-source platform that allows for the inclusion and development of plug-ins. However, creating a full PBL environment in one plug-in for Moodle is also complicated by variations in the PBL models used by educators (Ali et al., 2015).

3.2   The potential benefits of utilising Moodle for PBL

Online activities can support students in their reflections and provide teachers with insights into their students' progress. This requires the teacher to be present (visible and active) on Moodle (Mbuva, 2015). For example, if the teacher, through Moodle, becomes aware of individual or groups of students who lack knowledge about a subject, they can add material to Moodle that is relevant to that specific student or group to address the deficiency (Orfanou et al., 2015). When students can easily access learning materials and they use those materials frequently, their grades improve, according to some studies (Cardozo de Castro Junior et al., 2017). Feedback can occur within faster loops in Moodle, and long email communications can be replaced with discussion forums (Mbuva, 2015). According to Yu and Lee, '*Research shows that online peer feedback provides a less threatening environment that encourages greater and more equal member participation than face-to-face peer feedback*' (2016, p.469). As such, students will perceive the process of receiving peer feedback as less stressful when that feedback is provided online because no non-verbal communication is involved, they can read the feedback multiple times and they have more time to reflect on it. The results of most of these studies showed that Moodle can offer considerable support to students in terms of their learning (Cardozo de Castro Junior et al., 2017) when PBL pedagogies are applied and when the teacher acts as a facilitator of a learning space by applying a democratic learning approach (Stockleben et al., 2017).

When creating and using modules based on metacognitive, conceptual, strategic and procedural scaffolding, Moodle can be designed to support students in a PBL environment and enable activities that promote the development of problem-solving skills (Tiantong and Teemuangsai, 2013). Some find that essential tools for PBL environments, such as collaborative and communicative tools, are already available in the core Moodle system. Brabazon et al. (2012) developed a plug-in that supports PBL by providing personalised and context-specific learning episodes; indeed, hundreds of freely available plug-ins have been created by the Moodle community that can support the building of learning environments (Ali et al., 2015).

3.3   Useful pointers for utilising Moodle for PBL

Moodle supports various types of tools; moreover, linking to other external tools from within Moodle is a relatively straightforward process. Teachers should explore the possibilities in Moodle that best support their teaching (e.g. quizzes for training-specific terminologies, wikis and blogs through which students can share additional literature, YouTube videos) (Moreillon, 2015). Teachers can also experiment with Moodle together with their students to inspire the students to explore, on their own, what Moodle has to offer without fear of failing (Moreillon, 2015). Teachers have been encouraged to provide students with an opportunity to be co-designers of the Moodle space, as applicable to the nature of the course and project work. Engaging students in such design activities may increase their motivation and use of the materials and tools applied (Stockleben et al., 2017). Such opportunities may also be advantageous if students can provide each other with feedback and learn from each other's writings (O'Sullivan and Krewer, 2015).

According to Ali et al. (2015), advantages are associated with using Moodle's existing features and developing PBL plug-ins. First, the PBL approach benefits from Moodle's existing infrastructure, tools and features. Second, development efforts and resources are minimised. Third, the development process can benefit from the internal IT support that Moodle offers. Fourth, the approach can potentially be disseminated to other institutions (Ali et al., 2015).

Teaching goals, project information, course structure, dates and deadlines need to be communicated clearly, preferably from the beginning of the course (O'Sullivan and Krewer, 2015). When activities take place online, a facilitator must be present to support and move those activities in the desired direction (Stockleben et al., 2017), for example, being active in the students' discussion forums, which also provides the teacher with insights into the students' progress. Teachers also need to foster open dialogue, so students feel welcome to give and receive feedback, build on each other's statements and come up with wild ideas (Stockleben et al., 2017). In this vein, teachers should be equally explorative in their approach. For instance, instead of giving live presentations in class, students can prepare video presentations in advance that they then post on Moodle; their fellow students can then watch the videos multiple times, which can lead to feedback that has been better formulated and reflected upon (Moreillon, 2015).

