Automating the Comparison of Learning Design and Delivery Using Course Scaffolding in Moodle

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***Abstract*—Learning analytics from an LMS combined with design analytics from a learning design (LD) tool provide a foundation for checking the alignment of a course's LD and its delivery. For students to achieve the intended learning outcomes, a theoretically founded and innovative LD is essential. The next step is the orchestration of course delivery according to the prepared LD; however, due to real-life circumstances, delivery can deviate from the plan. Therefore, it is important to compare LD and delivery, identify potential differences, justify them, or redesign the course. In this comparison process, it is necessary to evaluate constructive alignment and assessment validity. These processes are described in the paper, along with their automation using the Balanced Design Planning (BDP) concept and tool for LD. The most significant achievement in this direction is the automatic scaffolding of a course in the open LMS Moodle directly from the BDP LD tool. This scaffolding functionality forms the basis for the development of an algorithm for the comparison of course LD and delivery.**

Keywords—learning design, learning analytics, quality assurance, constructive alignment, assessment validity, algorithms

I. INTRODUCTION

In the age when education is not only strongly supported, but nowadays also steered by technological development, course delivery in learning management systems (LMS) has become unavoidable in higher education (HE), and effective LMSs are essential components of universities' infrastructure [1]. While LMSs provide a platform for course delivery, detailed pedagogical planning is done within the area of learning design (LD). To support more widespread use of LD and hence the pedagogical soundness of (higher) education courses and study programs, the Learning Analytics Laboratory of the University of Zagreb's Faculty of Organization and Informatics (UNIZG FOI) has developed an innovative LD tool, available free of charge at learning-design.eu.

From the beginning, the Balanced Design Planning (BDP) concept and tool [2] have been developed in line with the principles of human-centered design, aiming for development of usable software by integrating user perspectives in the process of development [3]. In line with this approach, since 2021, the development of the BDP tool within several internationally oriented projects has considered the needs of educators, educational decision-makers and other stakeholders. To date, the BDP tool has been used by more than 1800 users, in the LD of more than 1800 courses and 25000 teaching and learning activities (TLA). The feedback received from users - either through structured research [4] or through regular use - has been implemented in the continuous improvement of the BDP tool.

Particularly, the feedback collected within several projects made it clear that educators strive for investing less time in the process of course preparation. Therefore, while they found LD with the BDP tool highly beneficial, they also found it time-consuming to first do the planning in the BDP tool and then prepare the delivery in an LMS [4]. So, to contribute to the time-efficiency of the design-delivery process, we introduced another innovative upgrade to the BDP tool: the functionality enabling fast transfer of LD directly to a Moodle LMS course, hereby referred to as "course scaffolding".

But besides providing a high practical value for educators, this automatic course scaffolding also provides the technical basis for further development of sophisticated learning analytics (LA), with important implications for quality assurance of HE [5]. Concretely, the current developmental work done by our research and software development team is focused on enabling the comparison of (ideal) LD planning with the (actual) course delivery in the Moodle LMS. As LD in the BDP tool relies strongly on contemporary pedagogical concepts like learning outcomes (LOs), constructive alignment [6] and assessment validity [7], the possibility of automatically identifying possible gaps between LD in the BDP tool and course delivery in the LMS could significantly contribute to the quality of courses and study programs.

In this preliminary report, after providing a short background, we present the research and development work done to enable the course scaffolding functionality. Then, we discuss the implications, as well as the ongoing efforts in terms of supporting quality assurance through the development of an algorithm for comparison of LD and course delivery. We also discuss further developmental plans, such as those related to supporting student mobility and student workload justification.

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The work has been done in line with the pragmatic worldview, as it stems from actual situations and aims to find solutions to identified problems [8]. Importantly, it is currently supported by two ongoing research-oriented projects with an international dimension: *Innovating Learning Design in Higher Education* (iLed) financed from the Erasmus+ program and *Trustworthy Learning Analytics and Artificial Intelligence for Sound Learning Design* (TRUELA) financed by the Croatian Science Foundation.

II. BACKGROUND

A. Learning Design

There are different definitions of LD, but basically, LD presents the order of TLAs, along with the respective resources and support for students [9], aligned with a chosen pedagogical approach [10], to be done by teachers and students in order for students to acquire the intended LOs [11]. While it guides educators in making informed decisions related to the design of TLAs [10], LD has a learner-centered nature, stressing the importance of designing learning experiences aligned with students' needs [12]. As such, LD aims to contribute to the efficiency of teaching and learning [12], and in this respect, there has been an increased interest in the integration and synergy between LD and LA [9], [13].

