

Learning Analytics Dashboard for Educators: Proposed Project to Design with Pedagogical Background

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ABSTRACT

In this article, the authors describe a prototype of a Learning Analytics Dashboard (LAD) for educators. It is based on the analysis of pedagogical actions and taking into the process and learning style of students in an online environment based on learning analytics (LA). A description of the Dashboard structure, divided into levels and categories based on available learning analytics, will allow the educator to dive deeper into the online course themselves and explore more. It will also allow them to determine the level of student performance, identify gaps in learning materials, and research student data.

The authors have identified further directions for the development of a LAD for a professor, including modeling algorithms for researching student behavior and learning style using Artificial Intelligence and presenting LA in a visualized form. This paper shows the stages of creating a professor's LAD prototype as a functional part of the adaptive learning system in the HASKI-System to analyze visual information obtained from LA and the possibilities to monitor the learning process, learning progress, student activity, and make decisions on careful intervention in the students' learning process.

CCS CONCEPTS

• Applied computing; • Education; • Distance learning;

KEYWORDS

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1 INTRODUCTION

There are various learning theories that are used to create learning environments: behaviorism, cognitivism, constructivism. There is also a learning theory based on e-pedagogy called connectivism [12, 31]. As Siemens [12, p. 3] describes, including technology and making connections in learning activities is beginning to bring learning theories into the digital age. In addition, connectivism provides a framework that can be used to better manage teaching and learning with digital technologies. However, it cannot be argued that there is a single theory that will explain technology-enhanced learning. Moreover, teachers play an important role in networked learning [15]. The general framework for learning analytics as a tool is indicated as a socio-constructivist pedagogical theory. The hypothesis of this theory is that active participants in the discussion demonstrate better learning outcomes [30, p. 45]. However, the authors [30, p. 48] argue that learning analytics does not support or ignore specific pedagogical theories, and as an abstract concept is pedagogically neutral. At the same time, researchers investigate the use of technological, pedagogical, and content models of knowledge that are useful for analyzing various aspects of educators' use of digital tools and digital competence in higher education [3, 24, 29].

In distance learning, however, face-to-face communication between student and educator is limited. Knowledge is shared through the transfer of theoretical material to the distance learning system and from there to the students. Instead of the pedagogical actions, students receive feedback in the form of messages and comments on completed activities. At the same time, the educator should analyze the education process and make decisions about intervening in the distance learning process. Therefore, in order to better manage learning and teaching with the use of digital technologies, the most commonly found online systems use a Dashboard. As part of the HASKI¹ (Hochschullehre: Adaptiv, selbstgesteuert und KI-gestützt; engl. University teaching: Adaptive, self-directed and AI-supported) project, this article proposes the prototype of a Dashboard for professors that will be used to visualize students' learning styles and learning process as a support for the traditional learning.

The article is structured as follows. Section 2 presents related works; section 3 shows the proposed Dashboard. In section 4, the

¹<https://www.th-ab.de/transfer/projekte/haski>

conclusions are presented. Finally, future research topics are presented in the section 5 and discussion questions are included in the section 6.

2 RELATED WORKS

Learning analytics is used to visualize information that can be useful to a professor during distance learning. More information about LA and some examples for creating Dashboard will be described in the next subsections.

2.1 Learning Analytics

In [5, 22], the authors describe how LA can be used as a learning instrument in the form of visualized information. In [21], LA is described as follows: learning analytics is the analysis of student data to improve education, as it focuses on studying the behavior of students in relation to the educational content provided.

LA is also divided into six dimensions: stakeholders, goals, data, tools, external constraints, and internal constraints [17, 30]. In this research, the focus is on the stakeholder - teachers. Teachers are interested in how analytics can improve their teaching practice or help them adapt their educational offerings to the needs of students. The goal of LA is to improve teaching and learning. Furthermore, the integration of learning analytics into the daily practice of different stakeholders (institution, teachers, learners, other) is a future challenge and should be accompanied by appropriate didactic and organizational frameworks [4]. In [21], the following goals of LA have been considered:

- Monitoring and analysis.
- Prediction and intervention.
- Tutoring and mentoring.
- Evaluation and feedback.
- Adaptation.
- Personalization and recommendation.
- Reflection.

