Study Program Curriculum Development with AI

Blaženka Divjak(✉), Petra Vondra, Darko Grabar, Barbi Svetec, and Josipa Bađari

Faculty of Organization and Informatics, University of Zagreb, Varaždin, Croatia
{bdivjak,petra.vondra,dgrabar,basvetec,jobadjari}@foi.hr

Abstract. This paper presents the latest research and development regarding the Balanced Design Planning (BDP) learning design (LD) tool, focusing on supporting curriculum mapping at the study program (SP) level through curriculum analytics and AI assistance. SP-level curriculum analytics enables the examination of coherence, balance, progression, and alignment across multiple courses. Support for horizontal alignment between learning outcomes, teaching and learning activities and assessment has previously been enabled through course design analytics. This latest development supports vertical alignment of courses and SPs through advanced curriculum analytics, focusing on analyzing mapped representations of the intended curriculum, and extends AI support for LD from the course level to the SP level. While studies have shown that AI-supported LD tools can scaffold educators' design decisions and support reflective practice while preserving human agency, limitations have been identified at higher, more abstract levels of LD. Therefore, as part of the BDP tool's design cycle, we present the technical upgrade and architecture of an AI assistant for curriculum design.

Keywords: Curriculum Design · Curriculum Mapping · Curriculum Analytics · Learning Analytics · Learning Design · AI Assistance · Study Program

1 Introduction

Today, (re)designing higher education (HE) curricula is challenging, requiring balance between theory and practice, alignment across course and study program (SP) intended outcomes, adaptation to external expectations and internal quality assurance (QA) [12].

Learning design (LD) at the SP level, i.e. curriculum design, presents a valuable tool in achieving these goals. *Curriculum design* is the intentional organization of learning outcomes (LOs), content, pedagogical approaches, learning activities, and assessment across courses to support student progression and achievement of program goals [2]. A more practical aspect is *curriculum mapping*, providing a systematic and visual representation of curriculum structures and relationships [18]. Using structured tools to develop curriculum design is a basis for systematic analysis beyond individual courses - *curriculum analytics*. Curriculum design and analytics are the focus of recent developments related to the Balanced Design Planning (BDP) tool for LD, so far used by almost 3000 users worldwide and iteratively validated by users in international contexts.

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This paper presents the latest upgrades of the BDP tool, supporting educators in designing not only courses but entire SPs (curricula). One aspect is curriculum analytics based on analyzing patterns of balance, alignment, and progression across courses. Another aspect is the upgrade of the AI assistant for LD (LeDA) [7].

2 Background

2.1 Learning Design, BDP and LeDA

While literature offers several definitions, in its essence, LD refers to the sequence of TLAs, related resources and student support [14], which should be done by educators and students to enable acquisition of the intended LOs [13]. LD supports educators in making informed decisions aligned with intended pedagogical approaches [4], and interest has been rising in the synergy between LD and learning analytics [14, 17].

This synergy is reflected in the innovative BDP concept and tool. The tool has been developed since 2021, following the design science methodology, with each design cycle leading to new innovative features [5–7], with the development thus far being focused on course LD supported by real-time design analytics. The BDP concept is strongly based on LOs and the principle of constructive alignment between LOs, TLAs, assessment, and student workload, paying great attention to student-centeredness. Accordingly, in the tool, LD starts with LOs and their prioritization [8], followed by detailed planning of topics, units and TLAs linked to the LOs. At the TLA level, planning includes student workload, delivery modes, collaboration and group work, assessment, learning types, etc. The BDP learning types include acquisition, discussion, investigation, practice, production, assessment, and are particularly valuable in designing learning in line with innovative pedagogies. Course-related design analytics is presented in a dashboard, providing insights to support sound pedagogical planning. [5–7] A recent innovative feature is the AI assistant in LD (LeDA) using API calls to an LLM (GPT) to support educators in developing sound LD, while preserving human agency and decision-making. The beta-version [7] provided assistance in course-level LD.

With the latest upgrades, the BDP approach has been extended to include more features related to SP LD, i.e. curriculum design. This includes two essential components: curriculum mapping and analytics, and a curriculum-level AI assistant.

2.2 Curriculum Design

The term ‘curriculum’ is often used interchangeably with terms like program, course, and educational experience. The nature of curricula is dynamic, including both structured and unstructured learning experiences [2, 12].

