Supporting Student-Centered Learning with Flexible Learning Trajectories and Open Learner Models

Pankaj Chejara, Kairit Tammets, Mart Laanpere, Annika Volt, Priit Tammets, Pjotr Savitski
Center of Education Technology, Tallinn University, Tallinn, Estonia
pankajch@tlu.ee, kairit@tlu.ee, martl@tlu.ee, annika.volt@tlu.ee, tammets@tlu.ee, gnum@tlu.ee

ABSTRACT: Flexible learning caters to each individual's learning needs, offering a solution to provide personalized learning while preserving the student's agency. However, effective utilization of this approach requires students to have some basic understanding of dependencies among learning contents, and the ability to track and assess their learning (i.e., metacognitive skill). Our research aims to address these challenges with a novel approach built upon an expert-designed domain model, flexible instructional trajectories, and open learner models (OLMs) to support students in flexible learning. We present our ongoing research work on leveraging log data to construct OLMs to provide meaningful insights into students' learning processes with the ultimate goal to foster metacognitive development and enable informed decision-making.

Keywords: Open Learner Model, Bayesian Modeling, Learning Path, Learning Trajectories

1 INTRODUCTION

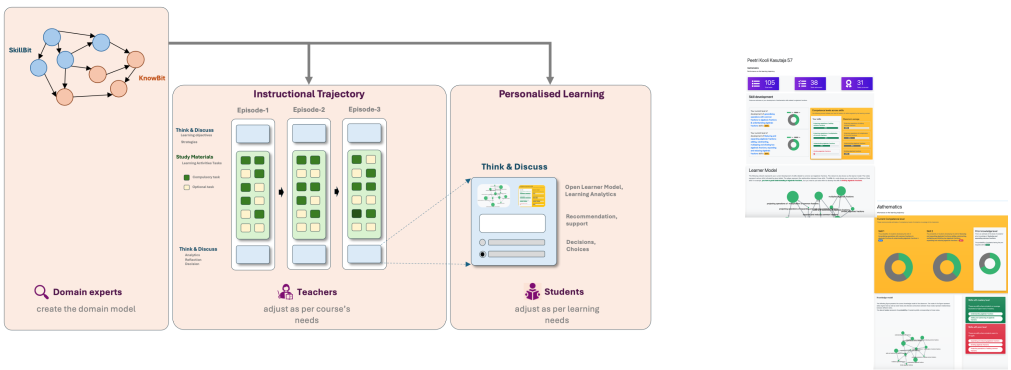
Flexible learning, which enables learners to progress according to their individual needs, is a key priority in the UNESCO 2030 Agenda for Education (UNESCO, 2022). The growing demand for flexibility in education is also emphasized by the European Association for University Trends 2018 report (Geabel et al., 2018). When discussing flexible learning, three core dimensions are often highlighted: time, place, and mode of learning (Hammersley et al., 2013). These dimensions enable students to have a personalized learning experience with greater autonomy. However, despite its importance, implementing flexible learning is not without challenges. Its success depends on students having a foundational understanding of learning content structure, as well as the ability to track and assess their learning progress.

In this paper, we present our research work on designing and developing flexible learning environments through the integration of pedagogical knowledge and learning analytics. Specifically, we developed dashboards for students and teachers that combine expert-designed domain models and Open Learner Models (OLMs) –a machine representation of student's learning– to provide insights into students' learning. This approach empowers learners by delivering data-driven feedback, enabling informed decision-making about their learning, while simultaneously fostering metacognitive development.

2 FLEXIBLE LEARNING WITH OPEN LEARNER MODELS

The research work is part of an Estonian national project with a focus on student-centered learning in primary schools. We have refined the concept of flexible learning by dividing it into three distinct but interconnected components (Figure 1.a): (1) Domain model, which defines the learning outcomes and related knowbits and skillbits; (2) the instructional trajectory, which is part of the instructional design and (3) the learning path, which is related to learning analytics. The instructional trajectory is a forward-looking plan designed by a teacher or instructional designer, grounded in a domain model (typically based on the national curriculum). It includes predefined learning outcomes, instructional episodes, tasks, hints, and additional resources (Volt et al, 2024). Drawing from the instructional design principles of van Merriënboer & Kirschner (2007), these trajectories incorporate flexibility through optional tasks, choices in task type and complexity, and personalized pacing, supported by metacognitive prompts to encourage reflection. In contrast, the learning path represents the learner's actual journey - a dynamic, digital record of their interactions with content, teachers, and peers. This path captures the learner's actions, choices, and outcomes in a machine-readable format, enabling advanced learning analytics to provide real-time feedback and support.