In summary, various factors that teachers can consider when designing and carrying out the teaching process using Moodle emerged through the literature review. However, the review also revealed that some actions may lead to varied results, depending on the context in which they take place. For example, although teacher involvement in activating students is important, simply inviting students to participate in an online exchange of ideas may not in itself foster dialogue. In some situations, where the objective is unclear or where the predominant culture of the course comprises one-way communication, students can be reluctant to engage in online dialogue. In other situations, if the teacher's pedagogical teaching style (whether in a physical location or a video meeting and in the Moodle activities) generally seek student involvement, then students may be more active in responding to such invitations. Therefore, before everything else, pedagogical choices and strategies need to be clearly defined and explained to students.

4. Results of the empirical study at AAU

Next, we present the findings of the empirical study, organised according to the three points of analysis: teacher input, student input and nominated courses.

4.1 Findings from the teachers

The first phase of the MCD project involved an empirical investigation intended to discover more about existing teaching practices at AAU, including teachers' motivations for their choice of design for Moodle modules and their experiences during and after implementation of the modules. To collect these data, four in-depth interviews were conducted, which included discussions about, and post-analysis of these teacher's Moodle rooms. The interview data revealed the following about the teachers interviewed:

- They lacked information about Moodle features and the potential of the specific AAU version (as each organisation decides which elements are installed into its Moodle system).
- They lacked knowledge or inspiration about how to work with these features pedagogically and within the framework of PBL.
- They felt quite alone in terms of designing their own Moodle rooms.
- They reused the prior year's module structure, even when a different teacher had taught the course previously.
- They met with their students on campus regularly; therefore, not everyone realised the benefits of using Moodle beyond information dissemination (such as sharing slides or similar activities).

Though these findings are not generalisable to all AAU faculty, the interviewed teachers noted that the issues they had with Moodle were similar to those that their colleagues experienced and similar to what the MCD project members had heard as teachers and supervisors for assistant professors throughout the years.

4.2 Findings from the students

The second phase of the project was designed to obtain a more detailed understanding of student Moodle use and experiences. The project team (with the IT department) arranged a nomination campaign in the format of a SurveyXact questionnaire; a banner appeared on the AAU Moodle main page in June 2018 that contained a link to the questionnaire. Students could nominate their favourite Moodle course and present an argument to defend their choice. These written arguments provided insights into the students' priorities in relation to the use of courses on Moodle. A total of 345 students completed the questionnaire, and 178 Moodle courses were nominated. The nominated courses were exceptionally varied in their subject matter, faculty, length, number of students (class size) and European credit transfer system (ECTS) size. Although the nominations provided a significant amount of data, they may not be statistically representative of the 20,000 students at AAU. However, they did provide in-depth understandings of the elements of AAU Moodle courses that students like and find meaningful.

The students' written arguments supporting their nominations were analysed. Most students answered directly to the objective of the survey, indicating the courses they nominated made good use of Moodle. However, a closer examination of the survey responses showed that some students were also critical. One student wrote: *'This way of collecting information is biased. You only want positive feedback. Moodle works very badly. There is not one single module where Moodle is used well'*. Another student stated: '*None of them [teachers] have used it much, and none of them have done it well. Therefore, no module can be nominated'*. The survey provided space in which students could provide such critical feedback, which the answers themselves reflect, and we found this

information from the students quite valuable. Also, in the preliminary analysis of Moodle courses, we discovered some courses that reflected almost no activity; moreover, in some courses, the few activities that did exist were not explicitly presented (with purpose or introduction), nor did they appear to be pedagogically designed. Thus, from these two data points (the students and the course analyses), we discovered that many AAU courses did not utilise Moodle to its full potential as a learning resource. Rather than further investigating the modules that did not make the best use of Moodle, the team turned to further identifying and analysing the courses that seemed to effectively incorporate Moodle, according to the student survey respondents.

Most nominations were submitted by students who had had positive experiences with Moodle. One student claimed: '*I have used Moodle during all of my semesters, and in my opinion, the teachers use Moodle diligently and effectively for the benefit of my learning experience'.* Another wrote, '*Most courses used it well – can't really pick ONE since most people structured the courses in lectures (some with dates) and gave the course materials under each lecture*'. The analysis also illustrated that some students did not recommend a single course but recognised a specific teacher or group of teachers, commenting on the teachers' excellent pedagogical skills in general more so than on their use of Moodle.

