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MONITORING OF STUDENT ENROLMENT CAMPAIGN THROUGH DATA ANALYTICS TOOLS

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Abstract. The market for new students is highly competitive. For this reason, higher education institutions (HEIs) can no longer rely on traditional strategies to hit enrolment goals. HEIs leadership must leverage new approaches, tools and skills to optimize the enrolment process, monitor the student enrolment campaign and improve marketing strategies to attract suitable students for future campaigns. This paper proposes a solution that facilitates and optimizes these processes. It introduces a model for monitoring student enrolment campaigns and a prototype of a correspondent software tool StEnrAnalyst, designed for the needs of different stakeholder groups (top and middle management, responsible bodies for student enrolment campaigns). StEnrAnalyst allows them to monitor the student enrolment campaign, generate reports for candidate students and enrolled student and make timely data-driven decisions to improve the process of applying and enrolling new students. Experiments with the model and StEnrAnalyst are conducted based on the information infrastructure of a typical Bulgarian university.

Keywords: data analytics;student enrolment;intelligent data analysis; monitoring; higher education

1. Introduction

Nowadays, the market for new students is highly competitive. Many higher education institutions (HEIs) receive funding based on their enrolled students. HEIs leadership are worried about how their institutions can improve management strategies to attract more students and increase enrolment rates. For this reason, among the main activities for any HEI are conducting and monitoring student admission campaigns.

Achieving enrolment goals by relying solely on traditional practices is no longer enough. Managers of HEIs must leverage new approaches and skills to compete in today's higher education marketplace (Simon 2020). The HEIs must embrace technology to deliver on modern student needs and eventually develop successful strategies to meet institutional requirements and enrolment goals (Unifyed 2020).

To facilitate the submission of documents for application, enable a more efficient enrolment process and earn a competitive edge, almost all HEIs implement student admission systems that allow future students to apply online. In addition, these systems help HEIs to guide prospective students through incomplete sections of the admissions process and provide them with personalised automated communication, improve response times for questions, and monitor marketing and student enrolment campaigns. These systems store personal data for prospective students (sex, age, location), data for previous training (educational institution, graduation success) and the desired study programmes. After conducting the entrance exams, responsible bodies from HEIs input exam results, and then the system ranks the candidates and sends automated notifications regarding acceptance status. By using software solutions to inform students where they are in the enrolment process, HEIs leadership can free their administrative staff by taking student application management and many data entry tasks off their plate (Ricoh 2022).

The large amount and variety of data stored in student admission systems allow HEIs to implement data analytics tools to optimize the enrolment process, monitor the current student enrolment campaign and improve marketing strategies to attract suitable students for future campaigns. In this case, developing effective enrolment strategies and ensuring student success comes down to better using the available data (Rapid Insight).

Data has no real value until higher education managers extract information from the data to make better decisions that lead to success (Eiloart 2017). To use analytics appropriately to meet enrolment goals, HEI leadership must invest in the right tools, technology, and talent to help look at data differently (Simon 2020). In recent years, HEIs have begun implementing data analytics tools to outline realistic targets to strategically tackle inefficiencies and solve declining student enrolment problems (Unifyed 2020).

Data analytics tools can help HEIs understand and leverage their data to identify and attract students and forecast enrolment. The use of data analytics during admission campaigns allows HEI leadership to monitor how many inquiries are coming in and turn into applications and how many applications turn into starts. HEIs can explore available data on prospective students (incl. demographic and performance data) to predict which applicants are most likely to be accepted and enrolled and the cities from which they will come so that intervention steps can be taken proactively (Simon 2020; Wiley2020;Ekowo& Palmer 2016; Kabakchieva 2012). By identifying and targeting applicants and students who are the best fit for the HEI, HEIs can operate more efficiently, enrol students more likely to graduate, and offer higher quality experiences (Wiley 2020; Slapak& Jenkins 2020).

Data analytics tools also help HEIs assess admissions and enrolment marketing campaign performance on-the-fly and identify new opportunities for manage-

ment of the enrolment process and marketing efficacy (Allegro Analytics 2019; Delcoure& Carmona 2019).

