Teaching Process and Student Result Analysis – Case study

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***Abstract*— Teaching process at the universities primarily focuses on the combination of theoretical and practical skills. When dealing with information technology, it is strongly important not to focus on the coding itself, but also to highlight the principles and technology behind the code. Students´ results are finally evaluated by the end of the semester and during the exam. However, it is important to ensure the continuous teaching process during the whole semester and study, as well. To do that, students must successfully complete tests, solve tasks and prepare for exercises. This paper provides a case study for teaching Advanced database systems and Analytics at the Faculty of Management Science and Informatics at the University of Žilina.**

I. INTRODUCTION

Universities play a key role in personal and professional development for many people. They are focusing on a specific area of study by enrolling in the specific study program. Although in bigger universities, individual subjects can be shared and combined across multiple programs [6], [9], there is always a mandatory plan for the curriculum. The University of Žilina covers 7 faculties – Faculty of Operation and Economics of Transport and Communications, Faculty of Mechanical Engineering, Faculty of Electrical Engineering and Information Technology, Faculty of Civil Engineering, Faculty of Security Engineering and Faculty of Management Science and Informatics (FRI). The uniqueness of the FRI lies in a combination of study programs that offer top-level education in the field of informatics, computer engineering and management at one place. The combination of these areas of education and research supported by zealous and competent professionals creates conditions that ensure sustainable success of the faculty.

FRI was established on 17th July 1990 from the Department of Technical Cybernetics by approval of the University Senate. At the present, there are near 6 500 students at the University of Žilina, including about 1 300 students at the Faculty of Management Science and Informatics. Our faculty provides bachelor's, master (engineering), as well as doctoral degree of study. All programs are officially approved by the Accreditation Commission of the Slovak Republic. The programs are interdisciplinary; they were conceived and created based on many years of the Faculty's successful research and educational tradition. Besides, we have an accreditation for the habilitation and inaugurations. Thus, FRI is a recognized teaching and research institution. It has many cooperations in the field of research, as well as teaching processes are synchronized across technical universities by focusing on the unique teaching process by the expert lecturers.

For personal and professional development, universities are responsible for providing these aspects [9], [19]:

- **Education and knowledge** – to provide specialized knowledge, expertise sharing and critical thinking. It focuses on career preparation.
- **Career opportunities** – a university degree is often a prerequisite for many jobs and careers. It opens doors to a broad range of job opportunities.
- **Personal growth** – to develop essential life skills (independence, time management, problem-solving) and shape identity.
- **Networking** – to build professional community, connections and friendships.
- **Critical thinking and problem solving**
- **Research and innovation** – universities are typically centers of research and innovation, contributing to advancements and bringing new research results to the curriculum.
- **Social and cultural exposure** – to keep people with different backgrounds and ideas to broaden the worldview, ideas and positions.

To make the study relevant and comparable across the region with other universities, it is important to cooperate with them [22], [23]. The Erasmus+ program is a European Union (EU) initiative designed to support education, training, youth, and sport across Europe. It provides opportunities for individuals to study, train, and volunteer abroad, and helps organizations collaborate across borders, targeting the following areas:

- Higher education
- Vocational education and training
- Youth
- Adult education
- Sport

Erasmus+ helps individuals develop a deeper cultural understanding, improves their employability, and contributes to the overall cohesion of Europe.

Erasmus+ project Including Everyone in Green Data Analysis (EverGreen, project ID 2022-1-SK01-KA220-HED-000089149) [25] aims to bring environmental data analysis to the wide community, to bring the topic of sustainability to the daily life, to become aware of the future of the planet. The consortium is formed by the University of Žilina (Slovakia,

consortium leader), University of Šibenik (Croatia), University of Maribor (Slovenia), University of Pardubice (Czech Republic) and Trokut Šibenik (Croatia) – technological incubator. Besides, we have two associated partners – Oracle Corporation and City of Kranj.