4.3 Findings from the nominated courses

At AAU, Moodle rooms are used for courses that contain small-scale PBL activities and exercises and for large-scale semester projects. Some of the Moodle rooms, related to the traditional modules, contained PDFs, PowerPoints and links to digital tools and exercises that supported the subject matter of the course through teacher-defined problems and exercises. However, use of these activities on Moodle in relation to the large-scale semester projects seemed to be limited; instead, knowledge-sharing between students and teachers primarily took place on campus or, perhaps, through other platforms, such as Facebook, that were not linked through Moodle.

The students who nominated a course for exemplary use of Moodle often, in fact, actually nominated their teacher(s). The analysis evidenced that nominated Moodle rooms did not necessarily display advanced use of Moodle or of its use in relation to student-oriented PBL activities. Teachers who communicated clearly, structured the course plan in relation to its learning objectives and then organised materials and formulated assignments and other activities according to this plan generally motivated the students. The students also appreciated the use of a wide range of Moodle activities, such as discussion forums, quizzes and interactive videos. Very few of the Moodle rooms contained external links to other activities, such as further interactive materials, collaborative resources like google documents, video conference rooms or similar external activities.

The analysis showed that, in general, the AAU courses did not make use of activities that can activate and inspire students' activities through Moodle, and only a few employed collaborative or peer-to-peer activities. Most of the Moodle rooms instead were used to provide students with an overview of the course and predominantly worked as one-way communication channels. Most rooms also contained a forum through which teachers could broadcast messages to all students enrolled in the course. However, only a few rooms exhibited evidence of communication 'loops', in which students interacted with the teacher and other students, asked questions and received responses and evaluations. Collaborative communication patterns that allow students to answer other students' questions and comments and partake in dialogue were rarely present in the Moodle rooms.

5.   What was developed

Communicating the findings and results of this study to AAU teachers and programme coordinators was a central goal of the project. Consequently, an online resource was developed called 'How to do PBL in Moodle'. This online resource addressed some of the issues and needs identified during the research process. Figure 1 presents a poster that illustrates the project and resulting Moodle resources generated. The Moodle room was designed to inspire teachers in designing their courses on Moodle and for use in other pedagogical contexts, such as AAU pedagogical courses or one-to-one sessions between teachers and IT-pedagogical consultants. The design was based on a micro-pedagogical perspective that focused on how Moodle and its functions can be used in relation to the findings of the literature review (Section 3) and the analysis of the empirical data (Section 4).
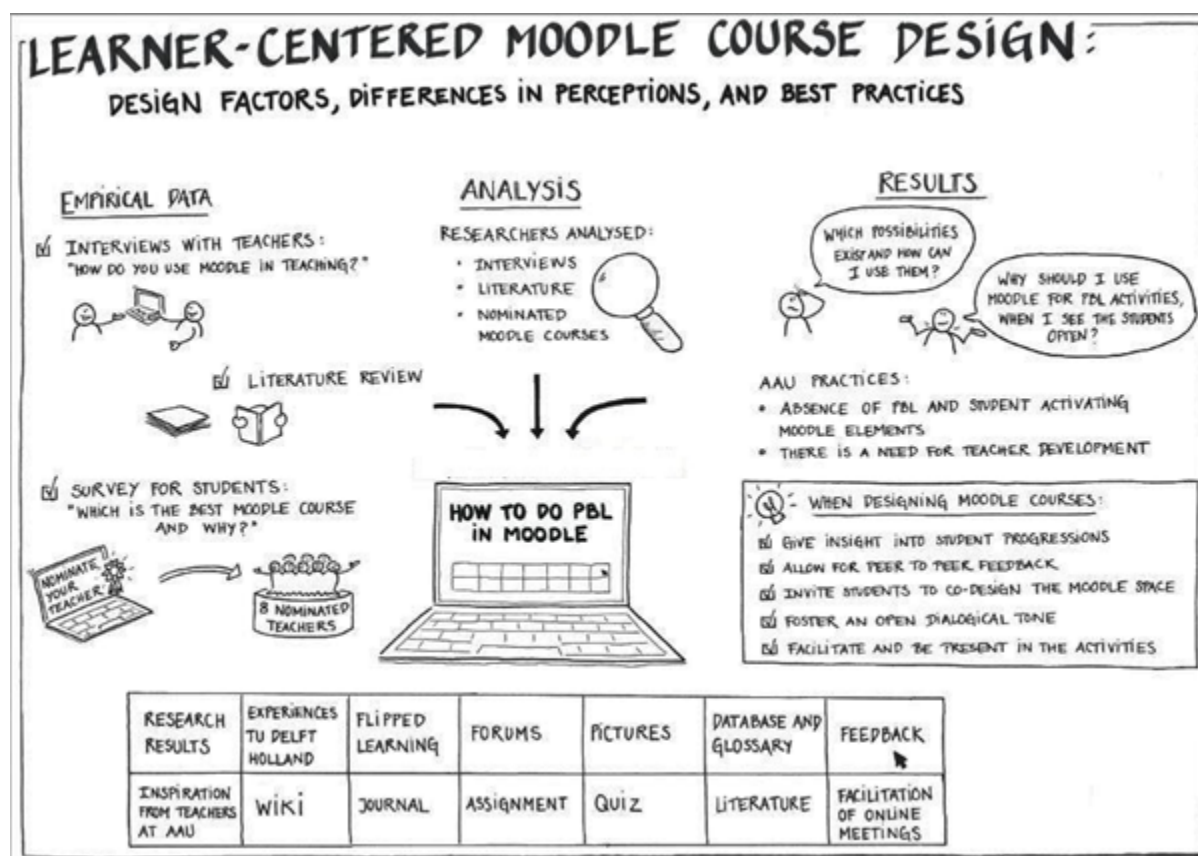
Figure 1: The MCD project, process and products (Source: Created by Heidi Hautopp and the team through a graphic facilitation process). ©MCD Team, 2019

