

Teachers' Data Literacy Skills for Pedagogical Decision Making: Needs Analysis in Lithuania and Germany

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Abstract. The purpose of the article is to analyse the needs of general education schoolteachers' data literacy skills that are important for the effective use of learning analytics in the teaching-learning process. The theoretical part of the article presents the idea of big data in education, highlights the aspects of pedagogical value of learning analytics technologies, provides the overview of learning analytic tools. Some overview and comparison of spread of learning analytics tools in general education schools in Lithuania and Germany is presented in the context of data-driven education. The empirical part of the article presents some results from a big qualitative study of teachers' experiences applying learning analytics tools in teaching - learning process. The main question of the current research is what data literacy skills teachers need in order to use learning analytics tools and make data based pedagogical decisions. Semi-structured interviews were conducted with 10 Lithuanian and 9 German teachers from general education schools, who already have had experience in working with learning experience platforms (digital learning platforms that integrate learning analytics tools). Interview data were analysed by means of content analysis. The results of the qualitative study showed that in order to use learning analytics tools it is important for teachers to have such skills as: digital literacy, data collection, data analysis and interpretation, etc. Comparative analysis of informants'

answers showed that teachers in Lithuania and Germany expressed similar needs for data literacy skills.

Keywords: Learning analytics, teachers' data literacy, needs analysis in Germany and Lithuania

I. INTRODUCTION

In the last decade, the paradigm shift from accountability-based education to data-based education, which focuses on continuous improvement, has put a strong emphasis on the purposeful use of data to improve the quality of education in European countries [1], [2]. Although data in education are still a relatively new phenomenon, the value of information obtained from data analytics is unique. From a research point of view, this is a promising opportunity to contribute to the personalization of student learning, as well as to the formation of educational policy.

The recent trend in digitalisation of education has fostered the rapid development of educational technologies (EdTech) such as computer-based learning environments, adaptive learning technologies, intelligent learning systems, "smart classrooms" and other. These technologies

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generate a lot of data about learners. These data may include simple/uncomplicated data such as time spent in a virtual environment or learning system or time spent on tasks. More complex data include various indicators of task resolution. These data are often digital, but often include text, images and video, and is often temporary in nature, capturing the interactions of system users during individual or group learning, as well as the longer-term learning plans of learners. Based on the named data characteristics, these data are classified as big data. Big data collected during the learning process are the domain of learning analytics [3], [4], [5].

Learning analytics has the greatest capacity to provide useful insights needed to make pedagogical decisions and to improve the quality of student learning [6]. Learning analytics technologies leave the decision-making to the human, but back it up with automated data analysis, possibly using AI techniques. In this way, the overall goal of learning analytics is to aggregate/accumulate data from various educational environments, perform their analysis, so that people can use the data to improve the solutions.

According to researchers, one of the main beneficiary groups of learning analytics data are teachers [7], on the other hand, it is teachers' readiness to use data to improve pedagogical activities and decisions that connects the essence of data analytics with the needs of educational theory and practice, educational content and understanding of how students learn [7], [8].

Research carried out in Germany [9] points that in data-driven schools the concept of and need for teachers' data literacy is expressed [10]. Research conducted in Lithuania [11] shows that Lithuanian schools create and accumulate data in different environments, but teachers require special knowledge and skills for analysis.

Asserting that teachers' use of data makes them more efficient in pedagogical practice immediately raises the question of how to unleash this potential. Therefore, the current study is timely and relevant effort aimed at filling the gap in scientific insights, helping to disclose the relevant data literacy needs of teachers in general education schools in Germany and Lithuania, responding to the priorities of educational and educational strategic documents in Germany and Lithuania [13] teacher education and professional development goals.

II. BIG DATA AND LEARNING ANALYTICS IN GENERAL EDUCATION SCHOOLS

The integration of big data aggregation technologies into digital education tools has several advantages for education [14]:

- Personalization of learning: big data can lead to personalized learning, which goes beyond adapting pedagogical methods or tasks to the specific learning needs of students, but enables learners to design their own learning based on how they learn, what their learning needs are, what their learning goals are, aspirations and even

according to the socio-cultural background of the learners [15].