Having emerged in the 2000s [9], LD emphasizes the use of technology and the sharing of good practices through online repositories [12]. In the light of the recent developments and challenges faced by society and education, including the COVID-19 pandemic followed by the explosion in the availability and use of generative AI (GenAI), LD presents a highly relevant field of both practice and research [2].

B. Balanced Design Planning Concept and Tool

Driven by the needs expressed by HE practitioners in several educational contexts, UNIZG FOI's Laboratory for Learning Analytics has developed an innovative LD concept and tool: the Balanced Design Planning (BDP) concept and tool (learning-design.eu).

Taking into account the practitioners' needs, in conjunction with contemporary LD practices, theoretical approaches and recent research findings, the BDP concept and tool support the development of student-centered LD, based on student workload, LOs and constructive alignment between LOs, TLAs and assessment [6]. Moreover, the BDP approach encourages educational innovation, as it provides an environment for LD aligned with innovative pedagogies (such as the flipped classroom or problem-based learning) and design analytics as the basis for evidence-based, theoretically sound improvement in LD.

In the BDP tool, course design starts with defining LOs and determining their relative importance by assigning weights [7], [14], as well as their levels [15]. Overall student workload (in hours or ECTS credits) is defined, along with the number of students and mode of delivery. The process continues with several levels of planning, which includes topics, units, and TLAs, all with links to the initially established LOs. On the level of TLAs, the tool offers the possibility to define details like student workload required to complete the TLA, mode of delivery, assessment details, indication of collaboration and group work, and feedback. Importantly, each of the TLAs is assigned an appropriate learning type: acquisition, discussion, investigation, practice, production, or assessment. Following the planning, the BDP tool provides detailed design analyses (focused on workload, assessment, and constructive alignment), as the basis for additional adjustments and improvements of LD. More details on the basics of the BDP concept and tool have been described in our previous work [2], [4].

Starting in 2021, the development of the BDP concept and tool [2], [16] has been done in line with the design science methodology, including problem investigation, treatment design and treatment validation [17]. To date, the BDP tool has undergone several design cycles, as a range of improvements and new functions have been introduced, with validation done by international HE practitioners in several Erasmus+ projects: *Relevant Assessment and Pedagogies for Inclusive Digital Education* (RAPIDE), *Digital and Entrepreneurial Skills for European Teachers* (eDesk), *Accelerating the Transition Towards Edu 4.0 in HEIs* (Teach4Edu4).

Recently, as part of the Erasmus+ project iLed, the BDP tool has been subject to detailed, survey-based user experience research with 53 HE practitioners from four European countries (Croatia, Germany, Finland, the United Kingdom), including educators, instructional designers, curriculum developers, researchers, technical experts, and decision-makers [4]. The research provided comprehensive insights into the needs and perceptions of different user groups in different educational contexts, then used in the further development of the BDP tool, which included availability in four European languages (English, Croatian, German, Finnish), possibility to create templates (supporting innovative pedagogies) and other adjustments to the user interface to enhance user experience.

III. COURSE SCAFFOLDING: LEARNING DESIGN TOOL TO LEARNING MANAGEMENT SYSTEM

One of the latest and most advanced developments related to the BDP tool refers to the possibility of transferring LD directly to the Moodle LMS, resulting in a scaffolded, structured e-course. This functionality has been developed through four major steps.

Step one: Conceptualization. The process started with defining the appropriate Moodle activities or resources (such as Page, Forum, URL, Workshop, etc.), which could be used to implement (TLAs of) each BDP learning type (acquisition, discussion, investigation, practice, production, assessment). This mapping resulted in a list of possible Moodle activities or resources for each BDP learning type, with the recommended activity or resources marked as default, but with a possibility to choose another option as well. Then, the course scaffolding workflow (Figure 1) was conceptualized, including (1) creating LD in the BDP tool, (2) configuring the course by defining an appropriate Moodle resource or activity for each BDP TLA and downloading a Moodle course backup, (3) restoring the course backup in Moodle. When transferring a BDP LD to a Moodle course, the LD/course elements would be mapped as demonstrated in the correspondence table (Table 1).