There are also descriptions of the goals of learning analytics for educators [11, 20] that include:

- to observe the learning process, the way students learn, their efforts;
- explore student data, know about student strategies;
- identify difficulties;
- identify patterns;
- find early indicators of success, poor grades, dropouts;
- draw conclusions about the usefulness of certain learning materials and success factors;
- to be aware, reflective, self-reflective;
- better understand the effectiveness of the learning environments;
- intervene, supervise, advise, assist.

The benefits of using LA in pedagogical practice are divided in: planning and designing learning; learning management; tutoring and pedagogical mediation, etc. [7, 17]

2.2 Visual Analytics

In the process of creating the Dashboard prototype, it was analyzed how the collection and processing of information can be supported

by visual analytics. Table 1 describes popular methods for classifying tasks in interactive visualization. It has to be noted that learning analytics allows teachers to know how effective interactive learning materials (content) are and allows them to constantly improve these materials. It is believed that learning success is influenced by several factors: individual attitudes and characteristics of the learning environment. [21] describes that the use of learning analytics in higher education has many advantages, but there are also certain problems (technical aspects, lack of technology and trained personnel, resistance to change, ethical use of data). A more detailed analysis of classification tasks in interactive visualization and the Model of Visual Analytical Dashboards are described in [23]. In terms of the visual perception, Dashboards have to combine the challenges of quick readability, coordinated actions, data tracking, private and public awareness. More details about visual perception, practices and characteristics of Dashboards, and the field of application are described in [2].

2.3 Information for Creating a Dashboard and Some Examples

In [1, 16, 25], a detailed description and various designs of Dashboards are presented. In [8], it is analyzed that in an adaptive LMS, students learn individually according to their own learning trajectory, so the Teacher's Dashboard should be aimed at helping the professor understand how students learn. It is also described in [19] that a Dashboard is used to visualize learning analytics to analyze learning data in order to improve the learning process. The information on the Teacher's Dashboard should contain data that allows you to understand the current and historical state of student learning; analyze educational materials; make flexible decisions; and carefully intervene in the learning process.

In [19, p. 806], the authors proposed the Teacher's Dashboard cycle, which is based on four key questions:

- What goals does the teacher have, and what function should the Dashboard fulfill?
- What data needs to be captured concerning collaborative learning?
- How should information be visualized on the Teacher Dashboard?
- What is the effect of providing teachers with a Teacher Dashboard?

The cycle in [19, p. 805] begins with defining the teacher's goal, followed by data collection, analysis and visualization, and the last step of the intervention (the consequences of providing educators with a Teacher Dashboard). In [10, p. 11 - 15], the authors analyzed examples of the use of learning analytics in education in the form of Dashboards, for example, RWTH Aachen: eLAT, Purdue University: Course Signals, Open Universities of Australia: PASS, University of Mannheim: LeAP, Open University of the Netherlands: LASER Dashboard. In other words, for each example of visualizing learning analytics in different online learning systems, Dashboards have been developed that correspond to the requirements of these systems. The HASKI project, which is being developed in an adaptive Learning Management System with artificial intelligence support, analyses two ways of studying, as described in the next section.

Table 1: Classification of tasks in interactive visualization

Name of Classification	Tasks
Task by Data Type Taxonomy [26]	“Overview”, “Zoom”, “Details-on-Demand”, “Relate”, “History”, “Extract”
Task Classification by Buja et al. [6]	“Finding Gestalt”, “Posing Queries”, “Making Comparisons”
Visual task classification by Keller and Keller [18]	“Identify”, “Locate”, “Distinguish”, “Cluster”, “Rank”, “Compare”, “Associate”, “Correlate”
Visual task categorization by Yi et al. [28]	“Select”, “Explore”, “Reconfigure”, “Encode”, “Abstract/ Elaborate”, “Filter”, “Connect”

Table 2: Activation of pedagogical knowledge of the educator

Pedagogical knowledge	Explanation
Level of student’s knowledge	Information for the teacher about the level of knowledge and skills of a particular student
Analysis of students’ mistakes	The educator analyzes the mistakes of a particular student to determine the causes of these mistakes
Learning progress of the student	The educator analyzes the student’s learning progress (the amount of materials learned and tasks completed)
Knowledge of the group	The educator has information about the level of knowledge and skills of students
Analysis mistakes in the group work	The educator analyzes mistakes during teamwork to determine the causes of these mistakes
Progress in the group	Information from the educator about the achievements of a group of students

Based on the analysis, we propose our own prototype that addresses the needs of professors working in the HASKI-System.

