Does Practice Make Perfect? Teaching Technically Demanding Content in Distant Mode in Higher Education

Hurri Päivi, South-Eastern Finland University of Applied Sciences, Finland
Helander Nina, South-Eastern Finland University of Applied Sciences, Finland
Ansamäki Jarkko, South-Eastern Finland University of Applied Sciences, Finland
Reijonen Atte, South-Eastern Finland University of Applied Sciences, Finland

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Abstract
This paper presents experiences of teaching technically demanding content in online and higher education context by utilizing learning analytics. The aim is to study how students learn technically demanding content in an online course in the light of learning analytics. The results of this paper are based on a pilot course implementation. The pilot course, Basics of data analytics, was taught as virtual, open university course during Spring 2024 in Finland. In the course implementation, students were provided distance learning materials, and they had practical SQL exercises that were provided through Azure Data Studio cloud service. In the final course examination that was provided through a learning platform called Moodle, students were tested by filling up SQL sentences. The virtual learning environment, including the SQL server, Azure Data Studio and Moodle, provided the possibility to follow the amount and quality of the students' practical rehearsals. These were then further compared with the measurable examination results that the students' gained in the end of the course. The full paper presents the results of the learning analytics and shed light on the further development of teaching technically demanding content in distant mode.

Keywords: Data Analytics Teaching, Online Teaching, Learning Analytics

Introduction

Timely access to knowledge and inspiring hands-on exercises play a critical role in students' learning in technically demanding topics, such as data analytics courses. Hands-on learning environments are needed to provide practical insights when teaching abstract concepts (Gupta, 2023). Thus, teaching of relevant tools for students to better learn data analytics is in essential role (Zheng, 2019). Furthermore, it would be beneficial to have such rich environments for learning that take into account also the human and social aspects and leverage the human approach and abstract thinking (Medina-Hernández et al., 2022).

According to previous studies, teachers have brought up a high level of interest, but rather limited capabilities in learning analytics development (West et al., 2016). Especially in teaching data analytics, it can often happen that teachers which don't have a strong background in data analysis and statistical methods face challenges in identifying both the potential benefits and challenges of learning analytics (Kiwelekar et al., 2022). However, it would be beneficial that teachers recognize their students' competence development already during the course. This requires that teachers have timely access to the learning data and furthermore, that they also have the necessary competencies to perform appropriate analysis of the students' learning. They would need more engagement with potential educational technologies and analytical tools to develop teaching and learning experience (Halibas et al., 2019).

This paper presents experiences of teaching and learning technically demanding content in online and higher education context by utilizing learning analytics. The aim is to study *how students learn technically demanding content in an online course in the light of learning analytics*. The results of this paper are based on a pilot course implementation. The pilot course, Basics of data analytics, was taught as virtual, open university course during Spring 2024 in Finland. The course was comprised of two sections, infographics (2,5 ECTS) and SQL (2,5 ECTS). SQL skills are of high importance in learning data analytics, so these skills were taught in the course very practically. Firstly, students were provided distance learning materials. Secondly, they had practical SQL exercises that were provided through Azure cloud service. Thirdly, students made examination in Moodle learning environment. In this examination, students were tested by filling up SQL sentences. The virtual learning environment, including the SQL server, Azure Data Studio and Moodle, provided the possibility to follow the amount and quality of the students' practical rehearsals. These were then further compared with the measurable examination results that the students' gained in the end of the course. Additionally, students' own perceptions on their course experiences were gathered through a small survey.

In next, we will first shortly open the bases of learning analytics and then we will present the empirical case study, followed by opening up the key empirical findings. The paper is ended with conclusions and discussion.

Theoretical Background: What Is Learning Analytics?

According to a widely used definition, learning analytics refers to an overall process that includes the phases of collecting, measuring, analyzing and reporting of data about the students' activities aiming to understand and optimize the learning processes, but also the environments for learning (Long & Siemens, 2011). To collect, analyze and report the data effectively, technology solutions are applied. In fact, modern learning analytics connects two

worlds: the world of learning—referring to educational research and pedagogical strategies - and the world of technology—referring to data analytics, visualization techniques, and artificial intelligence. Modern learning analytics builds on long-term developments in both of these fields, providing new insights into how people learn and furthermore, leading towards opportunities to enhance the effectiveness of learning programs (Clow, 2013; Nistor & Hernández-Garcia, 2018).