Modern analytical tools support HEIs managers (deans, vice-deans, vice-rector, rector) to make decisions for improving the students' recruitment process. Data analytics tools allow them to monitor and evaluate current campaign performance against previous periods, discover enrolment trends (Kardan et al. 2013), identify the actions associated with attracting and recruiting students (Delcoure& Carmona 2019), align marketing and sales resources and budgets, optimize student recruitment and enrolment processes, increase visibility and real-time access of campaign performance (Candlefox 2022). The data analysis on enrolled students shows how well the institution performs at a detailed level. HEIs managers can use results to identify key trends that could affect the overall success of admission to HEI. Suitable for tracking trends are the most preferred study programmes and whether there are study programmes preferred mainly by women or men (e.g. whether the percentage of women applying for STEM curricula is close to that of men). Ultimately, connecting data with decision-making within enrolment management areas enables analytically focused institutions to thrive at a time when others feel the unintended consequences of choosing not to invest (Simon 2020).

In addition, data analytics allow anyone to perform extensive education analysis and share key findings across the HEI (Eiloart 2017). From this perspective, data analytics tools are an effective way to monitor and improve the performance metrics of the HEI itself.

This paper proposes a solution that facilitates and optimizes these processes. It introduces a model for monitoring student enrolment campaigns and a prototype of a correspondent software tool StEnrAnalyst, designed for the needs of different stakeholder groups (top and middle management, responsible bodies for student enrolment campaigns). StEnrAnalyst allows them to monitor the student enrolment campaign, generate reports for candidate students and enrolled students and make timely data-driven decisions to improve the process of applying and enrolling new students. Experiments with the model and StEnrAnalyst are conducted based on the information infrastructure of a typical Bulgarian university.

2. Model for monitoring of student enrolment campaign

When submitting application documents, the following data for each candidate student are stored in the student admission system: full name, address, telephone number, grades from the diploma for completed secondary education, desired study programme, required competitive exams and information on paid application fee. These data are inputted by the candidate student (when applying online) or by a member of Committee for acceptance of documents (when students submit documents on-site).

When conducting the competitive examinations, the chairman of each committee for reviewing the competitive exams shall enter the grades from the first and second examinations and the final score from the competitive exam. Then a member of the Committee for declassification of works enters the scores from the exams of each candidate student, and then the system performs a ranking of students.

Based on a literature review in the field (Simon 2020; Unifyed 2020; Rapid Insight 2022; Wiley 2020; Ricoh 2022) and data stored in the student admission system of a typical Bulgarian University 4 models with a set of indicators that serve as a business logic basis of the developed data analytics tool are proposed (see Section 3).

The models for monitoring student enrolment campaign defines what data the tools can extract from the institutional information infrastructure that stakeholders can use to monitor student enrolment campaign at the university. These models are developed for the needs of four different stakeholders' groups – programme managers (PM), deans (D), rector (R), committees for organizing and conducting a student enrolment campaign (secrecy of examination works, reviewing the competitive exams, announcing the results of exams and rankings, enrolment of accepted students) (C). Each model consists of measurable indicators allowing the relevant stakeholder to track data for students' enrolment for different purposes, e.g. monitoring, analysis, forecast, intervention, and recommendations.

Models are built as hierarchies of indicators of different levels. Indicators from Level 1 represent the object/subject to which the collected and aggregated data relate – candidate student, interest in study programmes, enrolled students, competitive exams, gender gap. These indicators group together Level 2 indicators that allow the relevant stakeholder to track specific data. Each Level 2 indicator contains a set of measurable attributes whose values are extracting from the student admission system and system for enrolment of admitted students. Table 1 presents the proposed models in general and their indicators of Level 1 and Level 2 for each stakeholder group. Indicators of Level 2 that are part of the model for the relevant stakeholders are marked with "+".