To make the data analysis widespread, it is necessary to prepare content and materials not only for the university students, but also NEET community and self-study. Besides, it is necessary to prepare the environment and accept the content and requirements in the vocational schools and business community [25].

One of the main outputs of the project is to bring new subject content focusing on the data analysis, environmental content and advanced database technologies. At the Faculty of Management Science and Informatics, it has been implemented as a regular mandatory subject course.

This paper evaluates the results and course conditions. Precisely, since the conditions to pass the exam evaluated over time, it is worth evaluating the results by focusing on the impacts and significance. Namely, we are addressing the importance of extra points, remediation test and possibility of transfer bonus points to the missing mid-term exam points.

There are three research questions discussed in the paper:

- RQ1 - What impact do bonus tasks have on student results?
- RQ2 - What are the consequences of remedial tests?
- RQ3 - What options can be applied to achieve better student results in terms of motivation?

The proposed paper is organized as follows. Section 2 introduces the teaching process of the Advanced Database Systems and Analytics course by focusing on the conditions, teaching and knowledge evaluation. Section 3 points to the reached results and evaluation study. Section 4 discusses the results of propagating the recommendations and methodology. Conclusions are present in section 5, enhanced by the future research investigation strategy.

II. Advanced database systems and Analytics course

Advanced database systems course is a clear continuation of the introductory subject Database systems taught primarily during the summer semester of the second year of the bachelor study. Based on already reached fundamental database systems knowledge - relational paradigm and SQL, it delves into more complex and specialized topics, targeting the analytical environment and robust databases. The following list makes an overview of the covered topics:

- **Transaction management** – ACID properties (atomicity, consistency, isolation and durability, concurrency, deadlock detection and prevention, parallelism and locking.
- **Object extension of the relational databases** – object databases, XML, JSON and transformations.
- **Distributed databases** – fragmentation, replication and distributed transactions (+ related protocols).
- **Database security, encryption and storing files inside the database** (as Large objects – LOBs).
- **Data warehouses, OLAP** (Online Analytical Processing) – transformation between OLTP (Online Transaction Processing) and OLAP systems, big data, integration.
- **Advanced indexing and storage optimization techniques** – access methods, index structures, in-memory databases, memory structures, block loading.
- **Query optimization** – planning, execution, cost-based optimization, data view materialization, query transformation.
- **Aggregate and analytic functions in SQL + Group by enhancements, window clauses**
- **Complex data analysis** highlighting the topic of the environmental data.

From the data analysis point of view, the last 5 points are significant, although all of them are used to build a complex analytically oriented environment. One way or another, when dealing with the data analysis, it is strongly important to focus on the data storage, access efficiency delimited by the indexes, analytical queries and interactive graphical reports [11], [12], [15], [17], [18].

A. Data analytics

The data analytics course is part of the Computer Science, Information Systems, Business Analytics and Statistics field. Universities offer various courses, which may cover a broad range of topics. Based on the analysis of curricula at multiple universities, the core topics covering data processing and analysis are:

- **Introduction to data analytics** – core principles, types of data, data sources, basic visualization principles.
- **Statistical analysis** – descriptive statistics, probability theory and hypothesis testing.
- **Data mining** – pattern discovering, clustering, classifications.
- **Machine learning** – neural networks, decision trees, regression analysis, (un)supervised learning, etc.
- **Big data** – concepts, related tools like Hadoop, Spark, data storage, processing.
- **Business analytics** – forecasting, optimization, data-driven business decision-making.
- **Programming languages oriented to data analytics,** like Python, R, SQL, scripting.
- **Ethics, data exploitation, business data strategy and data excellence.**

Expected skills reached are:

- ability to interpret data,
- making competent data-driven decisions,
- understanding data analytics towards business environment,
- understanding statistical methods,
- realizing the importance of data, its reliability and interpretability,
- ability to create models based on the data, making and evaluating predictions.