- Adaptive learning: adaptive learning systems can continuously collect and interpret student data, change the direction and environment of students' learning, taking into account their needs and abilities [16].

- Accurate assessment: big data make it possible to monitor students in their learning process, so it is possible to apply new assessment methods that more accurately assess student achievements [17].

- Effective feedback: big data can help ensure a more reasonable and effective feedback cycle - students receive feedback in real time and based on their real contribution [18].

- Learning prediction: student behaviour, skills and learning outcomes can be predicted based on the analysis of student activities on digital platforms. This is also important for teachers - they can pay more attention to students with specific learning gaps [19].

In response to the emergence of big data in education learning analytics has become a rapidly developing field that includes learning analytics as a research field and learning analytics as a practical application field [12]. The focus on learning data analysis has opened a whole new field of educational research and provided an opportunity to reconsider how this type of analytics can help improve the content of a teaching/learning subject and improve the teaching and learning process in a technology-based learning environment [21]. Learning data analytics has become a new practice concept in educational institutions. According to [22] this is a new and promising method that expands practitioners' knowledge about the teaching and learning process.

The beneficiaries of learning analytics technologies first of all are teachers who want to analyse their classroom situations in more detail [7]. Learning analytics tools allow teachers to form timely and meaningful assessments of ongoing learning activities. Learning analytics tools increase teachers' understanding of student achievement [23],[24], potential misconceptions (e.g. guess correct answers) [23] approved curricula and training effectiveness [25]. Learning analytics can inform teachers about the quality of instructional content and the impact of teacher-proposed activities and the effectiveness of their assessment process [26]. Teachers can use these data to learn how students are learning and what their main strengths and weaknesses are. Based on fine-grained evidence, such as the level of computer-based assessment skills, engagement in activities, etc., teachers can also make important pedagogical decisions. These fine-grained data are also important for monitoring performance changes [27]. Teachers can effectively use detailed information about students' knowledge gaps in different subject areas. Information about a student's strengths and weaknesses could be used by the teacher to plan interventions where the student needs help moving forward. In this way, learning analytics tools can help teachers highlight students who may need extra help [28], [29], [30] or reflect on different

ways to encourage students to learn further [29]. On the other hand, learning analytics tools can assist teachers in considering the design and development of new course programs [31] and help them improve the quality of digital textbooks and instructional materials [32]. Many educators strongly believe that, when used properly, learning analytics can be an essential tool for closing the achievement gap, increasing student success, and improving the quality of education in the digital age [7].

III. TEACHERS' DATA LITERACY SKILLS AND LEARNING ANALYTICS

It was proven by research studies that data-informed decision-making can contribute to better student achievement [34], [35], [36]. However, to reveal the full potential of data in education, more scientific insights are needed on how exactly teachers could effectively use data in their pedagogical practice [35]. In education research, the concept of teacher data literacy competence has evolved from a focus on the skills that teachers need to engage in, collect, analyse and interpret instructional data and perform data-based pedagogical actions [37]. Teachers need competencies to interpret data and combine it with their pedagogical knowledge to benefit educational practice [38].

The problem of data literacy among general education teachers is relatively new [39], but there are already scientifically based arguments that teachers lack data literacy and that actions are needed to improve this situation [40]. A key concern is to find a way how to empower teachers to effectively apply data to improve instruction [41], [42]. The results of other studies [43] emphasize the need to develop teachers' competencies to effectively use data for pedagogical decisions. Corrin et al. [44], who conducted an experiment with a group of teachers, found that the participants in the study lacked the competence to correctly interpret the data. Herodotus et al. [45] research revealed that it was difficult for teachers participating in the study to plan appropriate pedagogical interventions based on the data. [46] research highlighted the need for teacher competence development in the field of data analytics application.

In addition, general education schools are increasingly using digital learning environments [47], so the focus of research in recent years has been on the introduction of data generated by these environments into the decision-making process of teachers and their effective use [49]; [48] emphasize the need to help teachers master data-driven technologies. According to [51] effective use depends on various components - general characteristics of teachers, such as technological skills, age, gender, as well as their pedagogical knowledge, professional routines, ability to understand and interpret data, etc. There is a lack of scientific research on how these factors interact and what impact they have on pedagogical practice and the teaching/learning process.