3 DEVELOPING THE REQUIREMENTS OF THE PROFESSOR’S DASHBOARD

This section analyses the pedagogical knowledge and actions that professors perform when teaching at a university and how these actions can be partially interpreted for an adaptive learning system in a professor’s Dashboard.

3.1 Pedagogical Background

During full-time education at a university, a teacher performs various activities:

- plans lectures and creates educational material;
- teaches and advises students (accompanies them during their studies);
- offers tasks of varying complexity;
- regularly analyzes the learning process and progress during lectures and practical classes.

In Tables 2 and 3, we have identified pedagogical actions and the transfer of pedagogical knowledge in full-time education. There is more detailed information on some activation of pedagogical knowledge transfer by teachers in Table 2.

This raises the question of how pedagogical knowledge about the progress of students (Table 2) may be visualized in the Dashboard of the educator. At the same time, that would be useful if the teacher could receive an automatic visualized display of knowledge, learning progress and mistakes in students’ tasks for a group of students. Therefore, the issue of a Dashboard for educators with a thorough analysis of learning is an important part of adaptive learning system as a support for the traditional learning. Further,

Table 3 also analyses the pedagogical actions performed by the professor during the students’ education. As a general conclusion, the professor not only teach, but also support the student with certain pedagogical actions to motivate and support them during the course or in the group. So, in the process of teaching, the educator must have information not only on how to teach, but also on how to analyze the knowledge transferred to students.

Thus, at each stage of learning, the teacher makes decisions about intervening in students’ learning activities. Teaching staff takes extra time to monitor students’ progress. At the same time, teachers can use instruments and methods that can improve student learning, and learning analytics offers potentially powerful ways to do so [9]. That’s why, the issue of a Dashboard for educators with a thorough analysis of learning is an important part of online learning system. Also, the description in [22, p. 349-351] of the use of Dashboards in the educational process reflects the importance of effective teacher support during the learning process.

In the next section, it is discussed about structuring data by subject area. In fact, collecting such data is an important process in an online learning system that supports traditional learning to populate the professor’s Dashboard.

3.2 Design a Dashboard

The HASKI-System is adaptive, self-managed and supported by artificial intelligence. It is aimed at supporting students in their learning, so it is student-centered and preserves individual student data and is a support to traditional learning. This system, with the support of artificial intelligence, automatically creates different learning paths and offers a choice of which learning path the student wants to follow. That is why the professor is able to monitor the learning results of the group only, as there is personal data protection. The main user of the Professor’s Dashboard is the educator.

Table 3: Pedagogical actions in the course of training

Pedagogical actions	Explanation	Type of lessons
Transferring theoretical knowledge	Transfer of theoretical knowledge from educator to the student	Lecture
Formulating the task and analyzing realization	The educator provides comments to make sure the exercises are understood or completed. Feedback focused on the content of the exercise	Practical lesson/ Laboratory practice
Education process	The educator is teaching, consulting, coaching, and providing feedback on how the assignments were completed	Lecture/ Practical lesson/ Laboratory practice/ Group activities
Personal connection	The educator contacts and supports with motivational messages	Consultations during training
Social connection	The educator organizes students in a group activity and comments on the learner's	Group activities

Table 4: Learning analytics in the Professor's Dashboard

Question	Types of LA	Type of identification or measure
How much time do students spend?	Time	Period of time (during the day) / Average time (month, weeks, days, minutes)
How many mistakes do students make?	Learning progress	Gaussian distribution / Student score / Failure analysis
How often was a certain learning element visited?	Clicks	Total number of visits (popularity) / Analysis of visits to a content format and changes in content format
What did you not like / suggestions for improvement?	Feedback	General information / Comments / Information about communication platform / Rating of learning elements and materials

The educator creates content (theoretical and practical tasks and exercises) for students to learn. With the use of the Dashboard, the teacher can analyze student activity in using different formats of the provided learning materials; popularity of subjects; attendance and completion of learning elements; quick feedback; learning style and student performance, and much more. A more detailed analysis of the development of the professor's Dashboard is presented in the next sub-sections.