B. *Environmental data analysis*

Environmental data analysis involves examining data related to the environment, such as air quality, water quality, climate patterns, biodiversity, and land use [2], [4], [5], [7], [10]. The goal is to identify trends, detect patterns, make predictions, and support decision-making regarding environmental conservation and sustainability [16], [20], [21]. The process of the data analysis consists of several steps, which can be categorized into the following general outline of the steps [8], [20], [25]:

- **Data collection** – gathering the data from various sources, like sensors, satellites, weather stations, vehicles, infrastructure, etc [21]. It typically includes hydrological data, atmospheric data, ecological data. All the data are temporally oriented [13]; thus, each data tuple is depicted by the particular time frame expressing validity of the data.
- **Data cleaning** – commonly, raw data are incomplete and consists of the noise. Besides, there can be data which are not important for the processing and consecutive analysis. The emphasis should be on missing values, inappropriate values, outliers, error correction, normalization and format standardization.
- **Data exploration** – visualizing, summarizing and reporting data using tables, charts, graphs and summaries in the form of histograms, scatter plots or heatmaps. It is just an initial analysis of the data set content. Without knowing principles and basic characteristics of the data, it is impossible to dig deeper into data analysis and provide sufficient outputs and results.
- **Statistical analysis** – applying statistical methods to assess relationships and test hypotheses.
- **Predictive modeling** – prediction of the future trends requires machine learning and other statistical modeling techniques. It is worth noting that external factors and environmental evolution should be taken into consideration in this step.
- **Temporal and spatial analysis** – commonly represented by geographic information systems providing visualizations, analyzes and interpretation of the spatial components in a temporal environment.
- **Interpretation and report creation** – to communicate and present outputs effectively, it is necessary to present results in a simple and understandable manner to the wide community [22], [23], [24]. In terms of environmental data analysis, it is even more important, because many times, people are not aware of all the impacts and consequences for the future of the planet. This part consists of reports, dashboards, correlated tables, charts, etc. The content and form of the presentation should always handle the recipient type – researchers, students, public community, environmental activists and professionals, etc.
- **Decision-making** – the ultimate goal of the data analysis is to make qualified data-driven decision making by presenting recommendations, strategies or plans.

Fig. 1 shows the flow of data processing.

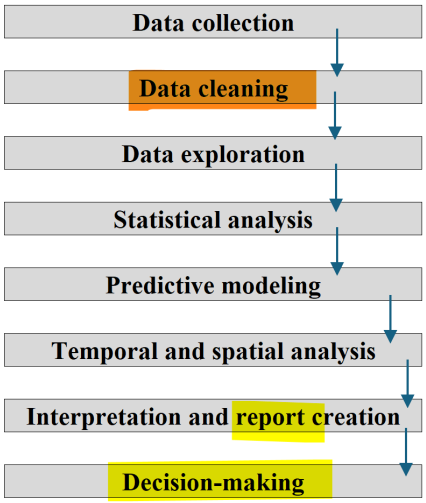

Fig. 1. Data analysis process flow

C. *Core database system course*

Database systems course is a bachelor´s degree study subject mandatory for the Informatics study. It covers these topics:

- Data modeling and design
- DataBase Management System (DBMS)
- Structured Query Language (SQL)
  - DDL – Data Definition Language
  - DML – Data Manipulation Language
  - TCL – Transaction Control Language
  - DCL – Data Control Language
- Relational algebra and calculus
- Normalization
- PL/SQL (procedures, functions, packages and triggers)
- Transaction support – core principles
- Cloud and data-driven application development

III. Teaching Process & Study & Results

Advanced database systems and Analytics is a compulsory course, part of the core and profile study. It consists of 2 lectures and 2 lab exercises per week. The whole semester takes 13 weeks of study. The course workload is 125 hours, and the student reaches 5 ECTS credits, if passed successfully.