Table 1. Models for monitoring of student enrolment campaign

Indicator – Level 1	Indicator – Level 2	PM	D	R	C
1. Candidate students	1.1. Number of submitted documents from candidate students			+	+
	1.2. Number of candidate students per region			+	+
	1.3. Number of candidate students per town				+
	1.4. Average success from the diploma for completed secondary education per candidate student				+
	1.5. Grades from the diploma for completed secondary education per candidate student				+
	1.6. Desired study programmes per candidate student		+	+	+
	1.7. Requested exams per candidate student			+	+
	1.8. Ranking result per candidate students		+	+	+

Indicator – Level 1	Indicator – Level 2	PM	D	R	C
2. Interest in studying programmes	2.1. Number of candidate students with an interest in the study programme	+	+	+	+
	2.2. Number of candidate students with an interest in the study programme (first wish)	+	+	+	+
	2.3. Number of candidate students with an interest in the study programme (second wish)	+	+	+	+
	2.4. Number of candidate students with an interest in the study programme (third wish)	+	+	+	+
	2.5. Number of submitted declarations for next ranking per study programme	+	+	+	+
3. Enrolled students	3.1. Number of enrolled students per study programme	+	+	+	+
	3.2. Number of enrolled students per professional field		+	+	
	3.3. Number of enrolled students per faculty		+	+	
	3.4. Number of enrolled students with excellent grades from competitive exams per study programmes	+	+	+	
	3.5. Number of enrolled students with excellent grades from competitive exams per faculty		+	+	
	3.6. Number of enrolled students with excellent grades from competitive exams per professional field		+	+	
	3.7. Average score of enrolled students per study programme	+	+	+	
	3.8. Maximum score of enrolled students per study programme	+	+	+	+
	3.9. Minimum score of enrolled students per study programme	+	+	+	+
	3.10. Number of enrolled students from each region per study programme	+	+	+	
	3.11. List of enrolled students per study programme	+	+		+
4.Competitive exams	4.1. Number of candidate students with only matriculation exams			+	+
	4.2. Number of candidate students who have submitted documents for taking the exam			+	+
	4.3. Average grade per exam			+	+
	4.4. Number of candidate students who took each exam			+	+
	4.5. Number/ratio of candidate students with grades Excellent 6.00 per exam			+	+
	4.6. Number/ratio of candidate students with grades Excellent, Very good, Good, Satisfactory and Poor per exam			+	+
	4.7. Grades from competitive exams per student			+	+

Indicator – Level 1	Indicator – Level 2	PM	D	R	C
5. Gender Gap	5.1. Numbers/ratio of women and men among candidate students per study programme	+	+	+	+
	5.2. Numbers/ratio of women and men among candidate students per professional field		+	+	
	5.3. Numbers/ratio of women and men among candidate students per faculty		+	+	
	5.4. Numbers/ratio of women and men among candidate students per study programme (first wish)	+	+	+	+
	5.5. Numbers/ratio of women and men among enrolled students per professional field (first wish)		+	+	
	5.6. Numbers/ratio of women and men among enrolled students per faculty (first wish)		+	+	
	5.7. Numbers/ratio of women and men among enrolled students per study programme	+	+	+	
	5.8. Numbers/ratio of women and men among enrolled students per professional field		+	+	
	5.9. Numbers/ratio of women and men among enrolled students per faculty		+	+	
	5.10. Average grade of women and men per exam			+	
	5.11. Maximum score of enrolled male and female students per study programme	+	+	+	
	5.12. Minimum score of enrolled male and female students per study programme	+	+	+	

Data Analytics tool description

Based on the proposed models (Section 2), a corresponding data analytics tool for monitoring student enrolment campaign StEnrAnalyst is designed and implemented.

As a result of an analytical review of software solutions for extracting, analysing and visualizing data from various information sources, technologies and tools for tool development were selected. The StEnrAnalyst tool is developed by the integration of existing software solutions *JasperReportsServer* and *Jaspersoft Studio* tools (developed by TIBCO Jaspersoft) and the software framework *Dynamic Presentation Framework* (developed by a team working at the University of Plovdiv).