3.2.1 Analyzing Type of Learning Analytics to Create a Dashboard. The HASKI-System uses an adaptive Learning Management System (LMS) to personalize the learning path for the student and offer adapted content for the student's profile. In this project, the content adaptation system uses methods to identify learning styles through the Index Learning Styles (ILS) Questionnaire using the Felder-Silverman Learning Styles Model (FSLSM), given an adaptive LMS [13, 27, 31]. However, this is only the first step in determining the initial trajectory of a student's learning. After a certain period of time, the system will collect learning analytics data that will support the planning of a new learning trajectory for the student with adapted content to the student's profile, as well as help the professor to focus on improving student learning behavior in relation to the educational content provided. In this case, the university teacher will not be able to analyze the individual learning path of a student in an adaptive LMS, considering the protection of personal data. To start working on the proposal to create a Dashboard, several questions were addressed. The answers to these questions allowed making conclusions about the benefits of visualized learning analytics. Also, using these questions, it was analyzed what type of

learning analytics can be got and how to identify and measure it. More details are found in Table 4.

Analyzing Table 4, it can be said that the time spent by a student during distance learning matters a lot. By analyzing the time, it is possible to determine whether it is enough to complete tasks of varying complexity, how much time the professor planned to complete the tasks and how much was used by the students, how much time the student spends studying a particular topic, etc. By visualizing the learning progress of a student or a group of students, it is possible to identify their level of knowledge. Depending on the situation, the professor can offer tasks of a different difficulty or reflect on the results of the student's progress and make careful predictions about intervening in the distance learning process. The type of learning analytics, known as clicks, is able to demonstrate interest in learning a course element in a distance learning system. It can also identify whether the format of the learning material is relevant, for example, changing the format from video to audio or from text to presentation will indicate a possible different learning style of students.

Regarding feedback, it is important to note that in a HASKI-System, with the help of artificial intelligence, messages will often be sent regarding recommendations and suggestions for changing the identification of a new learning style or changing the learning path, but the visualization of students' preferences and comments has to be displayed on the Professor's Dashboard. For the purpose of fully understanding the learning analytics analysis that will be placed in the Dashboard, we have separated the subject area into categories: Course, Topic, Sub-Topic, Learning element. The learning

Table 5: Details of learning analytics visualization in the Professor’s Dashboard

Types of LA	Dashboard category	Proposal visualization
Time	Course, Topic, Sub-Topic, Learning element	Heat Map, Bar Chart, Column Chart
Learning Progress	Course, Topic, Sub-Topic, Learning element	Line Chart, Bar Chart, Gaussian distribution
Clicks	Course, Topic, Sub-Topic, Learning element	Bar Chart, Column Chart
Feedback	Topic, Sub-Topic, Learning element	Bar Chart, Column Chart