Curriculum mapping refers to a systematic process of documenting and visualizing relationships between curriculum elements, such as LOs, course content, TLAs, assessment methods, and progression; making explicit how individual courses contribute to SP goals and qualification frameworks. It is described as “a procedure that creates a visual representation of curriculum based on real time information” [18].

Curriculum analytics applies analytical and computational methods to create insights and interpretations, extending curriculum mapping which focuses on representation.

Using data from mapped curricula, it enables quantitative and qualitative analysis of curriculum characteristics, such as distribution of LOs, balance of learning types, assessment load, progression of cognitive demand, and alignment with qualification standards [14]. Curriculum analytics is commonly applied at SP level, as its main purpose is to examine coherence, progression, and alignment across courses [2, 5, 14, 18].

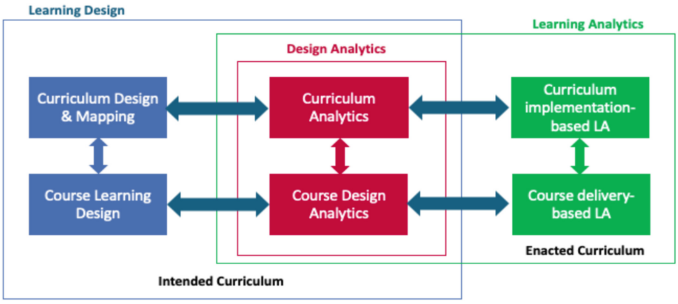


Fig. 1. Relationships between the key practices related to curriculum design

Curriculum analytics is also conceptualized as a form of design analytics, with curriculum structures captured in LD serving as a data source for evaluation and enhancement [5]. Combined with learning analytics derived from LMSs (focused on enacted learning), curriculum analytics supports comparison between intended and enacted curricula (Fig. 1), informing curriculum enhancement, QA, and strategic decision-making. Capturing LD through structured tools such as the BDP fosters this.

2.3 Generative AI, Learning Design and Curriculum Development

In course design, human–AI partnerships can yield outcomes that surpass the creativity and efficiency of individual efforts. Educational developers and learning designers increasingly combine human expertise with GenAI tools to create interactive learning content aligned with pedagogical intent [15]. Applications of GenAI extend across multiple aspects of teaching and learning, including curriculum and course design [3, 19]. Still, domain expertise and instructional design competence are essential to ensure the quality, coherence, and reliability of AI-generated outputs [3]. GenAI is a design partner that can augment educators' capacity to create context-sensitive learning experiences, with an emphasis on ethics, transparency, and human oversight. [11].

Recent work explores how these principles can be operationalized through AI-supported LD tools. Divjak et al. [7] demonstrate how an AI assistant embedded within an LD tool can assist an educator to scaffold design decisions, support reflective practice, and facilitate constructive alignment at the course level. However, besides positive pilot feedback, this work also highlights a limitation: the reduced effectiveness of AI support at more abstract levels of LD. Building on this, this study extends AI assistance beyond individual courses by enabling LeDA's support in LD at the SP level, i.e. curriculum design, thereby contributing to broader curricular coherence and QA goals.

3 Methodology

The BDP concept and tool have been developed in line with the design science methodology, using an agile approach and responding to the current user needs and QA requirements. In this sense, all the major phases of the BDP development have included three main tasks of the design cycle: problem investigation, treatment design and treatment validation [5]. This applies also to curriculum design, as follows.

With respect to **problem investigation**, feedback from previous phases of the BDP tool development has been considered, especially user feedback related to the pilot study on AI assistance in course LD [7]. Specifically, this study follows up on the recommendation to support the SP perspective and enable links between courses and SPs. Furthermore, the requirements of the QA processes in HE were considered [9]. To widen the understanding of the requirements of curriculum design, a literature review has been conducted, presented in the Background section.

Regarding **treatment design**, a technical upgrade was introduced to the BDP tool, and a beta-version of curriculum design enabled. This includes course LD informed by SP requirements, curriculum mapping, advanced curriculum analytics focusing on analyzing mapped representations of the intended curriculum, and extending AI support for LD from the course level to the SP level. The details of the curriculum design functionalities and the AI assistant architecture are presented in the Results section.