Examining and measuring the data collected on learning platforms is key area in learning analytics. Hernández-de-Menéndez and colleagues (2022) have carried out an extensive review of learning analytics and they provide a comprehensive discussion on the data sources of learning analytics. The digital footprints of student activities left on learning platforms tell about the learning process and help monitor and analyze it in real time. Data can be used to support the student and produce automatic feedback and adaptive tasks to guide the student in the right direction. It is important to keep in mind that learning data is harnessed to support the students, but naturally also teachers benefit from learning analytics in many ways. For teachers, learning analytics can provide, for example, information on course fluency, the functionality of pedagogical elements or assessed prerequisites. With the help of data, the teacher deepens the understanding of the learner's experience and develops teaching. This in turn frees up time for personal interaction with the student. For a student, learning analytics can mean, for example, information about workload and graduation based on credit accumulation, or suggestions for courses or necessary actions, such as registrations.

In fact, learning analytics can be examined at several different levels of actors. The actor level determines the contexts in which information is used. It is important to identify the contexts and the purposes of data use in order to clearly define data protection issues related to different situations and also the ethical issues (Zilvinskis et al., 2017). In overall, learning analytics can be the key success factor in future teaching, helping learners find their own path towards top learning outcomes. At best, it can provide a view of the learning experience, motivation, well-being and personalized competence development. Students can receive personal feedback and support for independent learning at just the right time (Hernández-de-Menéndez et al., 2022).

Empirical Case: Data Analytics Virtual Course Implementation

The empirical case of this study is virtual course implementation of Data analytics. This was a pilot course named as “Basics of Data Analytics” and it was provided as open university course during Spring 2024 in Finland. The course was in total 5 ECTS and it was comprised of two sections, infographics (2,5 ECTS) and SQL (2,5 ECTS). In this paper, we concentrate on the SQL part of the course implementation due to its rather demanding technical content. SQL skills are of high importance in learning data analytics, so these skills were taught in the course very practically. Firstly, students were provided distance learning materials. Secondly, they had practical SQL exercises that were provided in SQL Server database management system. Students connected to SQL Server in Azure cloud service using Azure Data Studio program. Thirdly, students made examination in Moodle learning environment. In this examination, students were tested by filling up SQL sentences. The virtual learning environment, including the SQL server, Azure Data Studio and Moodle, provided the possibility to follow the amount and quality of the students’ practical rehearsals. These were then further compared with the measurable examination results that the students’ gained in the end of the course. The course implementation and the supporting technical tools and platforms are illustrated in next Figure 1.