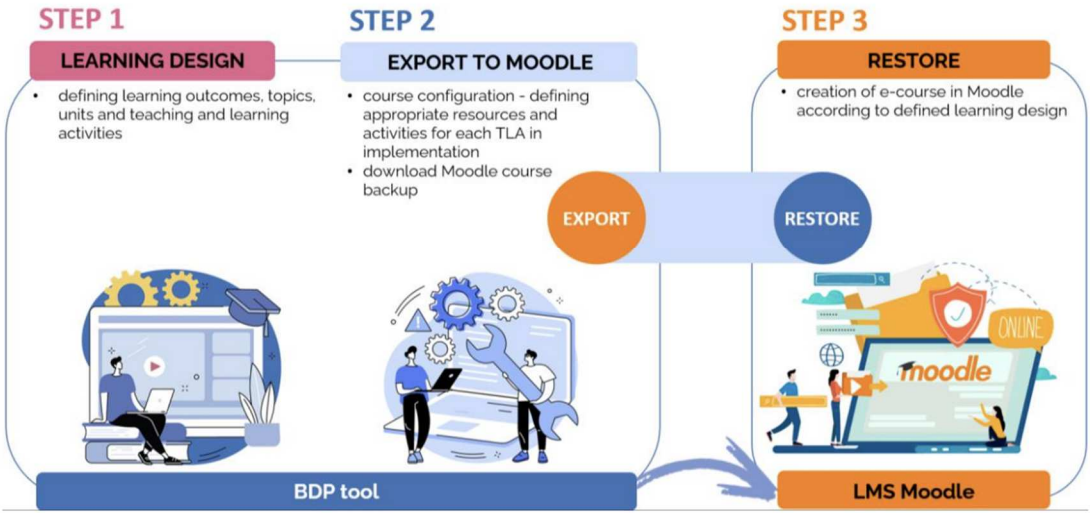

Fig. 1. Course scaffolding workflow

Step two: Prototyping. In the next step, a minimal viable product (MVP) was developed to demonstrate the core functionalities and test the technical viability of the concept. The first version of the prototype enabled the transfer of the basic structure of the BDP LD to the Moodle course. Then, rapid prototyping was done, with several iterations of the prototype developed to explore various design ideas, validate assumptions, and collect feedback from potential users. Creating simple Moodle activities or resources based on BDP LD was enabled. Finally, the final technical development specification for export was developed and final specific requirements, functionalities, and technical details defined.

Step three: Development. This step was done using an agile approach, ensuring adaptability, and enabling the integration of feedback. Based on the validated prototype, the full-scale implementation of the software solution was done: the final export module functionality was developed, enabling the transfer of content from a BDP LD to a Moodle course, based on the matching of BDP TLAs with appropriate Moodle activities and resources. An example of matching TLAs from the BDP LD with the appropriate Moodle activities and resources is presented in Figure 2. The final stage of development was focused on optimizing the code efficiency, performance, and scalability, to ensure that the solution is aligned with quality standards and can cater for possible growth. Final adjustments to the code base were done to ensure that the export functionality is easy to maintain and adaptable to future needs.

TABLE 1. CORRESPONDENCE BETWEEN BDP AND MOODLE ELEMENTS

BDP LD	Moodle course	Data
Course details	Introduction theme: About course page Learning outcomes page	ECTS, workload, number of learners, mode of delivery, contributors, learning outcomes (title, weights, level according to Bloom's taxonomy)
Topic	Theme	title, description, learning outcomes
Unit	Label	title
Teaching and learning activity	Selected resource or activity	learning type, workload, activity delivery, students' collaboration, work in groups, feedback, assessment, learning outcomes

Step four: Piloting. In the piloting phase, the export functionality has been tested on several courses at the owner HEI and opened for all the BDP tool users. It has also been presented to international partner HEIs in the iLed project and at an international *Learning Analytics and Knowledge 2024* conference to collect wider preliminary feedback and support more widespread use. The received feedback has been highly positive, stressing the practical and time-saving value of the developed functionality.

Following the piloting phase, a further upgrade has been made. In order to achieve the greatest possible compatibility between the BDP tool and the Moodle LMS, the Moodle plugin "Custom fields" has been installed. This enabled defining and storing additional data at resource/activity level (Table 1) and full alignment with the TLA metadata stored in the BDP tool.

IV. IMPLICATIONS AND FURTHER DEVELOPMENT

The described scaffolding of LD directly in the LMS has a range of implications.

One group of implications refers to the **practical value for educators** presented by the currently available functionalities, i.e., the described scaffolding functionality enabling a fast transition from an LD to its orchestration in the Moodle LMS, which has been explicitly asked for by educators. Having a course scaffold - aligned with sound LD prepared, analyzed and improved in the BDP tool - available in the Moodle LMS in a couple of simple steps can provide important support to educators in terms of:

- **ensuring their courses are pedagogically sound and quality-assured**, as a course structure is built on the basis of a learner-centered, constructively aligned LD
- **saving the time needed to prepare a course in the LMS**, as a course structure with titles and descriptions is transferred automatically
- **simplifying the process of creating a course** for those less experienced in working with the Moodle LMS.