[52] report that research on learning analytics in Germany is scarce and that there are only a few projects

focusing on the implementation of learning analytics systems. Since 2019 several research projects have been funded by the German Federal Ministry of Education and Research focusing on technology integration and analytics in educational organizations [53]. For example, the aim of the project 'Utilizing Learning Analytics for Study Success' is to conduct a systematic review and construct a set of policies for German education institutions to adopt learning analytics capabilities into their existing learning environments. However, it became evident from the integrative review that robust empirical findings on a large scale to support the effectiveness of learning analytics actually retaining students onto courses are still lacking [52]. The project findings of the interview study indicate that more work on ethical and privacy guidelines supporting a wider adoption of learning analytics systems is needed as well as work towards a standardized learning analytics system which can be integrated into any learning environment providing reliable at-risk student prediction, prevention and intervention strategies [56]. In particular, personalized learning environments are increasingly demanded and valued in education institutions to create a tailored learning package optimized for each individual learner based on their personal profile which could contain information such as their geo-social demographic backgrounds, their previous qualifications, how they engaged in the recruitment journey, their activities on social media and websites, as well as tracking information on their searches [57]. Besides the technological challenges, teachers' capabilities are also changing when implementing learning analytics systems. Not only new teachers' roles but also further professional development of teachers is required for successful implementation of learning analytics systems [55].

In Lithuania, it can be said that two ambitious educational projects have been implemented and their harmony and common pedagogical direction is extremely important for the digital transformation of education. The project "Creating and implementing digital educational content" [59] has an aspiration to update education programs and the results of the update will be described and placed in a virtual environment so that teachers can use them to monitor individual student progress and provide support. In addition, it is planned to update already created digital teaching resources and to create and adapt open digital teaching resources, which are needed for the implementation of updated common programs. The project "Artificial intelligence in schools: scenarios for the development of learning analytics while modernizing general education in Lithuania" [65] focused on the benefits of learning experience platforms in general education schools particularly putting the emphasis on use of learning analytics in teachers' practice. [11], [61] studies conducted in Lithuanian general education schools showed that teachers have not relevant skills for working with data, and moreover, they feel a lack of such skills. However, at the moment, there is a lack of more detailed research in Lithuania, dedicated to the issues of teachers' data literacy competence and its development. In addition, in Lithuania, research related to digital student data, digital data analytics

tools, ethical issues of data collection and use, etc. was not detected.

IV. DESIGN OF THE EMPIRIC STUDY

The goal of the empiric study was to disclose the teachers' needs for digital literacy skills in school of Germany and Lithuania.

To achieve this goal - individual interviews with teachers, who use the educational platforms that integrate learning analytics in their pedagogical practice, have been carried out. In Lithuanian general education schools, we have interviewed teachers that use the following platforms that integrate learning analytics and artificial intelligence: EdutenPlayground, Matific, FastForWord, Egzaminatorius.LT, EduAI [60]. In Germany – Stemify, Möbius.

The research population was formed using criterion selection [12]. Teachers with at least one year of experience working with this type of platform were selected as the study population. The form of selection of the sample of research participants was a convenient targeted sampling. The purpose of the convenient targeted sampling in this case was to include into the study group those informants, who are the most typical representatives in terms of the required characteristics. A total of 19 semi-structured interviews were conducted.

The data collection instrument consists of open-ended questions divided into several diagnostic blocks designed to reveal teachers' opinions about their work with learning analytics tools and the needs for certain skills to use learning analytics tool effectively.

Qualitative content analysis was chosen as a method for analysing written, verbal and visual communication messages [62] for the analysis of interview data and the presentation of research findings. Classical content analysis involves the techniques of reducing text into groups based on codes composed of variables (presence, intensity, or quantity of significant characteristics) [63]. Data analysis was carried out in several stages: 1. reading the interview text; 2. categorization based on essential words; 3. dividing the content of categories into subcategories; 4. description and justification of categories and subcategories with evidence extracted from the text [64].