Continuous assessment of the study includes active participation in each laboratory work. Each student, as a member of the team for the semestral work, must participate in analytic report creation based on the real data. Environmental aspects of the data are recommended. Besides, it is necessary to pass two tests (mid-term and end-of semester tests) successfully by reaching at least 36 points in total (60%). Each test is rated with a maximum number of points – 30. The content maps the discussed topics and is primarily practically oriented, but also theoretical questions are included. Additionally, whereas the course follows the Database systems course, students can evaluate their knowledge during the introductory test. In the past, this test was mandatory, and penalty points were given, if the result was less than 60%,

however, during the last accreditation period, such a requirement was removed and the introductory test became a motivating point, only bonus points can be reached, based on the result:

- <80% ; 90%) => 3 bonus points
- <90% ; 100% > => 5 bonus points

The conditions for the ability to register for the exam are:

1) Getting more than 60% from the two tests (more than 36 points from 60 in total).
2) Successful presentation of the semester thesis (including creating additional reports defined by the teacher directly during the presentation).

The maximum number of points from the semestral work is 40. Thus, in total students can get 100 points during the semester, 60 from the tests and 40 from the semestral work. To be accepted for the exam registration, at least 61 points must be reached.

The exam consists of around 30 questions and students can get a total of 100 points. Analogously, more than 60% is necessary for passing (at least 61 points). If the above prediction is passed, the overall grade is calculated from the sum of the exam and semester scores reflecting the following criteria. In total, 200 points can be reached. Table I shows the grade mapping.

TABLE I. GRADES

Percentage reached	Grade
More than 92%	A – excellent results
<85% ; 92%)	B – results above average
<77% ; 85%)	C – results on average
<69% ; 77%)	D – acceptable result
<61% ; 69%)	E – results fulfilling the minimum requirement
Less than 61%	F – failed – further work required.

Note that the tasks of the exam and primarily theoretically oriented and tasks are categorized based on the topic. For each topic, at least one point must be reached, otherwise the student fails the exam irrespective of the number of points obtained from the exam test.

Fig. 2 shows the average results for the last 3 years.

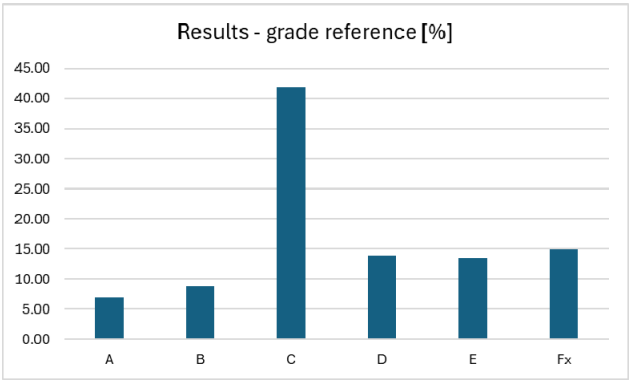

Fig. 2. Results – grade reference (total)

Table II shows the total number of enrolled students. However, it can happen that some students do not visit the lectures, nor labs and do not register for any activity, therefore, additional column is placed in Table II expressing the real number of students.

TABLE II. NUMBER OF REGISTERED STUDENTS PER ACADEMIC YEAR

Academic year	Enrolled students	Real number of students
2022/2023	84	76
2023/2024	66	59
2024/2025	112	80

The main investigation done in this paper reflects the bonus points and impacts on the results. Bonus points are points earned extra for activity in lectures, exercises, or as part of independent assignments completed at home and submitted by the specified deadline. They are primarily intended to improve grades, meaning they are added to the exam if the student successfully passes it (he gets at least 61%). Tab. 3 shows the maximum number of bonus points, as well as the average per academic year.

During the first investigated academic year – 2022/2023, bonus could be used exclusively after passing the exam. It helped 4 students to improve the result by one grade. As evident from Table III, there was a significant lack of interest in bonus points, the average number of bonus points was only 2.75. Students, unlike in the past, no longer place emphasis on grades and results themselves can be degraded to the binary value – pass / fail. It should be noted that there is no strong motivation among the students compared to the possible earnings in a commercial company while studying. 2 students registered for the remedial test (40% limit for the standard tests was applied to be able to register there), however, one of them failed and was not admitted to the exam.