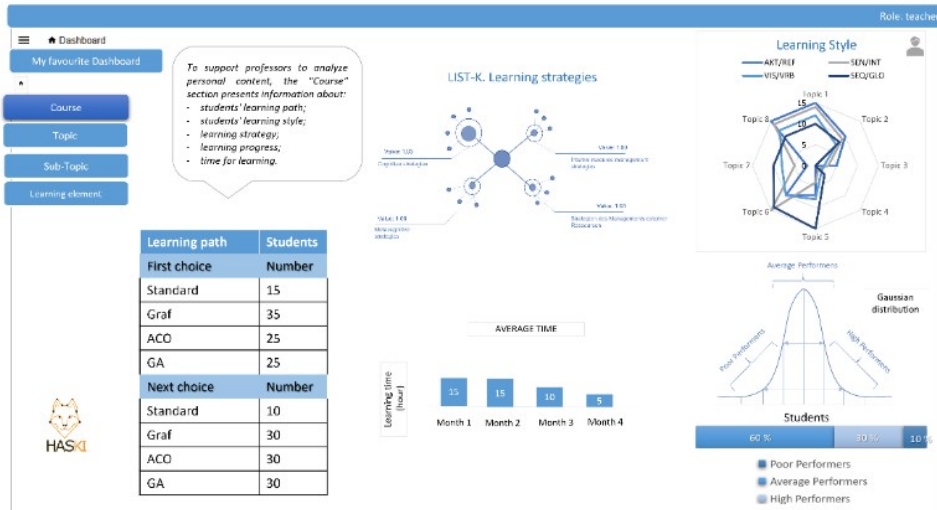


Figure 1: Prototype of the Professor’s Dashboard for the Course

element (LE) contains learning information and activities: Commentaries, Content Objects, Reflection Quizzes, Self-Assessment Tests, Discussion Forum Activities, Additional Reading Materials, Animations, Examples, Real-Life Applications, Conclusions, Assignments [14]. Table 5 identifies the data that will be useful to a professor for analyzing a student’s learning process.

To create further recommendations for the design of the Dashboard, teachers have been identified: what types of learning analytics we will need; how to measure them; in which categories of the Dashboard, they will be placed and what suggestions for the type of visualization can be provided; how the teacher can analyze the graphical representations; what actions the professor can take to improve the adaptive learning system in the future.

The next subsection shows in more detail, using the example of the first prototype of visualization, what pedagogical actions can be implemented using a visual Dashboard. Based on the results of such a deep systemic analysis in the form of visualization on a Dashboard, the professor will be able to reflect on the results and think about the possibility of carefully intervening in the distance learning process.

3.2.2 Proposed Project to Design Professor’s Dashboard. All of the predefined types of learning analytics were assigned to the appropriate category. In each of these categories, there is graphical information visualized by the type of learning analytics data. At the Course level, the professor will be able to analyze (Figure 1):

- what learning path the students have chosen (Bar Chart, Column Chart);
- what learning style students use to learn (Scatter Plot, Graph);
- what is the learning strategy (Line Chart);
- how much time the student spent studying this course (Bar Chart, Column Chart);
- what is the performance and effectiveness of the entire group of students (Line Chart, Gaussian distribution)?

At the Topic level, the professor will be able to analyze (Figure 2):

- how many Topics were completed by students and over what period of time (Bar Chart, Column Chart);
- how much time a student spent studying different topics (Bar Chart);
- how well the entire group of students performed at the Topic level (Line Chart);
- what is the popularity of Topics among students (Bar Chart)?

At the Sub-Topic level, the professor will be able to analyze (Figure 3):

- whether the Sub-Topic was completed or not, liked the study or not (Bar Chart, Column Chart);
- how much time the student has spent studying (Bar Chart);