V. IMPLEMENTATIONS AND DISCUSSION

After analysis of the research results the following categories have been formed: technology management skills, skills of interpreting data summaries received from learning analytics, skills to analyse student learning, the need for competence development, and leadership skills in learning analytics. The following categories represent the teachers' skills in using learning analytics tools in Lithuania (table 1).

TABLE I. Teachers' skills in using learning analytics tools in Lithuania.

Category	Subcategory	Illustrative thesis
Teachers' skills in using learning analytics tools	Technology management skills	“First of all, we have to master the technology. I understand that not everyone likes it, some people are still afraid of them (technology).” (No. 2)
	Skills of interpreting data summaries received from learning analytics	“... additional training for teachers on how to study and analyze statistics, because a lot of statistics are presented and especially that skills map is fascinating, but I personally do not have enough skills, well, that system is sometimes difficult to understand.” (No. 4)
	Skills to analyze student learning	“...the teacher's ability to analyze children's learning is important. If until now it has been scattered knowledge, now I have it and can look at it digitized, at any time I can open the last lesson, even the lesson at the beginning of the year, and see how the child did in this or that topic. We, the teachers, are not learning analysts, as far as we can manage it, either on paper or in Excel, so we do need skills to compare what is presented.” (No. 7)
	The need for competence development	“But the teacher has yet to be trained. Because the teacher can manage, raise the bar, help to jump according to each, this is where the personalization is - according to each child...” (No. 6)
	Leadership skills in learning analytics	“we started with teachers who are pioneers, who are more forward looking and have more enthusiasm for these things, we started with them. Then the other teachers started watching - "What are you doing there?" It looks pretty good, pretty fun, how can we get in on it?” (No. 3).

When talking about teachers' skills in using learning analytics tools, the informants emphasized ICT management skills. In their words, teachers should first of all be "technology-friendly" - they must want to apply technology in the teaching/learning process and manage it effectively. “*Not everyone likes working with computers and some find it counterproductive, but applying learning analytics requires skills of technology usage.*” (No. 5) Informants acknowledged that among teachers there are doubts about the benefits of integrating technology into education.

Research participants also emphasized that in order to successfully use learning analytics, you need to have the ability to interpret data summaries and statistics. <...> *we face the problem of data analysis and interpretation, we see that it is really difficult to read the graphs, although we really make them very simple, but it is simply difficult. <...>We see that this skill [data analysis] is not very strongly developed.* (No. 10.) As a result, it is important to be able to understand the "outcome" of learning analytics - in which pieces of data analysis are presented, to

understand how it can help answer various questions related to the learning process.

In addition, according to the informants, it is important to be able to interpret data and connect them with opportunities for improving the learning process. Such teacher' skills would promote data-based pedagogical decisions. "*<...> now I have it and can look at it digitized, at any time I can open the last lesson, even the lesson at the beginning of the year, and see how the child did in this or that topic*" (No. 9).

Another important aspect emphasized by the research participants is the need for the development of skills to use learning analytics. *<...> learning on the program [name of the program] is about strengthening self-knowledge and the ability to learn.* (No. 10).

Moreover, leadership appears to be a very important skill to apply learning analytics programmes at schools "*we followed teachers, teachers who were pioneers came to us, they started using, and slowly other teachers started using. So there were teachers who convinced other teachers that this was actually a good thing*" (Nr.3). In the opinion of the informants, the most important factor that can influence the wider use of learning analytics in Lithuanian schools is teacher training and support for teachers on how to apply these technologies in the educational process.

Some similar results appeared in the interviews with German teachers. Main skills in using learning analytics tools in Germany are: computer literacy, data collection skills, skills in data analysis, competence in learning to learn and openness to innovation.