With permission from the nominated teachers, direct links to the eight Moodle courses that received the most nominations were included in the Moodle room designed as part of this project, thus enabling other AAU teachers and coordinators to view and draw inspiration from these real cases. The project members also added appropriate materials and developed videos and texts to illustrate how to utilise specific Moodle functions and tools for student-oriented and PBL activities (e.g., blended learning formats and digitally supported campus teaching), as these elements were not prevalent in the nominated modules. Also included in the room were materials linked to existing internal and external AAU sources, while other materials drew on the experiences of the project members' own use of PBL-supporting activities in Moodle. Results and findings from the investigations and videos from the project members' visit to TU Delft University were also added to the room.

6.   Lessons learned from the MCD case study

The analysis of the MCD empirical material shows that many AAU Moodle rooms did not use student-based or PBL-inclusive activities. Instead, the rooms primarily served solely as content holders. This poses a challenge for both teachers and students, similar to what Ryberg, Buus and Georgsen (2011) referred to as content silos that promote teacher-centred pedagogies, not collaborative learning and project-based pedagogies. The use of Moodle rooms as content holders may also constitute a problem for AAU students during their large-scale semester projects. Here, they are supposed to use knowledge gleaned from the traditional modules, though such knowledge was not easy to locate across the different Moodle rooms (modules). Perhaps this situation is a consequence of what Ali et al. (2015) referred to, namely, that Moodle was designed with traditional teaching in mind and that the traditional teaching approach does not necessarily adapt well to PBL approaches.

The findings raise the question as to how Moodle can be used for PBL activities when many educational programmes at AAU are full-time, day study programmes. Employing technologically enhanced learning via Moodle for PBL activities does not seem to be a natural choice for faculty when they teach and meet with students in real life. At AAU, students visit the campus almost every day during the semester. Teachers may find that students' physical presence makes them reluctant to utilise Moodle to a greater extent. Also, a large

proportion of the instruction at AAU takes the form of supervisory teachings due to the PBL model. Though some use Skype or similar tools, supervision primarily takes place on campus.

Thus, both opportunities and challenges were present in the application of PBL activities to Moodle. If teachers feel competent using Moodle tools and can foresee a meaningful strategy for these tools within their teaching, then Moodle can support their overall learning approach, as highlighted by Cardozo de Castro Junior et al. (2017) and provide a meaningful space for students' PBL activities.

During the MCD project, multiple local AAU-developed guidelines and experiences were located regarding the use of Moodle, such as technical materials (on the AAU website); additionally, we were directed to pedagogical materials from past AAU PBL development projects. We discovered that relatively few from the faculty appeared to be aware of these materials, as they seemed to be unused. From our research conducted with other universities and educational institutions, both nationally and internationally, we found that this situation is the norm rather than the exception in most such settings. Although these materials are sometimes known to management, teachers are not aware of them. This raises the need to discuss and determine a strategy for how to assemble, communicate and make the most of such initiatives.