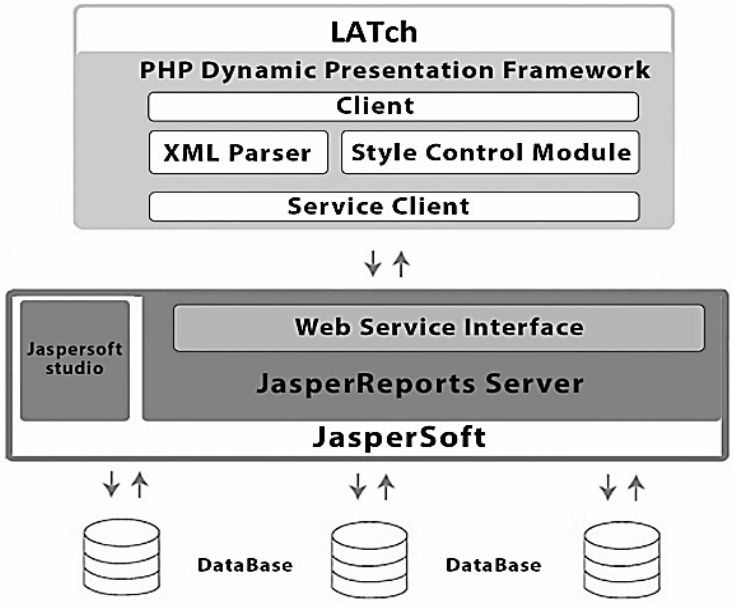


Fig. 1. StEnrAnalyst architecture

The architecture of the StEnrAnalyst tool (see Fig. 1**)** follows the standard type of 3-tier architecture with well-known three layers – *Presentation, Application and Data layers*. The software framework DPF is at the core of the *StEnrAnalyst Presentation Layer*. Through DPF, user request the generation of a report by a chosen template and view the result of the request (so called visualized report). There are currently four separate user roles: programme managers (PM), deans (D) and rectors (R), and committees (C). The report templates design tool Jaspersoft Studio is used for implementing the core functionality of the *StEnrAnalyst Application Layer* and its business logic. Key elements of this functionality are modelling the developed models for the needs of four different stakeholder groups (see Section 2) and acquisition of values for the models' indicators of different levels from the student enrolment system used at HEI and/or other systems from the information infrastructure. *Data Layer* of the StEnrAnalyst application includes various databases of the institutional information infrastructure (student information system, student admission system, student enrolment system, etc.) as well as the JasperReports Server repository itself. JasperReport Server addresses them to retrieve the necessary data when generating reports.

In the first stage, the institutional information infrastructure (including student admission system and student enrolment system) of a typical Bulgarian university

(namely the University of Plovdiv "Paisii Hilendarski") has been analysed. The analysis has been done in terms of its use as a data source (about the training, the results achieved, etc.) when forming values of the indicators from the proposed models.

In the second stage, templates of reports were designed using Jaspersoft Studio based on the proposed models as sets of indicators (see Table 1) for the needs of different stakeholders (programme managers, deans and rector, members of committees) when making decisions for the management of the university processes. All developed templates of reports have been stored on the JasperReports Server. JasperReports Server plays an intermediate role between the three architectural layers. Firstly, DPF requests the REST services of JasperReports Server to run a chosen template and generate a report through the Service Client. Then JasperReports Server Web Service interface responds to HTTP requests from the client application.

StEnrAnalyst help HEIs leaderships to take operational, management level or middle level management decisions.

The tool fills the templates with data directly retrieved from university information systems or obtained through calculations and generates monitoring reports depending on the user's role. The last is because indicators from Level 1 and Level 2 are the same for different stakeholder groups, but they differ in the Level 3, and this is embedded in the designed templates. For example, a programme manager can generate reports that provide data only for the study programme for which s/he responds, while the reports generated by the rector/vice-rector contain data for the entire university. For example, for the ***Indicator 2.1. Number of candidate students with an interest in the study programme*** the related data sources for acquisition of values of the indicators of Level 3 and the indicators/values themselves for each user role will be different (see Table 2).

Table 2. Indicators of Level 3 according to user role for Indicator 2.1

User role	Input data	Output Values
PM (Programme Manager)	Study Programme	Number of candidate students
D (Faculty Managers: Dean, Vice Deans)	Study Programme Without input data for the whole faculty	Professional field Study programme Number of candidate students
R (University Managers: Rector/ Vice-Rector)	Study Programme Faculty Without input data for the whole university	Professional field Study programme Faculty Number of candidate students

User role	Input data	Output Values
C (Committees for organizing and conducting a student enrolment campaign)	Study Programme Faculty Without input data for the whole university	Professional field Study programme Faculty Number of candidate students

Therefore, the generated reports for each stakeholder group contain different data retrieved from the data source depending on the user's role in StEnrAnalyst (PM, D, R and C). Reports can be generated automatically by the StEnrAnalyst according to a predetermined schedule and stored in its repository, or user can request the report generation when s/he wants to see the current situation. User with access rights can visualize and download each of the stored reports.