TABLE II. Teachers' skills in using learning analytics tools in Germany

Category	Subcategory	Illustrative thesis
Teachers' skills in using learning analytics tools	Computer literacy	"Most likely, children are superior to us in digital, although sometimes I start to doubt it, because the teachers are really competent enough, but for the most part it is true. Children know how to play games, but there has been no purposeful use of IT for learning for a long time" (No. 11)
	Data collection skills	"<...> we have to learn to collect the data that is needed. Don't pick just any and be happy that you have the data". (No. 12).
	Skills in data analysis	"Now about analytics with data, I think it's very new, fairly new, although it should be, maybe I'm not quite right, maybe working with data has been around for a long time, but very specifically, with such precision and such detail, how much time is spent, what tasks etc. i.e. and that it can be presented to the parent and that the teacher and the child can see, that's new enough" (No. 12)

Ability to learn and openness to innovation despite the age	"<...> [the teacher] is so receptive to innovations, technologies, who are not afraid of the computer, and cannot say whether they are younger or older, there are certainly older people who use it very well, you cannot predict the age limit and you cannot say that only young people, but maybe it depends on the teacher himself" (No. 14).
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Computer literacy remains one of the most significant skills needed to work with learning analytics platforms. This skill has grown significantly with the advent of distance learning. "*<...> technological literacy of teachers, it seems to me, has grown in half a year, in reality such a situation has happened that many things have really improved, some are more difficult, others are much easier, but it seems to me that this is still a situation from which something has come out good*" (No. 11.)

Competence in data collection and its low level were not relevant for teachers until they started using learning analytics platforms, as confirmed by the research participants. The results of the study showed that teachers often independently collected chaotic data without a system, without planning the purpose and purpose of its use. "*<...> we now have a lot of data about our students' learning, but we need skills how to decode it and link to pedagogical decisions*".

Data collection is closely related to the competence of data analysis and interpretation, which, as the research participants noticed, was very lacking when learning analytics started to work. *<...> because a lot of statistics are presented and especially that skill map is fascinating, but I personally [don't have enough] skills, well, that system is sometimes difficult to understand.* (No. 12). The development of data analysis competence is a part of the computer literacy competence (data management), but this competence is still lacking. As noted by the research participants, supporting the use of learning analytics platforms required filling in missing knowledge. It is important to mention that the study participants observed an increase in this comparison after starting to use learning analytics tools. In other words, working with the learning experience platforms (including training for working with learning analytics) has contributed to the improvement of this competence.

Ability to learn and openness to innovation are understood as the need to learn and persistent pursuit of a set goal, responsibility for one's learning; abilities to plan and reflect on the learning process and results, set measured further tasks, choose learning methods; knowing one's strengths and weaknesses, being interested in learning options. Research participants mentioned that "*<...> learning analytics impowers us to become teachers-researchers, I mean, to carry out own research and use results for the self-improvement*". However, as research participants stated, teachers themselves still lack this competence, especially when it comes to new digital learning tools (including learning analytics).

All in all, after analysing the research data, it can be seen that the application of learning analytics strongly depends on the skills of teachers and may be problematic if they are limited. The results of the study showed that teachers who are more open to innovation and are seeking to learn something new, constantly researching and interested, tend to use learning analytics platforms much more actively. Research participants emphasized that teachers need to be able to interpret the data generated by those tools and combine them with their own pedagogical knowledge in order to benefit educational practice. Data literacy skills include the ability of teachers to: understand what data are needed to solve a particular problem, collect these data, understand (student) data presentation and feedback provided by learning analytics tools, use these data and inform their decisions to provide better support for students. Research shows that teachers often lack the skills to analyse data and apply the results of such analysis in practice, as well as teachers lack the ability to set specific goals, collect data and plan interventions to achieve that goal. The research emphasizes that teachers need to acquire a certain level of data literacy, which means the ability to transform information into practical knowledge and practice by collecting, analysing and interpreting all types of data, and also to implement certain pedagogical actions on the basis of such analysis. It combines the essence of data analytics with educational theory and practice, educational content and an understanding of how students learn. Therefore teachers feel the need to become teachers-researchers, who are able to raise problematic question, collect necessary data, analyse and interpret it and to take data-based decisions to solve the issue. These skills should be in the focus of teacher training and professional development programmes in Germany and Lithuania. Also, comparative analysis of informants' answers showed that teachers in Lithuania and Germany expressed similar needs for data literacy skills.

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