PART 2

7. Investigating organisational implementations through an activity system analysis

Learnings from the MCD project pointed to a complex organisational structure as the basis for using Moodle at a PBL university. We used Engeström's activity theory to map the organisational structure in order to investigate and uncover the contradictions revealed in our project that impacted the use of Moodle for PBL within AAU.

7.1 Human activity theory

Yrjö Engeström developed the theory of the human activity system, upon which this investigation built (Engeström, 1987; 2001; 2011). Problems, contradictions and conflicts caused by the historical development of the organisation prompt a need for change and can act as starting points from which members of the organisation can learn. Figure 2 illustrates the human activity system that comprises six components: subject, object, instruments, rules, community and division of labour.
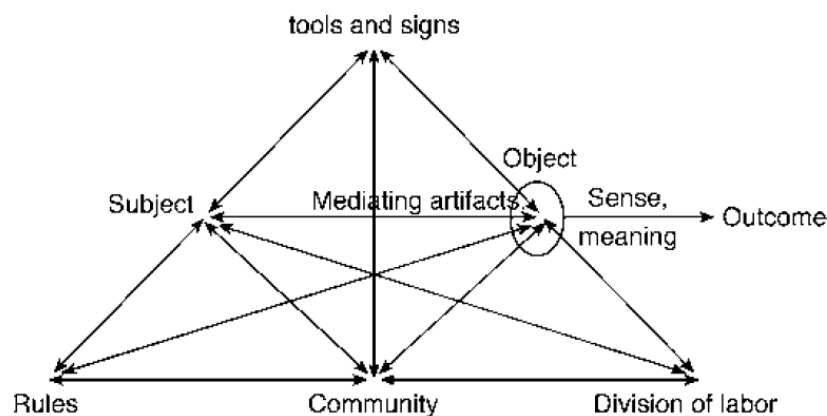
Figure 2. The human activity system (Source: Engeström, 1987, p.78)

A *subject* may be a person or group of persons striving to achieve a shared object; this process is influenced by the instruments, rules, community and division of labour. The *object* initiates and motivates the subject's activity, as the object is the purpose and the meaning of the human activity system. The object defines the direction in which the subject moves, and the object motivates the subject to strive against this object. When the subject moves against the object, learning is created. The object has the potential to change the other five elements, and it reveals internal contradictions in habits, working processes and historical development (Engeström, 1987). *Instruments* include physical tools, IT systems and language. The instruments define obstacles and enablers for the subject to achieve the object. *Rules* equate to formal guidelines and regulations as well as habits and norms. The *community* is the organisation, the line of business or the working group in

which the learning is constructed. Finally, the *division of labour* describes different community roles and obligations.

7.2 Interacting activity systems

In more complex organisations, several activity systems exist. The model in Figure 3 shows how they can relate to each other. The interesting part is that such systems do not necessarily have a shared vision or object. According to Engeström (2001), the object of activity within the interacting activity system is a moving target – the different states of the object are represented in the model by Object 1, Object 2 and Object 3 (see Figure 3). The object moves from an initial state (Object 1) to a 'collectively meaningful object constructed by the activity system' (Object 2) and, finally, to 'a potentially shared or jointly constructed object' (Object 3) (Engeström, 2001, p.136).
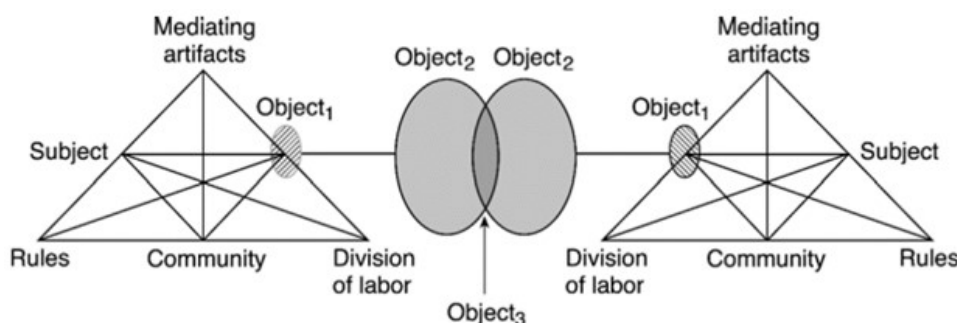

Figure 3: Model of the interacting activity system (Source: Engeström, 2001, p.136).