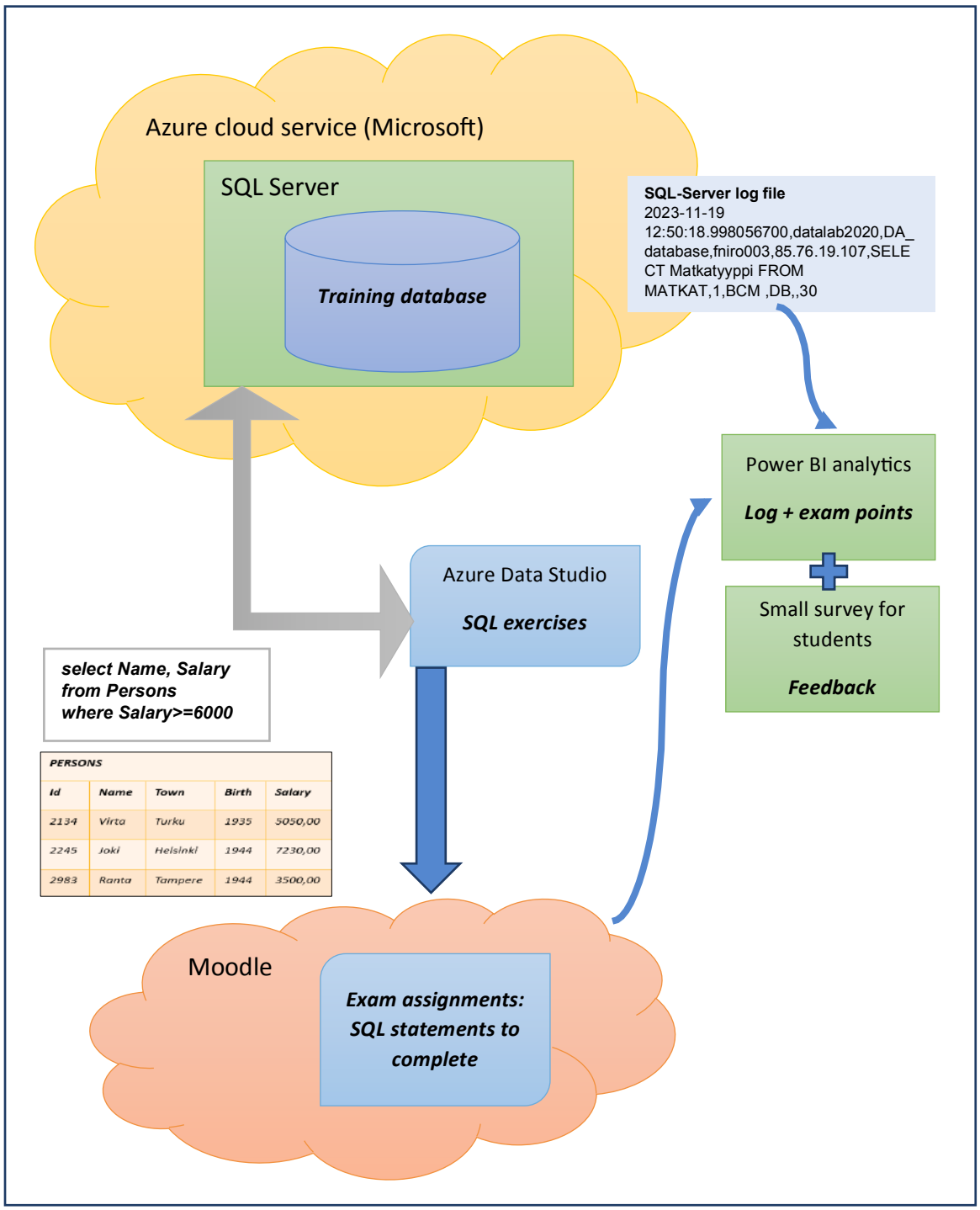
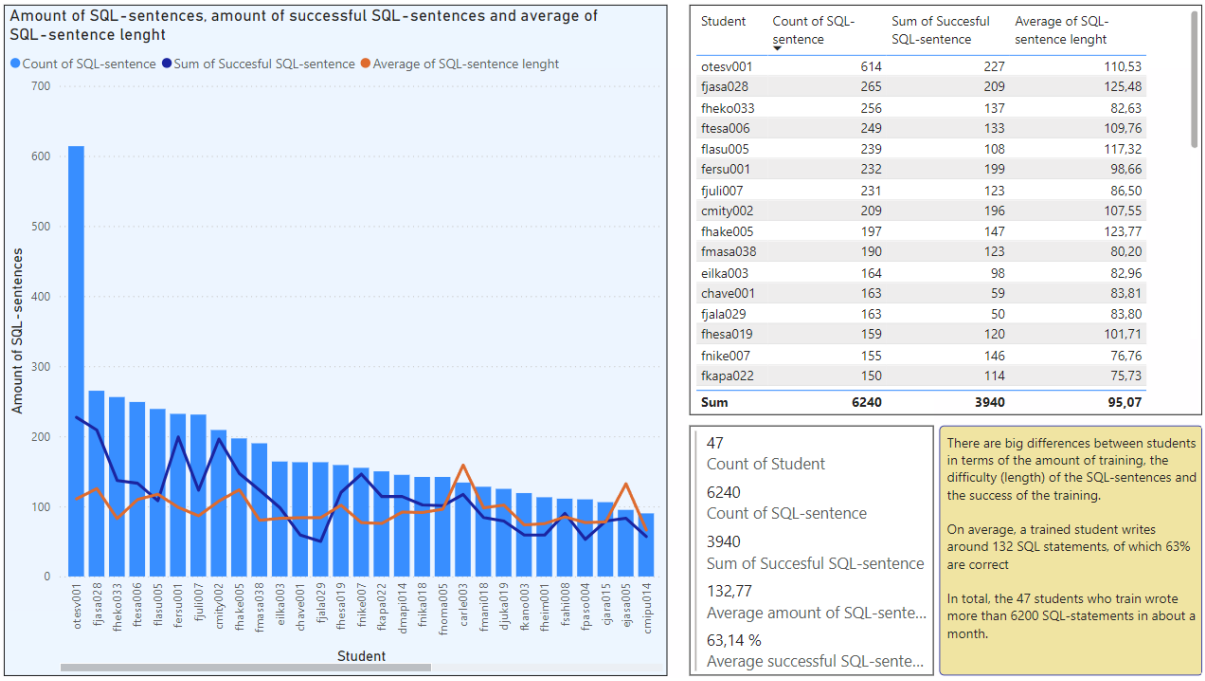