As part of **treatment validation**, the beta-version of the curriculum design support is currently piloted in the revision of a postgraduate-level SP, as a platform for experimentation. The entire curriculum (15 courses) is being revised in line with QA principles [9], using the BDP tool, course-level design analytics, and insights provided at three levels: SP board, course teachers, student feedback.

4 Results and Discussion

The beta-version of curriculum design support includes curriculum mapping and advanced curriculum analytics, and extending AI support for LD to the SP level. The upgrade responds to the quality requirements applied in HE, reflected in accreditation and QA processes [9], as well as contemporary research related to curriculum design [17].

4.1 Curriculum Mapping

While SP LD, i.e. curriculum design, had been envisaged in the BDP concept since its inception, with the latest upgrade, additional aspects of curriculum mapping have been introduced, and more elaborate curriculum-related information is to be provided by the educator. This includes SP details (description, workload, target groups, delivery mode), SP LOs, and distribution of six BDP learning types. It also includes identification of the SP type (more theoretical, practical, or mixed), links between course and SP LOs, with degrees of contribution (low, medium, high), and marking obligatory/elective student workload. This approach enables structured comparison across courses.

Regarding the SP type, curriculum literature often distinguishes between theoretical knowledge and practical application, recognizing the need for their integration in curriculum design [2]. The classification of courses into theoretical, practical, and mixed types is employed in this study to support systematic LD and curriculum analysis. Rather than representing fixed or mutually exclusive categories, these types capture dominant orientations reflected in learning types, LOs, TLAs, and assessment. The approach relying on prevalence and emphasis helps avoid deterministic mappings between cognitive levels, learning activities, and program orientation.

The SP integration into the overall design process enables systematic mapping of course-level LOs to program-level LOs, thereby ensuring vertical alignment between program and course design [5]. Course LOs contribute to the achievement of program LOs to varying degrees, commonly operationalised through three developmental stages (e.g. introduced–reinforced–mastered; slightly, moderately, or substantively) [1, 10, 16] or graded levels of contribution (e.g. low, medium, high).

4.2 Curriculum Analytics

Curriculum analytics (design analytics at the SP level) enables an overview of TLAs at the SP level (all courses). It also enables comparisons among courses based on characteristics of TLAs (collaboration, group work, delivery mode, feedback), workload (per learning type: course – SP, planned - designed workload), assessment (type, provider) and LOs. In this sense, it aggregates course design analytics available so far.

The upgrade enables some new, curriculum-specific insights. The BDP concept and tool rely strongly on two principles: horizontal and vertical constructive alignment [5]. The first principle refers to the alignment between LOs, TLAs and assessment, and has been enabled by course-level design analytics as a fundamental part of BDP. The second principle refers to the alignment among courses and SPs. This upgrade enables educators to identify those links and provides respective curriculum analytics, with insights into contribution of course LOs to SP LOs, mapping of course-level assessment to SP LOs, and alignment of assessment at course and SP level. It also enables comparison between intended and designed distribution of learning types, as well as between the average distribution of learning types at the SP level and within a particular course (Fig. 2). Together with vertical constructive alignment, this feature is valuable in QA, especially when it comes to fostering the use of innovative pedagogies.

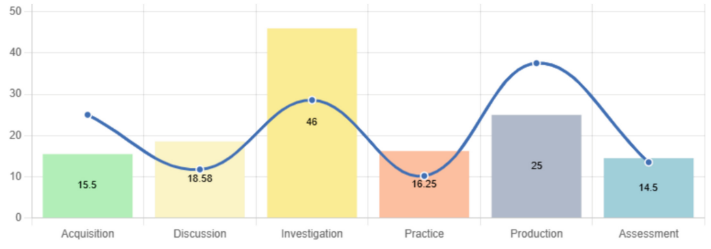


Fig. 2. Comparison of SP average (curve) and course-level learning types (bars)

4.3 Upgraded AI Assistant

The upgraded AI assistant (LeDA) architecture extends the original AI-assisted LD tool [7] by integrating curriculum design support and enhancing contextualization and data retrieval mechanisms. The key novelties of the upgraded architecture are (1) the integration of SP design support into the LD process, (2) introduced AI support for curriculum design and enhanced AI support at course level, with a feedback loop from SP to course level, (3) Contextual Data Retrieval System, and (4) Knowledge Base.