Engeström (2001) stressed that the human activity system provides a spectra of multi-voices, as the subject most often comprises a group of people with different experiences and perspectives, which they express in varying ways, and that changes in the activity system are driven by the following four types of contradictions:

1. Primary: Contradictions within a component
2. Secondary: Contradictions between different components
3. Tertiary: A culturally advanced object externally influencing the system
4. Quaternary: Contradictions in the relations between different systems (Engeström, 1987)

8. Analysis of the AAU activity systems as it pertains to PBL and digital teaching/learning

Data from the project reflected four systems but primarily informed about two activity systems: the teacher system (T-system) and the student system (S-system). The other two systems indicated in the data were the educational programmes (EP) and AAU. Certainly, more systems exist within such a large, complex organisation, but from a PBL and digital teaching/learning perspective, we found these systems to relay important factors. The subject of the T-system consists of the people at AAU who are in contact with students through teaching and/or supervision. The subject of the S-system is the people who attended the different educational programmes offered at AAU. The relation between the T-system and S-system can be considered asymmetrical due to the inherent authority that the T-system has over the S-system. On the other hand, the S-system, due to the impact that passing an exam/module has on a student's education, can make demands of the T-system related to preparing them accordingly.

8.1 The Educational Programmes and Aalborg University as a double contextual frame

The data in this project primarily informed about teachers and students using Moodle for PBL; they did not provide enough information to describe the activity systems of EP and AAU in detail. It was, however, apparent in the data and the tensions we encountered that these activity systems had an impact on the T-system and S-system. Therefore, we have represented the EP and AAU activity systems as a double contextual frame surrounding the teacher and student activity systems. On a broad level, AAU is influenced and governed by the laws pertaining to universities in Denmark as well as by the economical setting. The frame in some ways acts like a 'culturally advanced object' influencing the T-system and S-system, and tertiary contradictions arise when it is introduced, which we expand upon in our discussion. Analysing the impact between this frame and the two activity systems adds to a better understanding the use of Moodle for PBL at AAU.

8.2 The objects of the interacting activity systems

Like most universities, AAU maintains a digital strategy (AAU, 2018), and through the frame, it impacts on the T-system; therefore, Object 1 in this situation can be defined as 'digitally supported teaching'. From the perspective of the S-system, the students chose to attend this specific university, which, like most others, offers digitally supported teaching; therefore, Object 1 can be defined as 'digitally supported learning'. As described previously, Moodle was selected by AAU as the university's primary technological tool and the official LMS. Through the frame, the use of Moodle impacts the interacting activity systems – T-system and S-system – and all teachers are required to use the AAU version of Moodle with the chosen templates and plugins for their classes. Moodle then becomes an access point for all students when attending AAU. For the T-system, Object 2 can be defined as 'use of Moodle in one's own teaching practices - with Moodle as a prerequisite' and for the S-system Object 2 can be defined as 'Moodle as an access point to learning – with Moodle as a prerequisite'. As described in Part 1, AAU uses PBL as its primary pedagogical approach, and student learning is required to be based in real-life situations; thus, Moodle becomes a tool for PBL. For the interacting activity system and through the impact of the frame, Object 3, the potentially shared jointly constructed object (Engeström, 2001, p.136), therefore, can be defined as '(joint understanding of how) Moodle supports PBL'.

8.3 Mediating artefacts

In educational research that applies Engeström's work, we see how artefacts pertain to different levels of use, (and here as inspired by among others Leadbetter, 2004). One level is Mediating Artefacts as methods, where artefacts are used as signs which guide and direct processes and procedures towards the objective. The other level, is Mediating Artefacts as tools, which are used to identify and describe the objects.

In this light, within the T-system, PBL can be considered a mediating artefact as methods. PBL is a pedagogical method, and includes both teaching approaches as well as student participation. In addition to PBL, each teacher employs different methods and didactics to support PBL within their education and specific topic. They also supply students with theories from their areas of expertise in alignment with the curriculum of the education. Digital tools are also part of the Mediating artefacts in use at AAU, both hardware as mobile devices, computers, and also different software, as the LMS Moodle. Teachers can exert control over some artefacts and choose whether to use them; others are dictated by the frame.