Figure 1: SQL Learning Environment

Key Empirical Findings

Learning analytics solutions integrated in the online course implementation enabled us to monitor the student's activity in the virtual learning environment, see following Figure 2.



Student	Count of SQL-sentence	Sum of Succesful SQL-sentence	Average of SQL-sentence lenght
otesv001	614	227	110,53
fjasa028	265	209	125,48
fheko033	256	137	82,63
ftesa006	249	133	109,76
flasu005	239	108	117,32
fersu001	232	199	98,66
fjuli007	231	123	86,50
cmity002	209	196	107,55
fhake005	197	147	123,77
fmasa038	190	123	80,20
eilka003	164	98	82,96
chave001	163	59	83,81
fjala029	163	50	83,80
fhesa019	159	120	101,71
fnike007	155	146	76,76
fkapa022	150	114	75,73
Sum	**6240**	**3940**	**95,07**

Figure 2: Amount of SQL
(*The amount of practical training and the success varies a lot from student to student.*)

Training increased towards the end of the course (Figure 3). At the same time the mount of the right SQL-sentenced didn't improved in the same proportion. Possibly the reason is that students wrote more difficult SQL-sentences at the end of the course.

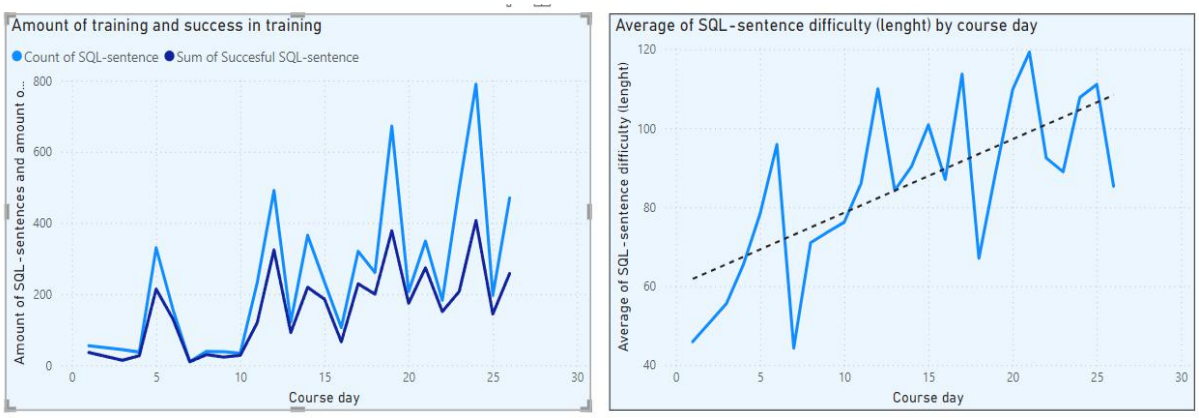


Figure 3: Amount of Training and Success and Average of SQL (*Training increases towards the end of the course, but success in training does not improve in the same proportion.*)

We were also interested in to analyze what kind of results were achieved with the learning environment as well as what was learned in the end based on the exam results.

In overall, students did very well in the course. Altogether 65 students took the exam, and of them 60 students passed the course and thus received the badge for SQL. The requirement to pass the course was half of the exam assignments correct. However, the students did far better than this, as the exam yielded an average score of 27.26 out of 35 points. Thus, 77.9% of the completed SQL statements were correct in the exam.

When looking at the learning analytics data more carefully, we can draw the empirical conclusion of this case course that students achieved better exam results when they practiced more, see following Figure 4.