At the curriculum-level, LeDA now supports educators in formulating and revising LOs, using information from the Knowledge Base (e.g. levels of Bloom's taxonomy, qualification frameworks), and taking into account the SP description (e.g., type of the SP, educational level, mode of delivery, target groups, etc.). It also helps identify the most appropriate distribution of learning types based on the SP descriptors, interpret curriculum analytics, and develop course LD which takes into account curriculum-level inputs (e.g. LOs, SP type, other courses of the SP). Finally, it includes a general conversational AI assistant (agent) providing feedback to the curriculum mapping.

The LeDA architecture is structured around three main layers (Fig. 3): BDP LD environment, AI-powered LeDA subsystem, and external LLM services.

When users request AI assistance, the request is forwarded to the LeDA subsystem, consisting of four core components. **GenAI Application Module** prepares structured prompts, communicates with the LLM and returns structured responses to users. **Contextual Data Retrieval System** selects and aggregates relevant program- and course-level data and Knowledge Base for each AI query. **Knowledge Base** stores curated LD resources, examples, and domain knowledge (e.g., Bloom's taxonomy, program/course type, course structure, definition of weight, horizontal and vertical constructive alignment) and structured data collected through the Data Importer. **Data Importer** collects data from external data sources (e.g. institutional regulations, LO frameworks, pedagogical and didactic frameworks, accreditation requirements).

The GenAI Application Module integrates user queries with contextual data retrieved from the BDP environment and the Knowledge Base. These enriched prompts are then sent to the LLM (GPT 4o) via API calls. Returned responses are post-processed and adapted to the BDP data model before being presented to users. This ensures semantic coherence, and compatibility with program and course data structures. Users retain full decision-making authority and may accept, modify, or reject AI-generated suggestions. Selected AI-generated suggestions can be directly implemented at course and program levels, enabling seamless integration of AI-supported design elements.

At the SP level, LeDA supports users through predefined prompts structured across several design dimensions. These include prompts for generating LOs, generating LOs based on selected levels of Bloom's taxonomy, and revising LOs. Dedicated prompts also enable targeted revision and refinement of individual LOs. Additional prompts support analysis and alignment of intended learning types with program LOs, and interpretation of curriculum analytics related to program overview, workload distribution, assessment–LO alignment, constructive alignment, and AI use.

In addition to predefined prompts, users have access to a general conversational AI assistant at the program level, enabling open-ended dialogue, reflective inquiry, and holistic discussion of curriculum design and mapping.

Integration of curriculum design support also enhances AI-supported design at the course level. By incorporating program-level details, LOs and intended learning types into contextual retrieval, LeDA generates more relevant, consistent, and pedagogically grounded recommendations for individual courses. This multi-level contextualization strengthens alignment between course-level LD and program design. Furthermore, the introduction of a Contextual Data Retrieval System and Knowledge Base strengthens the grounding of LLM outputs, reduces generic recommendations, and facilitates the application of retrieval-augmented generation principles. This architecture supports responsible human-AI collaboration, where AI acts as an intelligent assistant [11].