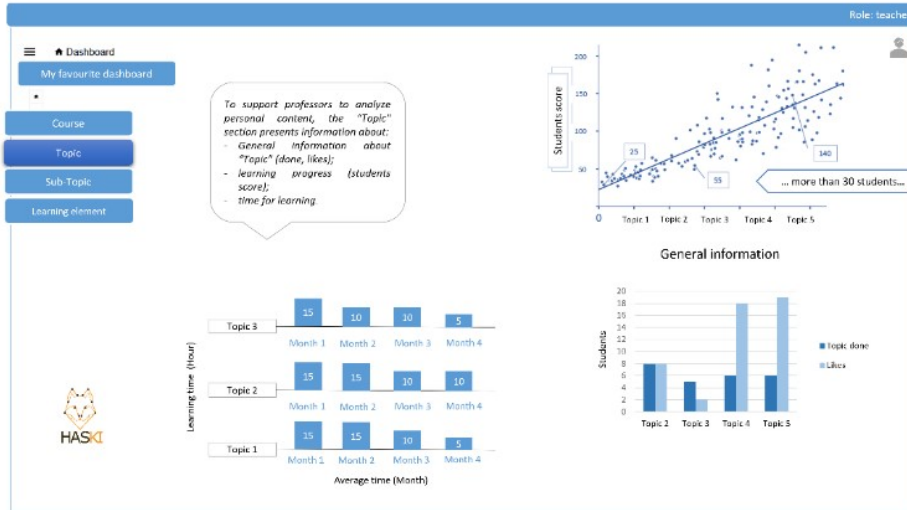


Figure 2: Prototype of the Professor's Dashboard for the Topic

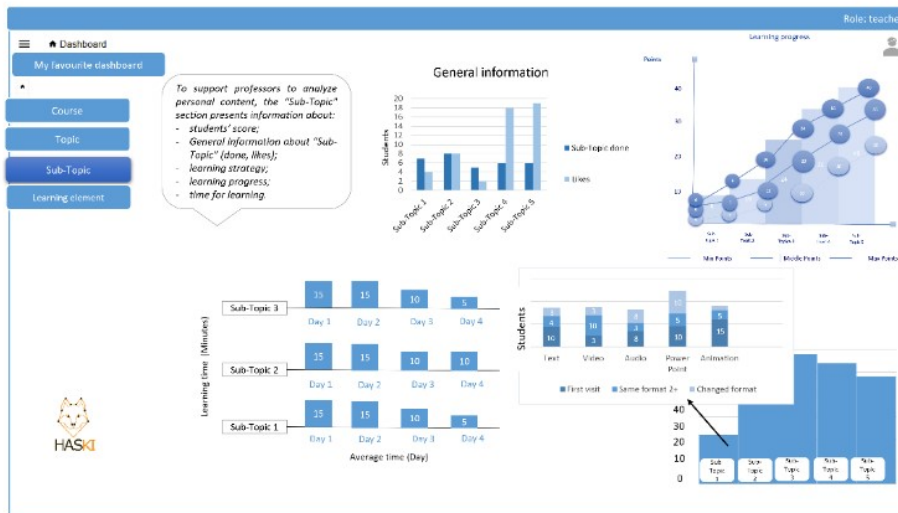


Figure 3: Prototype of the Professor's Dashboard for the Sub-Topic

- how many students have completed the assigned tasks and how many are at risk (Bar Chart);
- what is the success and learning outcome of the entire group of students in terms of scores for completed tasks (Line Chart);
- what formats of learning elements were used by students during their education, how many times the format was changed: video, audio, text, animation, etc. (Bar Chart, Column Chart)?

- whether the learning element has been completed or not, whether the student liked the training or not, how many students repeated the assignment (Bar Chart, Column Chart);
- at what time of day the student studied the material (Heat Map);
- how many students have completed the assigned tasks and how many are at risk (Bar Chart, Column Chart)?

Then, at the level of the Learning Element, one finds information that we have divided into separate items named «Time», «Knowledge Level», «Clicks», and «Feedback».

At the level of the Learning Element for general information, the professor will be able to analyze (Figure 4):

At the «Time» level in the item learning element, the professor will be able to analyze (Figure 5):

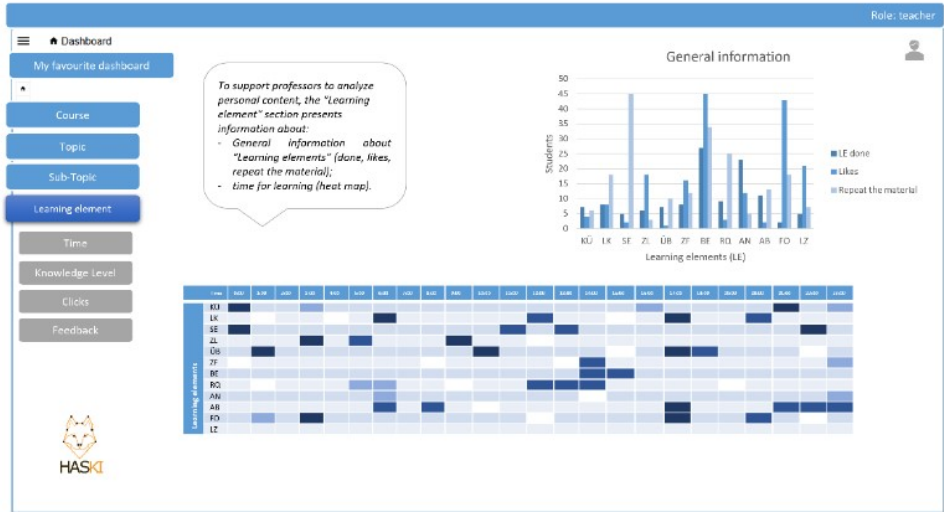


Figure 4: Prototype of the Professor's Dashboard general information for the Learning Element