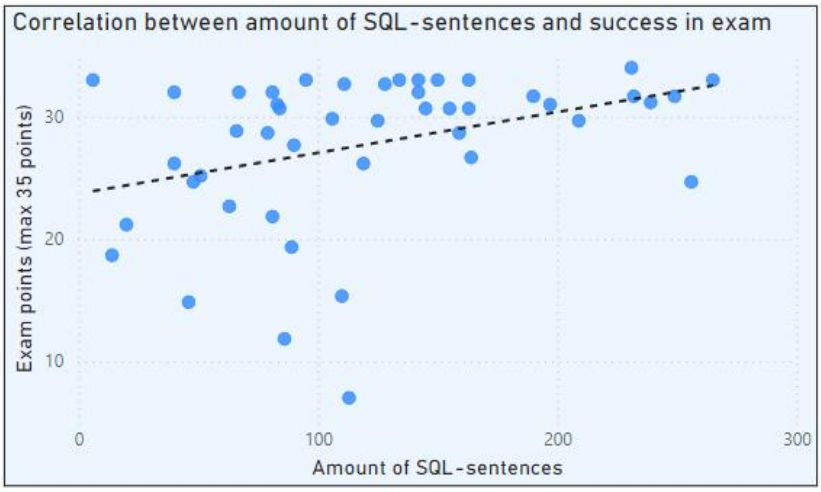


Figure 4: Correlation Between Amount of SQL (*Practice improves exam success.*)

In following Figure 5 we can also see that students did better in the exam when they had practiced more difficult SQL sentences and not just tried the easier ones.

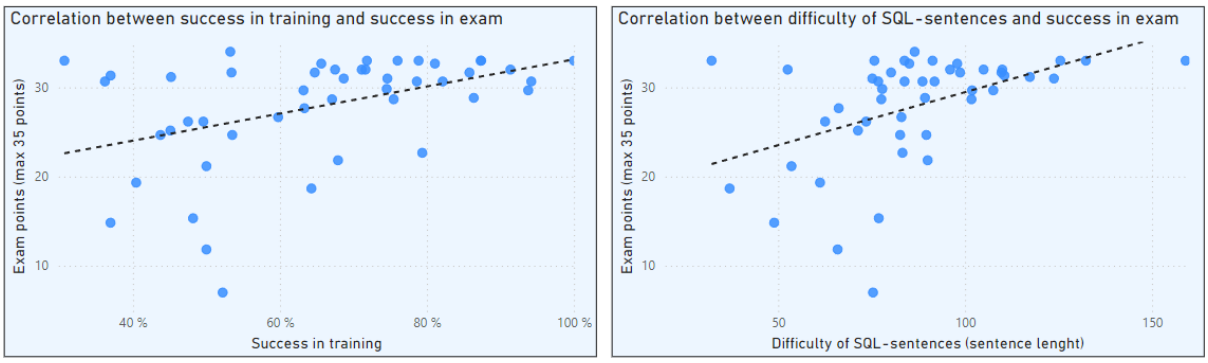


Figure 5: Correlation Between Success in Training and Success in Exam, and Correclation Between Difficulty of SQL (*You will be more successful in the exam if you have practiced more difficult (longer) SQL sentences and managed to get the correct answers in the exercises.*)

It is also important to get insight on how the students perceived studying in this kind of technically demanding content. This kind of student feedback was gathered after the course through a small survey that included both numeric evaluations and open ended questions, where students were able to leave free-form feedback.

Based on the open-ended questions that students felt that the best thing about the course was in overall the SQL part as they felt that in that part, they learned a lot. As one of the students stated, “The SQL part of the whole was the one that I felt I learned the most from”. However, at the same time the SQL part was the most challenging part of the course SQL - studying the language “It took me a really long time to understand the logic of SQL”. This was partly because this area of the course was the newest one for many students, as stated “SQL language was completely new, I've never programmed. It was quite challenging to take control of things, and therefore perhaps remains detached from the practical level.” Some of

the students also were uncertain of the way that they should have practiced the SQL sentences as there was mentions like “Perhaps in this section you could have been directed to use or utilize Chat GPT. Personally, I didn't utilize but instead tried to practice commands traditionally.” It can be argued that if the student would have used Chat GPT in the rehearsing it would not increase the student’s own competences and thus, would have been visible through worse exam results.

Although SQL is quite theoretical and difficult to understand why it is needed or what to apply to in daily work, the answer regarding the entire course was that learning was useful (full course content infographic, SQL, Power BI basics), as illustrated in following Figure 6.