Students attending AAU have chosen to attend a PBL university (for some probably a more explicit choice than for others), which makes PBL an essential part of the mediating artefacts within the S-system. They share the digital tools described previously, although they often have different prerequisites for using them than teachers, which can be due to knowledge, experience and attitudes towards technology.

8.4 Rules

The T-system is impacted by the frame EP and AAU as well as by rules dictated from outside the systems of AAU. This is seen in how the Ministry of Education & Research and AAU direct educational programmes via economical support and regulations about preparation time per type of teaching method, or in how PBL and digitalisation must be visible in the study regulations. However, teachers are also able to impact the frame as coordinators and members of study boards, where they, on a micro level, can decide the educational design. Also, pedagogies and teaching methods chosen within the specific module, and even within each session, are largely decided by teachers, provided they fall within the broader frame of PBL and comply with the study regulations. In addition, norms form over time (historicity, Engeström, 2001, p.136) concerning teacher–student relationships, groupwork and how to approach teaching within an education and/or faculty. Some of the rules impact the T-system from outside the activity system of AAU; moreover, some rules, such as General Data Protection Regulation (GDPR), apply to both research (when applying research-based teaching), students' projects and handling students in general.

The rules of the S-system are both explicit and implicit (Engeström, 1987) and heavily impacted by rules from outside the activity system of AAU, such as GDPR, and the factors mentioned concerning the frame. The rules of what it means to be a student at a university in Denmark, from the application process to earning a degree, are largely governed by laws and guidelines dictated by the Ministry of Education. As in the T-system, students can impact the frame on a micro level by joining study boards and taking an active role in evaluations, which can impact the educational design of the programmes. In addition to the rules from outside the activity system of

AAU, PBL, groupwork, the curriculum of the different programmes and the norms of the faculty all affect the rules within the S-system through the frame and, similarly, the historicity of norms and values.

8.5 Division of labour

The conditions of the frame (see Section 7.1) and the rules (see Section 7.4) constitute how the organisation is structured. Due to the organisation's size and the lack of homogeneity among teachers (different disciplines, department cultures and employment positions), this area is quite complex. We have found in this context both horizontal and vertical divisions of labour (Engeström, 1987). Horizontally, teachers are assigned to teach courses in varied academic programmes and multiple semesters, though often within their research field or at least within a related subject area. Vertically, there are different roles when teaching, such as being responsible for a semester or module and consequently the Moodle content, or being a guest teacher within another teacher's Moodle room. Furthermore, teachers are also often vertically distributed to other tasks, such as research or administrative/managerial tasks at AAU. A smaller group are part-time teachers, who have jobs outside AAU (in companies or at other universities/colleges). As described in rules, impact can be made on the frame regarding divisions of labour as coordinators and members of study boards.

Academic programmes at AAU are separated by faculties and study boards, the S-system is as such influenced by the same conditions and the vertical division of labour as in the T-System. Due to the vertical separation students primarily work within their own education and rarely across different disciplines. Within the fields of study you have a more horizontal division of labour as the students are separated into semesters, and here work with other students within the same semester. Again, through evaluations and joining study boards students can, as describe in rules impact the frame.

8.6 Community

Within the T-system, a teacher can be a member of several communities, some aligned with each other, others more at odds with each other due to differing priorities. A teacher operates within one or more academic programmes, an institute, a faculty and the university. In addition, as a researcher, a teacher is also part of one or more research groups and laboratories that can be developed across institutes and academic departments. The priorities of the research community may not agree with those of the teaching-oriented communities, and although teaching experience is a prerequisite for a tenure position, it is the faculty member's research that gives true merit to a career path towards tenure and professorships.

As described in the section on division of labour, students are divided into semesters and study groups, which affects the community within the S-system. They are also affiliated with the institute and faculty, but usually more loosely. Through social activities, they can also be part of student organisations both within and outside the university.

9. Discussion

In the following we only touch upon the contradictions in a way that highlights the use of Moodle for PBL both within the interacting activity system and between the systems and the frame. Within the mediating artefacts, rules, division of labour and community in the S- and T-systems, and between the two interacting activity systems, several primary, secondary and quaternary contradictions arose based on priorities, attitudes and experiences with using Moodle for PBL. For example, the priority placed on research (in the teachers' career paths and the frames with explicit attention on external funding) as described can be at odds with the T- and S-systems' objectives to fully utilise Moodle for PBL, causing contradictions within the system. The impact of the frame as well as from outside the AAU system can also promote various contradictions, especially when it comes up against the individual approaches regarding both teaching and research. This can also lead to contradictions involving other components of the system, such as community. Similarly, students have implicit rules about what it means to be a student as it pertains to participation in class, groupwork and social activities, which also can cause contradictions.