During the next academic year – 2023/2024, growing interest in bonus points is more significant than before. Namely, the average number of bonus points was 13.10, which expresses almost 5-fold increase. The reason is that starting from this academic year we have allowed the exchange of bonus points for missing test points. Thanks to this, we expected a reduced number of students on the remedial test. However, in order to the missing points and their transformation to be deserved, the subject guarantee, after consulting with the teachers, decided on a ratio of 3:1. That is, 3 bonus points could replace 1 missing test point up to the minimum limit of test points. At the same time, in the case of exchanging points, an additional oral part of the exam was mandatory.

11 students registered for the remedial test in academic year 2023/2024, 3 of them passed it successfully.

Semestral work required building the information system covering the whole step-by-step process defined in Fig. 1. The team consisted of not more than 4 students, individual responsibilities and activities were shared among the whole team. Students could use any tool for data analysis and reporting. Although the analysis and report definition could be done, it is possible to omit core database technologies and principles, like SQL and use „drag&drop“ system.

Therefore, during the third year of the study (academic year 2024/2025), additional optional semestral work dealing with the environmental data analysis was added. It takes clean and preprocessed data [1], [3], [14], [20]. Students are required to use SQL aggregate functions and advanced analytics to provide the outputs and reports [25]. The data are strictly environmentally oriented. This additional semestral work is implemented just by one student separately and the results are presented during the lab.

TABLE III. BONUS POINTS - STATISTICS

Academic year	Maximal number of bonus points	Average number of bonus points (reference – real number of students)
2022/2023	12	2.75
2023/2024	29	13.10
2024/2025	35	13.56

Table IV shows the number of students registered for the remedial test, as well as passing percentage.

TABLE IV. REMEDIAL TESTS

Academic year	Number of students	Passing percentage
2022/2023	2	50
2023/2024	11	27
2024/2025	13	23

A graphical representation of the grades per academic year is depicted in Fig. 3 and Fig. 4. Absolute values are in Table V.

TABLE V. GRADES

	2022/2023	2023/2024	2024/2025
A	1	6	8
B	10	2	7
C	33	32	25
D	13	3	14
E	11	5	13

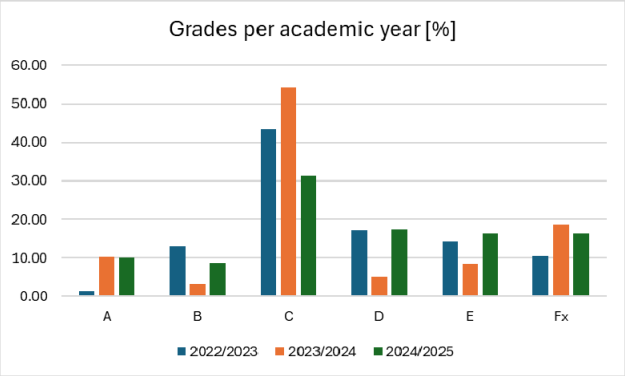

Fig. 3. Results – grade reference (per academic year)