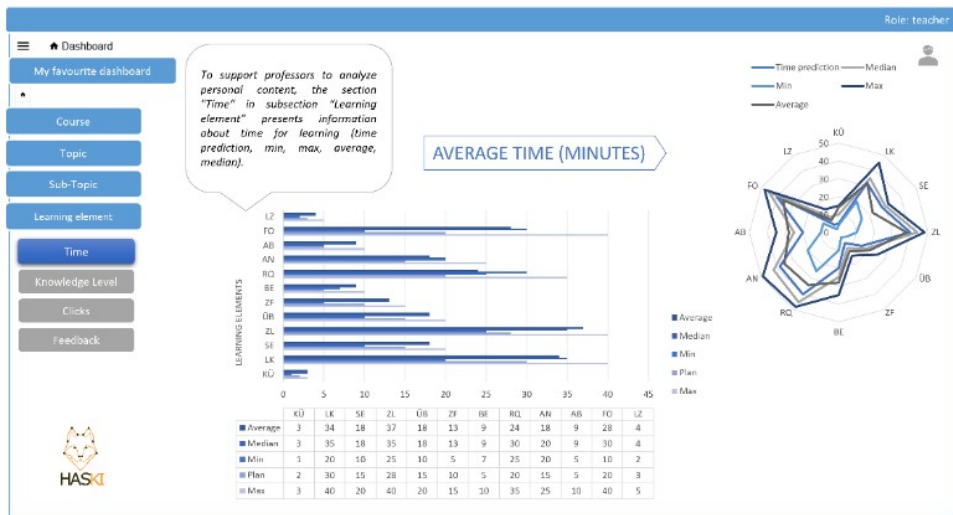


Figure 5: Prototype of the Professor's Dashboard at the «Time» level for the Learning Element

- how much time was expected to study each learning element (Bar Chart, Column Chart);
- how much time the student actually spent (Scatter Plot, Graph)?

These analyses will be helpful for the professor to identify shortcomings in the content (provide more time to teach the material, shorten the content, etc.)

At the «Knowledge Level» level in the item learning element, the professor will be able to analyze (Figure 6):

- the student's performance according to various indicators: the task was completed on the first try, or on the 2nd and 3rd tries, etc. (Bar Chart, Column Chart);

- the success of the course in percentage terms, only for certain elements (Line Chart)?

This analysis will help the educator determine the level of students' knowledge and the effectiveness of the content.

At the «Clicks» level in the item learning element, the professor will be able to analyze (Figure 7):

- the level of popularity of the learning elements (Bar Chart, Column Chart);
- the first visit, two visits in the same format (video, audio, text, animation), change of format (Bar Chart, Column Chart)?

This analysis can be used by the professor to determine the effectiveness of the learning format. At the «Feedback» level in the

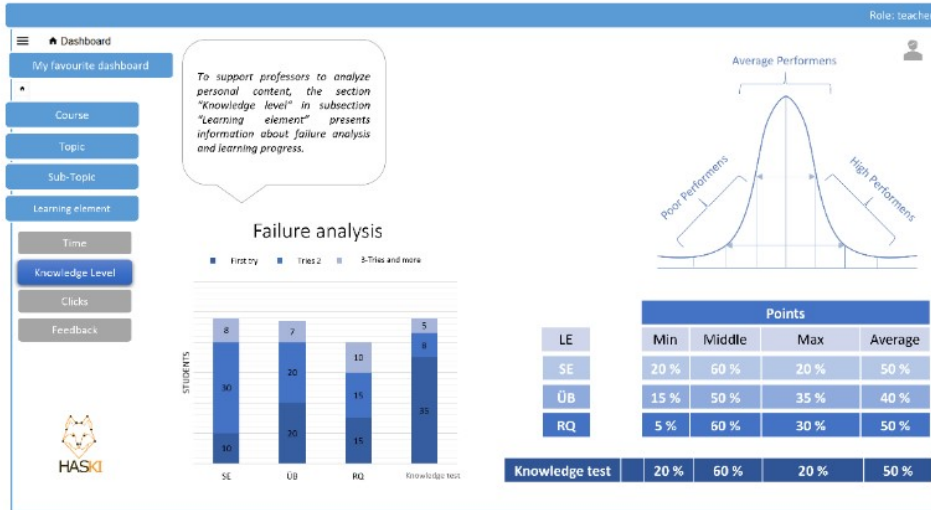


Figure 6: Prototype of the Professor’s Dashboard at the «Knowledge Level»level for the Learning Element