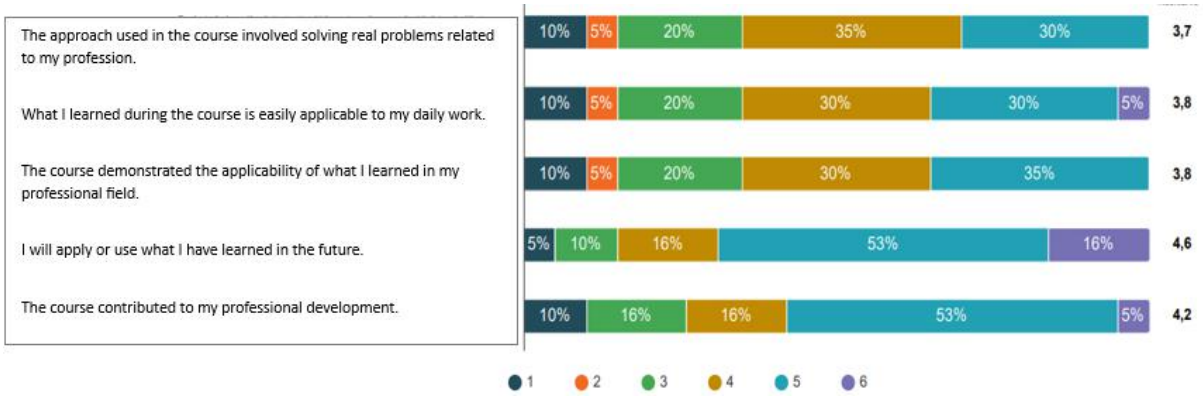


Figure 6: Course Evaluation (*The course was considered necessary [including sections infographic, SQL Power BI basics]*.)

Conclusion and Discussion

Previous literature has highlighted as one of the key challenges that teachers face in teaching data analytics the lack of practical guidelines for building hands-on experiences and training in the use of new technology. In this paper, we have presented a pilot course implementation of data analytics course, which included practical hands-on exercises for students and provided integrated learning analytics solutions. Through presentation of the results of the learning analytics we hope to provide inspiration for further development of teaching technically demanding content in distant mode and inclusion of learning analytics in this kind of teaching.

Firstly, based on the results of the empirical pilot study we can conclude that the learning outcomes of the course in relation to practical hands-on exercises is that practice pays off in learning this type of content. However, in the pilot course implementation there were 18 students who did not practice any SQL statements. Their result varied from almost full points to 12/35 points (pass limit was 50%). This indicates that the students enter to the course with varying competence level in data analytics, and this further affects the amount of practice that they need for good learning outcomes. These kinds of results of the learning-promoting effect of practical exercises are not very surprising and new but has now been tested in the context of data analytics teaching.

Secondly, based on the empirical results the key notion regarding the utilization of learning analytics can be concluded as following. To really get the full potential of learning analytics to develop the course and to support the student it would be required that the teacher could monitor the amount of practice already during the course. In addition to the number of

sentences, the number of successful sentences in relation to practice tells quite a lot. If most of them can't produce correct SQL statements despite practice, there is something wrong with the whole teaching. It is no longer about what the individual student does. The quality of training may be more important than its quantity (quality=difficulty level of tasks+success) and thus in the interest of learning analytics. Another thing is how easily this technical implementation can be made real-time, but whether the individual SQL language is essential enough in relation to the workload required to build analytics.

We also have some limitations in our study. Limitations are connected to the difficulty of SQL sentences and the correctness of SQL sentences. Our environment doesn’t include the logic of SQL sentence, only the sentence syntax. The same SQL sentence can be written in many correct ways but SQL Server only checks that the sentence has the right syntax. In the basic course we concentrate on writing syntactically right language. The difficulty of SQL sentence is represented by the length of sentence. More difficult SQL sentences are always longer because they need more definitions. These selections are accepted but have clear limitations.

In the future it will be beneficial to develop the environment automatic. In this study the part of manual work is rather big. Even the exercises and database are changed the Power BI interface and log data analytics are useable without enormous work. Secondly, we are interested in studying how students learning results change if the material provided is improved. We plan to make video material of SQL language and to offer students contact possibility with the teacher.

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