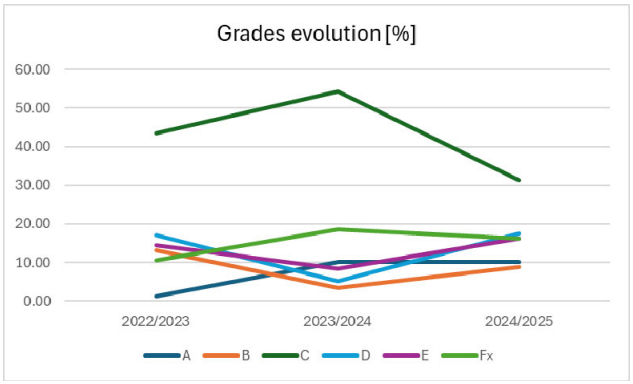

Fig. 4. Results – grade evolution

IV. SUMMARY & DISCUSSION

The conditions to pass the exam naturally evolve over time. Teachers try to find the most suitable solution in terms of the teaching efficiency, achieved results and overall costs. On the one hand, the goal is to increase the permeability of the object, but on the other hand, it is necessary to maintain or increase the quality [22], [23]. Technologies used in IT are changing very dynamically and quickly, and therefore teaching must respond appropriately to these changes. In this context, new topics and activities emerge with the aim of practical use of technologies with an emphasis on their characteristics, practical use, but also limiting factors. Environmental data analysis is a clear example. There is a key theory about data processing and evaluation, highlighting statistics, machine learning and predictions. This knowledge must be implemented practically to make direct contact with the data from the collection, through the cleaning, investigation, up to making reports to support decision-making.

Based on the information sheet of the subject Advanced Database Systems and Analytics, student engagement takes 125 hours of teaching. When reflecting lectures and labs delimited by 4 hours per week, own study, homework and home preparation requires 73 hours in total – approximately 5.5 hours per week. It covers implementation of tasks, self-study, testing, data processing in a whole spectrum, as well as preparation for the tests and exams. The home activity interacted with the teacher covers mandatory homework tasks, and semestral works.

In this paper, we investigated the impact of the additional tasks, done primarily at home, to the course results. As already stated, during the academic year 2024/2025, optional additional tasks were available. By its implementation, a particular student is rewarded with 10 bonus points. Each student implemented the activity on his own. That year, 80 real students were enrolled, 42 of them implemented the task, expressing 52.5%. This activity is estimated to require 10 hours of work. It is unlimited in terms of implementation timeline but must be ended and presented by the end of the semester. Compared to the previous academic year (2023/2024), this task improved the results and grades (see Fig. 3). It lowered the percentage of failed students. So, the ratio of the grades D and E increased precisely to the detriment of Fx grades (and partially C). So, it can be concluded that such a additional activity brings benefit and better student performance. But is that true? Is it worth the teacher's effort? Namely, it requires

significant teacher involvement to prepare and evaluate the student activities, which is many times not properly treated from the faculty and university point of view.

When looking at the absolute values of the grades, the average grades are almost the same (Table VI). Even this year, the global results are worse.

Thus, it can be concluded that additional activities are fruitful for students, who are and are keen of knowledge, data analysis and practical implementation. On the other hand, Students often rely on these bonus points and limit continuously preparing for tests.

TABLE VI. AVERAGE GRADES

	2022/2023	2023/2024	2024/2025
Average grade	2.3618	2.3644	2.4313

Bonus point management is an attractive activity for the students aiming to motivate students to be active, either during the lectures, labs, but also at home implementing additional tasks. Such an approach attempts to ensure continuous learning and preparation. As visible from the data and evaluation, unfortunately, bonus points can also have the opposite effect, namely reducing the importance of the tests themselves. Table VII shows the results. It can be noted that the addition of bonus points and the possibility of the transformation into missing test points can cause students to prepare less well for individual tests (mid-term and end-of semester) and therefore they obtain worse results. This is even more evident in the second, end-of semester test, where students are already calculating the minimum number of points required to be qualified for the exam registration. They lose the pressure on learning and improving themselves in a given subject area.

TABLE VII. AVERAGE RESULTS FOR THE TESTS

	2022/2023	2023/2024	2024/2025
mid-term test	18.58	19.11	17.49
end-of semester test	19.21	15.43	13.69

Graphical representation of the average results of the tests per academic year is depicted in following figures. Fig. 5 shows a bar chart, while the line chart is in Fig. 6 showing the trend.