Fig. 2. Matching BDP TLAs with Moodle activities/resources

Another group of (possible) implications relates to the current developmental work aiming to further exploit the potentials of the BDP tool with respect to **quality assurance**, which is, besides educators, of particular value for educational decision-makers (Figure 3). This requires work on algorithms and further software development, opening up a range of both conceptual and technical questions, with further explanation and a preliminary algorithm structure related to quality assurance presented in the following paragraphs.

According to the European Standards and Guidelines for Quality Assurance in Higher Education [5], study programs have to be designed in such a way that they meet the intended LOs. Furthermore, the delivery of study programs should motivate students to actively participate in the creation of the learning process, which should also be reflected in assessment. Moreover, study programs should be regularly monitored, reviewed and continuously improved, to make sure they meet the respective objectives and students' and societal needs.

Clearly, the BDP LD concept and tool support these essential dimensions of quality assurance in HE. Firstly, the BDP is strongly based on LOs, providing a platform for detailed planning - to the level of a particular TLA - with links to relevant LOs, ensuring constructive alignment between LOs, TLAs and assessment [6]. Moreover, it puts a special emphasis on the prioritization of LOs and assessment validity, i.e., the alignment of an assessment program with the intended LOs [7]. Secondly, the BDP concept and tool support LD planning in line with innovative pedagogies, based on student-centeredness and active learning, grounded in constructivist learning theory, like flipped classroom or problem-based learning, particularly with one of the recent functionalities enabling the creation and sharing of templates. Thirdly, the BDP tool provides rich design analytics, which support educators' reflection about and upgrade of courses.

However, what could have a particularly strong role in supporting the continuous improvement of courses and study programs and their quality assurance is LA providing comparisons of course LDs and respective realizations in an

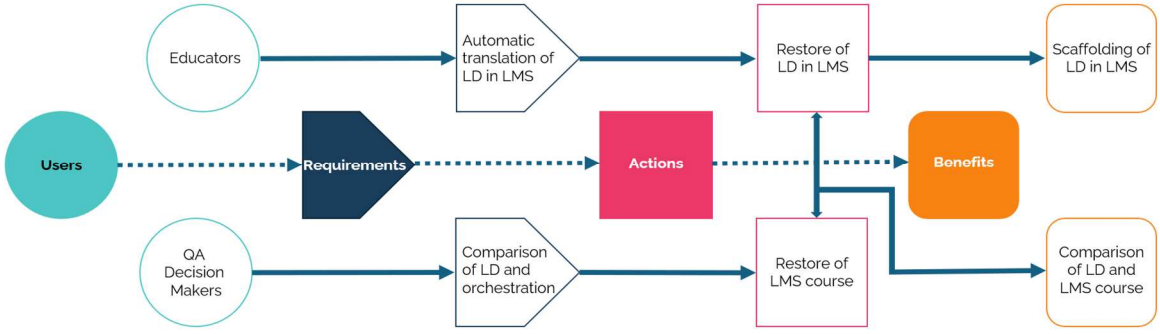

Fig. 3. The role of scaffolding in ensuring benefits for educators and decision-makers

LMS. Namely, LD presents a teacher's learner-centered vision of a teaching and learning process within a particular course, and the BDP tool supports theoretically and pedagogically sound planning. However, what is actually done in a "living" course does not necessarily have to match the planned LD. First, courses had been implemented in the Moodle LMS before the BDP tool was introduced. Second, actual circumstances can sometimes prevent the implementation of "ideal" LD. Third, even though courses are based on sound LD, as time progresses, changes can be introduced in the courses depending on the current context.

In order to support quality assurance by aligning courses with sound LD, currently, developmental work is being done at UNIZG FOI in order to enable a comparison between a course's LD and its realization in the Moodle LMS. In technical terms, the background for this has been developed with the scaffolding function and the upgrade enabling additional fields in Moodle, providing the option to store additional data at resource/activity level and full alignment with TLA metadata stored in the BDP tool. The current setup enables the creation of comparable Moodle backup files, as the basis for comparison.

While in technical terms the basis for comparison has been developed, there is now the conceptual question of what aspects of LD and actual courses should be compared to provide reasonable grounds for conclusions about the alignment of LD and course realization.