The data processing results are presented in tables and charts. Users can use them to perform various analyses on the retrieved data. For example, StEnrAnalyst allows the vice-rector to:

– monitor how many candidate students have submitted documents and from which region candidate students come;
– keeps track which exams have the most applications;
– monitor ranking result;
– monitor which are the most desired study programmes;
– track submitted declaration for next ranking;
– monitor the number of enrolled students;
– monitor the ratio of enrolled students with excellent grades from competitive exams, average score, maximum and minimum score of enrolled students;
– monitor the number of enrolled students from each region per study programme;
– generate list of enrolled students for each study programme;
– monitor the ratio of students ranked only with matriculation exams;
– monitor average grade per exam and number of candidate students who took each exam;
– monitor the number of candidate students with Excellent, Very Good, Good and Satisfactory grades of competitive exams;
– generate report with grades from competitive exams;
– monitor student enrolment campaign in terms of equality between women and men;
– generate annual reports for enrolment campaign;
– track trends by comparing monitoring results from different periods;
– make data-informed decisions to improve student enrolment campaign and the results achieved and determine whether the measures taken are effective and sustainable.

The StudEnrAnalyst is tested by users with different roles. Figures 2 – 4 show parts of 2 generated reports.

The user with the role Vice-Rector generated a report for indicator *3.2. The number of enrolled students per professional field*. The report shows that for the academic year 2022/2023, the most enrolled students are in study programmes from professional field *1.3. Pedagogy of training in ...* (524 students). The number of newly enrolled students in study programmes from professional fields *2.2. Philology* (515 students) and *4.6. Natural sciences, mathematics and informatics* (508 students) are also high. The students' interest is the weakest in study programmes in professional fields *8.4. Theatre and movie art*, *2.3. Philosophy*, *2.4. Religionand Theology*, *5.11. Biotechnologies* and *8.2. Fine arts* – 8 students enrolled in professional field 8.3, 14 students in professional fields 2.3 and 2.4 and 15 students in professional fields 5.11 and 8.2

The majority of students in full-time education have chosen study programmes in professional fields *2.1. Philology* (444), *1.3. Pedagogy of training in…* (409) and *1.2. Pedagogy* (408). A large part of the students who will study in part-time form of study has chosen study programmes in professional fields *4.6. Informatics and computer sciences* (139) and *1.3. Pedagogy of training in ...* (108). It is striking that students are interested in study programmes in professional fields *3.7. Administration and Management* (173) and *3.8. Economics* (256) in paid form, and the most of them have chosen study programmes part-time – 134 and 182 students, respectively. The increased interest in these study programmes in a paid form of education is due to the fact that in recent years, at the national level, there has been a significant reduction in places for state-sponsored training in study programmes in the relevant professional fields.

On the basis of the reports generated by the tool for different years, the HEIs management can compare the trends in student enrolment and their interest in study programmes in all professional fields. Fig. 3 shows the generated report for Indicator 3.2 for the previous year (2021). The results show that there is a greatly increased interest in study programmes from some professional fields (e.g. 4.6., 5.3.), while the students' interest in others has decreased significantly (e.g. 3.2., 3.6., 3.7., 3.8., 4.2., 4.3., 4.5., 5.11., 8.4., 9.1.). Such comparisons allow HEI leadership to analyse the reasons for decrease in the interest of students in study programmes, take corrective measures to increase the students' interest (e.g. organizing a wider application campaign to attract more students, improving the material base, increasing the quality of education, etc.), as well do all the best to maintains high standards for study programmes in which there has been increased interest in recent campaigns.

Fig. 4 presents a generated report of the average score of the applicant students in the competitive university entrance exams (Indicator 4.3). The high results of the exam in the *Russian language* (5.69) and *Physics* (5.61) are impressive, as well as the low average result of the exam in *History of Bulgaria* (3.07). Based on these

results, the HEI management and members of the committee that organizes these entrance exams can study in-depth the reasons for high/low average grades and take corrective measures (e.g. stimulating members of the faculty staff to conduct preparatory courses for the exams with low results that will lead to better performance of candidate students during the next enrolment campaign).