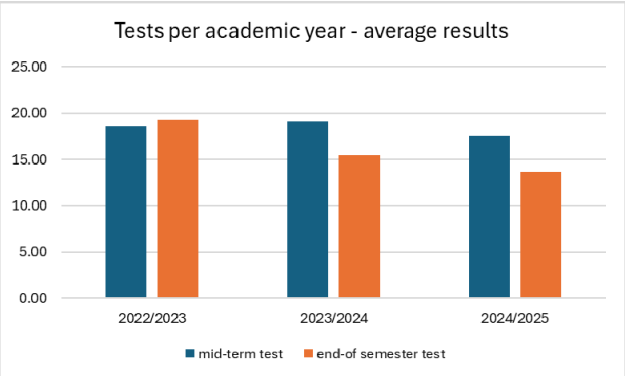

Fig. 5. Results – Tests per academic year – average results – bar chart

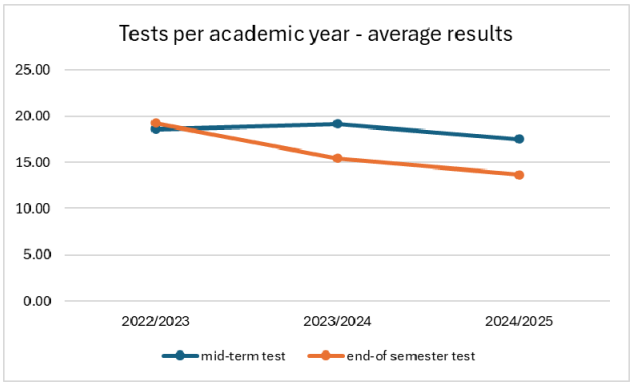

Fig. 6. Results – Tests per academic year – average results – line chart

V. CONCLUSIONS

Increasing the permeability of university courses typically means enhancing the flexibility or accessibility of courses across the institution. This can involve a range of strategies that make it simpler for students to explore and enroll in courses from various departments, fields of study, or even different universities. Here are some ways universities can improve course permeability: interdisciplinary courses and programs, cross-institutional collaboration, proper flexible course schedule, value transfer, recognition, support services, open enrollment for the courses, modular and open learning.

Erasmus+ project EverGreen refers to ensuring that all individuals, regardless of background or expertise, have the opportunity to engage with and contribute to environmental data analysis. This can involve making data more accessible, providing education and resources, and fostering collaboration across diverse communities.

To make sure everyone is included, it's crucial to focus on several key elements like inclusive data collection, collaborative decision making, access to green data, transparency or accountability.

This paper is devoted to the evaluation of the Advanced database systems and Analytics subject conditions. At universities, individual subjects are typically ended with an exam, during the semester students attend lectures, actively participate in exercises, where they practically implement the required tasks. They also usually implement semestral work, either as individuals or in teams. The acquired knowledge is evaluated through tests. The aim is to motivate students to work conscientiously throughout the semester, so that they are active recipients of knowledge. Bonus tasks and additional voluntary tasks are often used to ensure that, by providing the ability to get extra points.

In this paper, we are evaluating the impact of using bonus points and overall impact on the teaching process and results. The general condition of the evaluated subject consists of two tests – mid-term and end-of semester. One semestral work is mandatory. The subject is passed successfully if the student takes more than 60% from the final exam. The study took three years to complete. Initially, during the first academic year, bonus points could only be used on the exam, and only after it was successfully passed. This allowed the students to improve their score and get better grades. In the second academic year, bonus points could also be used and converted into points

during the semester, specifically for missing points from tests, so that the student could be admitted to the exam without having to take a remedial test. Surprisingly, this decision did not affect the average grade. During the last academic year, additional opportunities to get 10 bonus points was added, by implementing data analytics on environmental data. This decision brought great interest from students, with more than 50% of active students implementing the solution. It also brought additional activity for teachers in the form of consultations, preparation of materials and evaluation of results. However, student activities are always welcome. On the other hand, it showed a decrease in the number of points obtained from the tests. Furthermore, A deterioration in the average grade in the subject was identified (2.97%). The biggest change was in the second (end-of semester) test, where students often already had a good starting point and therefore underestimated this test, which was subsequently reflected in the exam, as well. The year-on-year decrease was 3.78 points for the second academic year and 1.74 for the third academic year, which expresses 19.68% (2nd academic year) and 28.74% (3rd academic year).

During the future research, we would like to investigate the results in a deeper way by focusing on various school types, NEET community and self-study techniques to find the best suitable and engagement of the students.

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