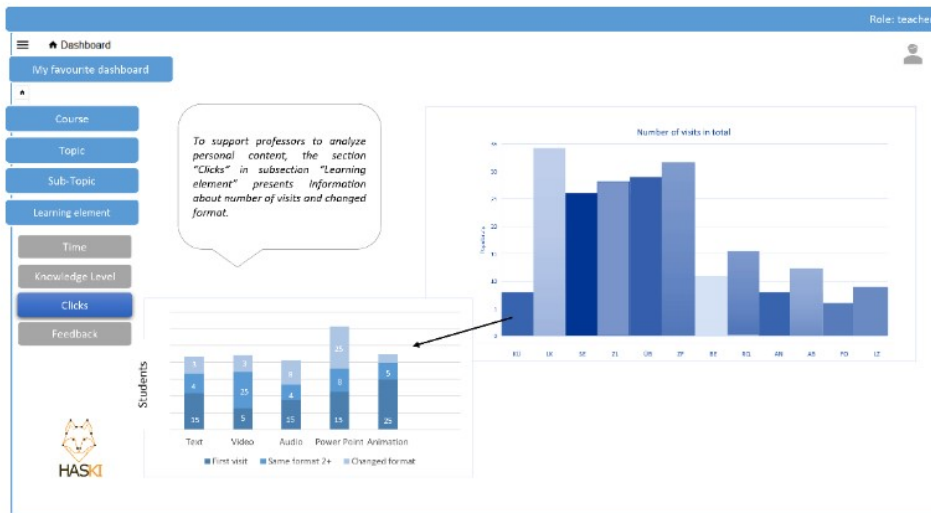


Figure 7: Prototype of the Professor’s Dashboard at the «Clicks»level for the Learning Element

item learning element, the professor will be able to analyze (Figure 8):

- the level of popularity of the learning elements (Bar Chart, Column Chart);
- information about a particular survey (Bar Chart, Column Chart, Scatter Plot / Graph);
- comments from students with encrypted names (Bar Chart, Column Chart, Scatter Plot / Graph)?

The proposed prototype of the Dashboard for professors is relevant for use in adaptive learning systems, especially in the context of filling with content, in which the professor itself develops learning materials. In this way, the educator can not only analyze students’ learning and identify moments of safe intervention in the distance

learning process, but also identify advantages and disadvantages in the proposed educational materials created for students.

4 CONCLUSION

This article presents the development of a prototype Dashboard as a teaching instrument used to help educators analyze student learning. The main idea is to encourage educators to reflect on their teaching style, which is indicated by data sets about the students studying in the course [30]. Through the visualization of learning analytics, the educator always has the opportunity to observe the learning process, progress, activity, or can also intervene in the learning process of students.

In the HASKI-System, the educator’s contribution to online learning is highly valued. In fact, the teacher acts more as a tutor and



Figure 8: Prototype of the Professor's Dashboard at the «Feedback» level for the Learning Element

mentor, while the student is self-motivated and learns without outside support. Therefore, in order to carefully intervene in the student's learning process, it is important to have a system for managing information obtained from learning analytics in the form of a Professor's Dashboard with detailed data.

5 FUTURE WORK

In the future, the functional Dashboard for Professors can be expanded based on the learning analytics obtained. Further, it is planned to use modeling of Object-Oriented Bayesian Networks to describe the student's learning behavior, determine the frequency of login, activity on the site, the pace of the course and grades for assignments, the number of discussion messages requested and the number of answers posted, and other information, and transfer it in the form of graphical data for the Professor's Dashboard. Also, using other algorithms, like Hidden Markov Models, and Recurrent Neural Networks, it is possible to analyze student participation in the course in time and generate warnings about the risk of leaving the course.

6 DISCUSSION

The following questions remain open: how to help teachers understand the need for digital competence; what recommendations should be given to a professor to understand learning analytics; how to support a professor in making a plan for careful intervention in the e-learning process to achieve a successful outcome; what automatic prompts and recommendations are needed for a professor to make decisions.

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