We implemented a Drupal-based learning platform[1] for flexible algebra learning for Estonian 9th-grade students, which allows teachers/instructors to create instructional trajectories using H5P elements. A domain model for Algebra was prepared by experts in mathematics didactics following the Estonian national curriculum. This model provided the basis for creating instructional trajectories which consisted of several episodes each covering one specific topic. These episodes were further divided into several tasks of different types: reading, watching videos, assessment, and problem-solving.



a. Flexible Learning b. Student & Teacher dashboard

Figure 1. Flexible learning and generated dashboard[2] with open learner model

Students' interactions with these tasks were recorded using xAPI statements. We extracted various features such as number of attempts, usage of hints, scores, etc. These log features were explored using Bayesian modeling to compute an estimate of students' mastering specific skills (e.g., dividing

1 VARA: https://vara.h5p.ee/

2 Dashboard prototype: http://eduflex.blog/en/

common fractions). These estimates were computed using *the Expectation Maximization* algorithm using extracted features. The estimates were then used to build a *dashboard,* following best practices from the literature (e.g., visualizing students' progress in a way easy to interpret, and along with classroom averages). We visualized OLMs in the form of a Bayesian network where nodes represent skills and knowledge, and edges represent relationships between them according to the domain model. The network shows students' current level of knowledge for each episode in learning trajectories. Figure 1.b shows student and teacher versions of the dashboard built upon developed OLMs.

3 CONCLUSION & FUTURE WORK

In this paper, we presented a novel flexible learning approach integrating three key elements - domain models, flexible learning trajectories, and students' Open Learner Models to create a more adaptive learning experience. Together, these elements form a cohesive system where instructional design, learning analytics, and learner autonomy converge to foster personalized, flexible, and effective learning environments. Our flexible approach creates a dynamic learning environment that is responsive to the unique needs and trajectories of individual learners. In our ongoing research, our next step is to analyze differences in how students navigate through flexible instructional trajectories. Using temporal Learning Analytics (LA), alongside student learning outcomes and self-reported measures, we will investigate how these navigation patterns are linked to learning gains, perceived effectiveness, and metacognitive strategies. Feedback from the LA community will be essential in guiding our research and selecting the most suitable methods and approaches for analyzing these relationships.

ACKNOWLEDGEMENT

This research was supported by the Estonian Ministry of Education and Research under the research project ÕLHAR1: "Flexible Learning Paths for Supporting Learner-Centered Learning in Schools", and by the Estonian Research Council's Personal Research Grant (PRG) under grant number PRG1634.

REFERENCES

1. Gaebel, M., Zhang, T., Bunescu, L., & Stoeber, H. (2018). *Learning and teaching in the European higher education area*. European University Association.
2. Hammersley, A., Tallantyre, F., Le Cornu, A. (2013). Flexible learning: A practical guide for academic staff. The Higher Education Academy.
3. Kirschner, P., & Van Merrienboer, J. J. (2008). Ten steps to complex learning: A new approach to instruction and instructional design. In 21st century education: A reference handbook (pp. 244-253). SAGE Publications Ltd.
4. UNESCO. (2022). Beyond Limits. New Ways to Reinvent Higher Education. In *Working document for the World Higher Education Conference*.
5. van Merriënboer, J. J. G., Kirschner, P. A. (2007). Ten Steps to Complex Learning: A Systematic Approach to Four-Component Instructional Design. Lawrence Erlbaum Associates.
6. Volt, A., Laanpere, M., & Kurvits, J. (2024). Supporting flexible learning paths with interactive learning resources in mathematics: lessons learned. Educational Media International, 1-16.