Several aspects, comparing design analytics from the BDP tool and LA from the LMS, that should definitely be considered are the following:

- *Constructive alignment.* LMS course structure and trace data compared to the LD TLAs and assessment, aligned with the intended LOs.
- *Assessment validity.* Prioritized LOs (LO weights) in the LD aligned with the actual assessment plans in the LMS and compared with students' assessment results.
- *Student workload justification.* Students' workload planned in the LD to be compared with insights based on LMS trace data, as well as multimodal data.
- *Pedagogical approach effectiveness.* Pedagogical approaches planned in LD compared with actual students' learning paths and assessment results.

In the following phase, for each of these aspects, an algorithm has to be designed, as the basis for the further development of a technical solution. Here is an example of a description of a possible algorithm for establishing assessment validity (in line with [7]):

- **Preparation phase:** defining criteria of alignment between ideal LO weights and actual assessment
- **Input:** data from the BDP tool (LO weights, links between assessment and LOs, planned assessment points) and the LMS (actual assessment points, students' results/obtained points)
- **Step 1:** comparison of the BDP and LMS data and identifying the gap related to assessment validity
- **Step 2:** analyzing the gap based on the defined criteria
- **Step 3:** determining the significance of the gap and categorization of a possible error
- **Output:** "traffic lights" demonstrating the level of alignment between the ideal LO weights (LD), actual assessment points (LMS) and student results/obtained points (LMS).

A. Further Development

While comparisons of LDs and their realizations in an LMS could have important implications for quality assurance of courses, comparison of LDs may have a high practical value in terms of student mobility.

Namely, in the European Higher Education Area, according to the ECTS User's Guide 2015 [18], the "golden rule" of recognition in the context of credit mobility assumes that all credits obtained by a student while studying abroad or taking part in virtual mobility should be transferred to the home HEI. While planning the mobility, courses should not be selected based on their equivalence with the courses of the home HEI, but LOs of the whole study program abroad should be compatible with or complimentary to the LOs of the home study program.

In practice, ensuring this compatibility of LOs is often based on comparing HEIs' course catalogues and consulting course teachers. Enabling comparison on the level of course or study program LDs could significantly simplify and inform this process, supporting meaningful recognition.

Moreover, as regards student workload justification and pedagogical approach effectiveness, there is a lack of clarity regarding what categories of data to use as proxies and how to include multimodal data as not all learning happens in an LMS, and incomplete data may lead to biased conclusions. Therefore, further work should focus on establishing the proxies and enabling the use of data which can be used as the basis for meaningful LA.

Finally, the connection between the BDP tool and the Moodle LMS enabling scaffolding provides a basis for the establishment of an LO-based learning ecosystem, using LD and LMS data to support students and teachers. Therefore, further development may include two main elements:

- development of a "course builder" for macro-level planning in the BDP tool, course topics, LOs, links between topics and LOs, and prioritization of LOs, in line with previous research work [7], [19]
- design of a dashboard providing LA comparing planned LD and realized course delivery in the LMS, providing alerts on deviations and suggesting an optimal learning path.

The overview of the planned ecosystem is presented in Figure 4.

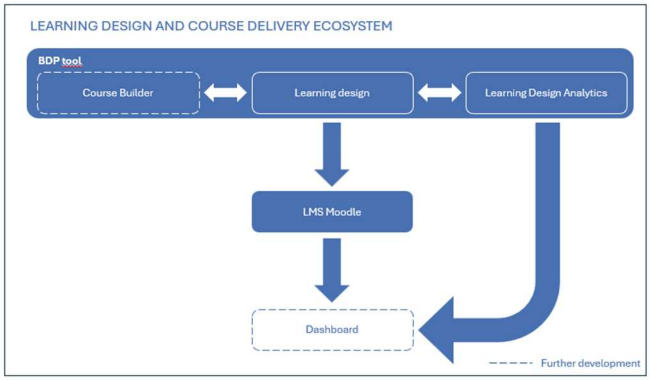

Fig. 4. Learning design and course delivery ecosystem

V. CONCLUSION

In this preliminary report, we presented the innovative LD concept and tool and the latest upgrade enabling automatic transfer of course LD to the Moodle LMS. Furthermore, we described the ongoing research and development related to algorithms and software supporting comparisons between LD and its delivery in the Moodle LMS. This functionality may have important implications for quality assurance of courses and study programs, as it would enable identifying the gaps between a plan and delivery. This would significantly contribute to the pedagogical soundness of teaching and learning. Finally, we presented directions for further development, related to supporting student mobility and justifying student workload.

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