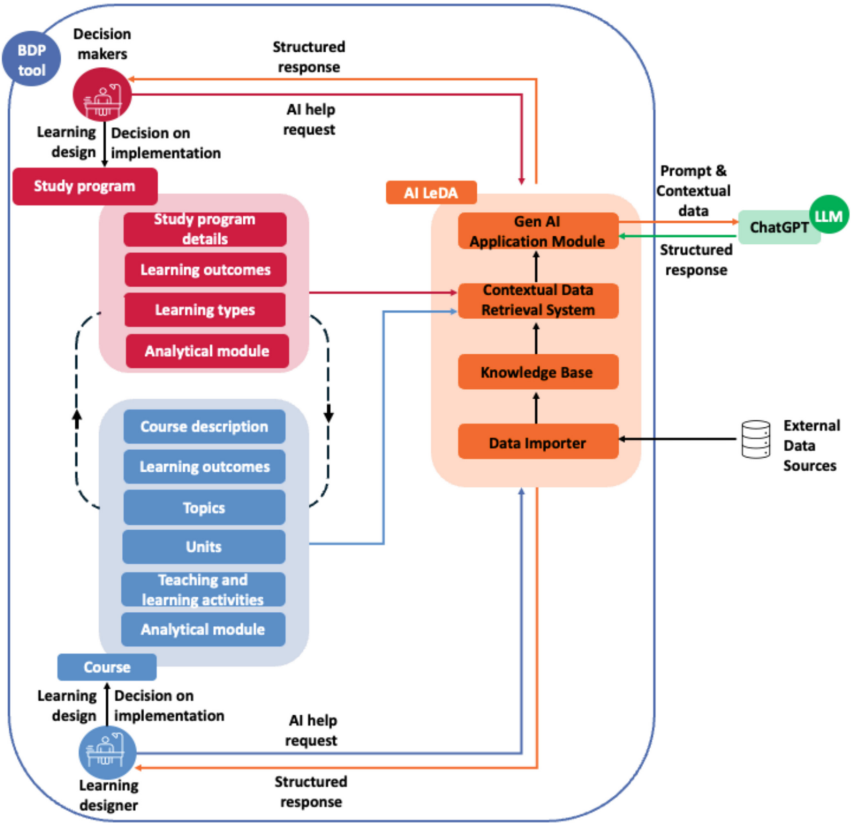


Fig. 3. The upgraded LeDA architecture

4.4 Examples of AI Assistance

AI Assistant Analysis. LeDA generates a structured response to a prompt related to the comparison between targeted and designed ECTS distribution across all courses within the SP. The response is organized into sections, including analytical summary, pedagogical interpretation, and actionable recommendations for improvement. Educators can translate numerical indicators into pedagogically grounded insights.

Feedback Loop From Curriculum to Course LOs. LeDA supports revision of course-level LOs by incorporating SP LOs when generating suggestions. A user can request the revision of an existing LO with an instruction to LeDA to maintain alignment with program LOs. LeDA generates a revised LO that is more concise, pedagogically sound, and aligned with program LO. This way the integration of SP data supports vertical alignment and enhances the quality of course design.

Prompts. LeDA currently includes 25 actions done by GPT which use pre-designed prompts (example below), and which take into account the SP descriptions and data, course details and contextually relevant entries from the Knowledge Base.

Learning Types Alignment:
Context: "You are a Learning Design assistant. You are given the details of a study program in JSON format, including its learning outcomes, currently planned learning types (and their percentages), and a list of all available learning types with their descriptions and examples. Your task is to analyze if the planned learning types are aligned with the learning outcomes. If 'plannedLearningTypes' is missing or empty, suggest an appropriate distribution of learning types from 'availableLearningTypes' that would best support the achievement of the learning outcomes. Provide a brief explanation of your analysis and then suggest optimized percentages for the learning types. IMPORTANT: You MUST ONLY use the names of the learning types provided in 'availableLearningTypes'. Ensure the total percentage of suggested learning types is exactly 100. Format your response as a JSON object with two keys: 'explanation' (string) and 'suggestions' (array of objects with 'name' and 'percentage')."
message: "Analyze the alignment for the study program data provided below in JSON format.\n\n### STUDY PROGRAM JSON DATA ###\n{spJson}\n### END OF JSON DATA ###".

4.5 Further Research and Development

The essential track, already in progress, is the validation of curriculum design support. In an ongoing pilot study, the BDP tool is used to revise a postgraduate level SP. We plan to extend the validation of curriculum design support in the revision of additional SP, followed by collection of user feedback, which will provide us with deeper insights into the practical usefulness of the functionalities and possibly inspire further development. Further development will include building the Knowledge Base further to enable more targeted, pedagogically sound and research-informed suggestions, helping educators in both course-level and curriculum-level LD. Further upgrades will also enable transparency, flexibility and adaptability of the Knowledge Base and prompts.

5 Conclusions

We present further development of the BDP concept and tool, which enables curriculum design support enhanced by an AI assistant using API calls to GPT 4o and a carefully designed Knowledge Base. New functionalities cover curriculum mapping, curriculum

analytics and the AI assistant with the supporting architecture. We provide examples of concrete curriculum analytics and discuss links with curriculum design. Curriculum and design analytics supported by an AI assistant provide visual representations and structured data, and curriculum mapping enables educators to identify gaps, redundancies and misalignments within and across courses.

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Disclosure of Interests. The authors declare that they have no competing interests.

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