Enrolled students 2022

3.2. Number of enrolled students per professional field

Professional direction	Grant		Paid		Total
	full-time	part-time	full-time	part-time	
1.2	406	50	1	4	461
1.3	417	109	0	7	533
2.1	441	42	17	11	511
2.2	39	0	0	17	56
2.3	14	0	0	0	14
2.4	14	0	0	0	14
3.1	52	0	0	0	52
3.2	50	18	40	41	149
3.3	15	0	7	0	22
3.4	35	0	0	0	35
3.6	110	0	17	20	147
3.7	51	0	49	134	234
3.8	92	0	82	181	355
4.1	53	26	0	1	80
4.2	43	11	0	0	54
4.3	91	41	0	0	132
4.5	17	0	0	0	17
4.6	354	136	4	9	503
5.1	28	0	0	0	28
5.2	32	0	0	0	32
5.3	200	0	0	0	200
5.11	15	0	0	0	15
8.2	15	0	0	0	15
8.3	19	0	0	0	19
8.4	4	0	0	0	4
9.1	19	23	37	43	122

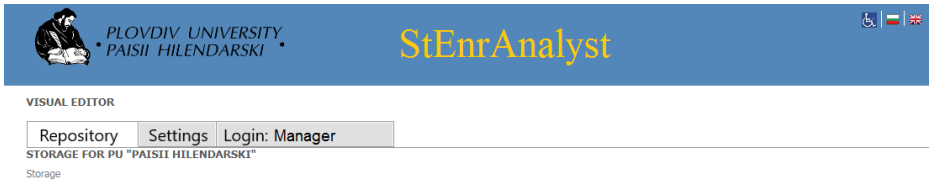
Fig. 2. Generated report for Indicator 3.2 (2022)

Enrolled students 2021

3.2. Number of enrolled students per professional field

Professional direction	Grant		Paid		Total
	full-time	part-time	full-time	part-time	
1.2	386	49	8	11	454
1.3	414	106	3	2	525
2.1	436	34	23	32	525
2.2	36	0	0	15	51
2.3	17	0	0	0	17
2.4	14	0	0	0	14
3.1	50	0	0	0	50
3.2	59	15	38	84	196
3.3	21	0	3	0	24
3.4	38	0	0	0	38
3.6	110	0	40	21	171
3.7	53	0	56	155	264
3.8	98	0	116	202	416
4.1	49	27	0	0	76
4.2	60	12	0	0	72
4.3	141	48	0	1	190
4.5	31	0	0	0	31
4.6	351	106	0	0	457
5.1	34	0	0	0	34
5.2	33	0	1	0	34
5.3	176	0	0	0	176
5.11	38	0	0	0	38
8.2	15	0	0	0	15
8.3	19	0	0	0	19
8.4	12	0	0	0	12
9.1	21	20	42	60	143

Fig. 3. Generated report for Indicator 3.2 (2021)



4.3. Average grade per exam

Exam	ID	Average grade
Bulgarian language	1	3.73
Mathematics	5	4.10
Informatics	7	4.78
Russian language	9	5.69
English language	11	4.27
French language	13	4.10
German language	15	5.26
Spanish language	19	3.40
Physics	21	5.61
Chemistry	23	5.05
Biology	25	4.91
History of Bulgaria	27	3.07
Geography of Bulgaria	29	3.70
Theology	35	5.46
Music	37	4.78

Fig.4. Generated report for Indicator 4.3

4. Conclusions

StEnrAnalyst is provided for real-time testing at the University of Plovdiv. Different stakeholder groups will use the tool to generate reports needed for monitoring of students' enrolment campaigns. Feedback from the ongoing evaluation of the tool by various stakeholder representatives will be taken into account in the development of the final version.

In the future, the functionality of the tool will be expanded to allow data extraction for other quantitative indicators. In addition, all users will have access to dashboards that will allow them to track tendencies based on different factors

The tool can be adapted for the needs of each HEI, regardless of the type of the relevant university information systems. For this purpose, it needs to identify data analytics purposes and map the context at the university.

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