Several of the contradictions can be traced back to the impact of the frame on the interacting activity T-system and S-system, such as an impact that acts like a 'culturally advanced object' (tertiary contradiction). We can conclude that many of the contradictions that arise within the interacting activity system do so because decisions often are made within the frame and outside the system. Due to the great influence and impact of the frame, as well as influences outside the AAU system on the interacting system and on the individual system, it can be

difficult for both the individual systems and the interacting system to engage in expansive learning because the model of expansive learning is based on the premise that the setup of the activity system can be changed and the potentially shared jointly constructed object (Engeström, 2001, p.136), based on what has been described, can be questioned.

During the end of the MCD project and in the months that followed, AAU investigated and established a centre for digitally supported learning with central and local members at the faculty level, identifying the objective to work on the macro, meso and micro level of the university (Horst, 2012, p.7). So far initiatives from the central unit have mainly been concentrated on the macro level, that is, related to the strategic level of the university. The centre works from an understanding of the micro level and develops recommendations for the macro level based on the frame of anchoring PBL and the use of Moodle. The frame then determines the suggestions to be implemented throughout all of AAU, providing knowledge and suggestions to the strategic educational board on how to work with and integrate PBL and how to incorporate digitisation into the AAU academic programmes, which the strategic board then initialises work on, via the study boards and the study regulations. Initiatives from the local unit that we are members of (humanities faculty) have primarily worked on a micro level supporting teachers in their teaching approaches, via courses and mentoring in specific modules, i.e. how to use peer grade pedagogies for a specific topic. Our activity system analysis suggests, however, the need to address the meso level more systematically, which could be a constructive next step. Such a next step requires profound knowledge of the contradictions in the system.

As part of the project, we visited TU Delft, which has changed its LMS within the last two-three years and which is also characterised by a PBL approach. The decision makers at that university implemented the new LMS according to two central guidelines: how the LMS can make teaching easier for teachers and how the LMS can make learning better and easier for students. These guidelines turned the usual approach to selecting an LMS based, first and foremost, on economic and technical constraints and possibilities on its head. This selection criteria can act as inspiration for addressing some of the contradictions we have pointed to in this analysis and what to keep in mind, especially at the meso level.

Thus, it would be fruitful for the AAU study boards, programmes and semester coordinators to discuss the identified challenges and opportunities presented in this paper (Parts 1 and 2) to investigate how the future use of Moodle from a PBL perspective can be incorporated into their specific programme. Such developments should, according to Tiantong and Teemuangsai (2013), rely on knowledge of the subject matter and a close theory–practice relationship as well as knowledge of IT-based learning pedagogies and learning design processes, to scaffold the students' progress.

10. Conclusion

Based on the research questions, an important finding from the project is that regardless of which Moodle course design or activities teachers choose, the choice must be rooted in pedagogical reflection, as highlighted by Tiantong and Teemuangsai (2013), and the content and activities used in Moodle must be clearly communicated, whether this is on a micro, meso or macro level (Horst, 2012), not only to ensure clear objectives and expectations for students' work, but also to exhibit these to the students in Moodle, as suggested in O'Sullivan and Krewer (2015).

The paper presents insights into teachers' and students' experiences with Moodle, especially in relation to PBL-activities at universities. The discussion raised questions of concern as to how the organisation can support faculty in using Moodle for PBL activities, addressing the contradictions found in our activity system analysis. Furthermore, contradictions arose as dilemmas or challenges in priority, such as when implementation of a new pedagogical use of technologies requires efforts that may conflict with endeavours to secure research merit. Perhaps the unfortunate coronavirus pandemic crisis that triggered the fastest and most comprehensive implementation of online learning, including PBL across AAU, can, from a long-term perspective, provide a basis for investigation into the many practises and their potentials and challenges.

Finally, the paper provides other higher education institutions with knowledge on Moodle use, including what is at stake; defining areas to discuss, highlighting competence-development initiatives and design strategies to consider; and illustrating that there are contradictions that educators, the leaders \ management and also the administration should be informed of.

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