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Transforming Public Services Management: a P-Graph Methodology Case Study and Scenario Analysis

Boglárka Eisinger*, László Buics

Széchenyi István University, Department of Corparate Leadership and Marketing, 1. Egyetem tér, Győr 9026
eisingerne@ga.sze.hu

This study advances university enrolment optimization in Public Services Management towards sustainability, utilizing case studies, scenario analyses, and P-Graph methodology. The study evaluates administrative workloads across three intensity levels—low, average, and highly overloaded—and enhance our methodology by incorporating data that influences the process's inception and conclusion in all scenarios. Our research is further expanded with qualitative alongside quantitative methods for a thorough perspective. Our findings indicate substantial overtime and high turnover rates among administrators due to enrolment demands. The P-Graph methodology exposes significant inefficiencies and difficulties in meeting standard hour targets. It also reveals the optimal process flow and resource allocation, promoting its wider application in public service sectors for sustainable management practices. In collaboration with administrators to meticulously record task times and case revisits, the research offers an in-depth evaluation of administrative efficiency and resource utilization. The study concludes that managing an average enrolment of 4,200 students is inefficient for administrative employees, leading to high overtime rates that harm staff well-being. Our holistic approach, augmented with initial and final process impact data plus qualitative insights, highlights the P-Graph methodology's potential in transforming Public Services Management. This method not only enhances process efficiency and resource allocation but also aligns with sustainability objectives, marking a significant stride in sustainable public service practices.

1. Introduction

There are many studies on the problem of human resource planning and labour demand in different organisations, in this research topic this issue is examined in the field of higher education. The difficulties of human resource planning in higher education institutions arise in several areas: teaching staff, teaching and support staff, management and research staff. However, the effective management of human resources does not only raise budgetary, human factor or process management issues, but also problems of sustainability of the institution, its processes (Tick, 2007) and its human resources. In the public sector, sustainability and efficiency are closely linked, as sustainability is about meeting human needs fairly and efficiently. It requires elected officials, politicians, non-profit organisations, the business sector and citizens to work together to develop sustainable policies and practices. Non-profit organizations and public sector representatives should work with private companies to help make public sustainability a reality.
Globally, access to quality public and social services is critical to economic and social well-being. Efficiency and sustainability are necessary to minimise corruption, promote local economies and improve public services. A study conducted in Romania found that a total of 11 out of 42 counties met the criteria for public expenditure efficiency (Dincă et al., 2016). Local authorities are close to citizens and, unlike other levels of the public sector, they are more flexible in integrating sustainability principles into their operations. To this end, Domungues et al. (2015) have developed a conceptual framework, using a case study to show how useful a sustainability label can be to support local governments in evaluating (Domingues et al., 2015). Local governments are unlikely to adopt comprehensive sustainability performance measures unless they are given a competitive position on this issue (Adams et al., 2014). Another important issue is the problem of human resource planning for research surplus in non-profit organisations and higher education, which is driven by globalisation and internationalisation

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through the achievement of academic excellence, innovation and research productivity in higher education institutions. Despite this, many institutions fail to realize the importance of HR management in creating a knowledge economy (Chatterjia and Kiran, 2017). The core function of HR management is to translate organizational strategy into human resource priorities and human resource plays a major role in the realization of organizational vision and aspirations (NOE et al., 2003). In a higher education institution undergoing research university transformation, a comprehensive review of the functions of human resource is essential to achieve the growing goals. A rigorous analysis of the nature of the work entrusted to the staff of the institution is essential. HR management must also take into account different processes and management strategies to contribute to the growth of the organisation (Kucharcíková et al., 2015).There is relatively little literature on the use of systematic decision-support tools to facilitate human resource planning in higher education institutions (Macke and Genari, 2019). Early examples of methods used include goal programming (Feuer, 1985) and simplified population balance models (Wei, 1998). Optimal organizational structure and task allocation are critical to fostering an innovative work culture (Fonseca et al., 2019), so effective decision-support tools for HR management in higher education institutions should have a strong structural component that takes into account workflow linkages.

Input-output (IO) models show a promising approach. IO models were first developed for the analysis of economic systems (Leontief, 1936). The IO framework is able to take into account the workload arising from the needs of external and internal customers. This methodology has been used to determine the staffing levels of libraries, municipal offices (Correa and Guajardo, 2001) and hospitals (Correa and Parker, 2005), among others. To conduct a study within a business or organization, a fuzzy input-output optimization model for allocating scarce labor resources was developed by Aviso and colleagues (Aviso et al., 2018), in which organizational dependencies among employees or departments are taken into account to ensure minimal loss of vital services to external customers. The lack of systematic HR planning in many higher education institutions means that the growing number of academic researchers and increasing research capacity is not matched by a commensurate increase in the number of research and support staff, so the capacity of support units (e.g. finance, legal or procurement offices) can become a bottleneck in a period of rapid growth in research intensity (Aviso et al., 2019).

A P-Graph-based human resource planning problem is presented by Aviso and colleagues (Aviso et al., 2017a.) for reallocating human resources in an industrial factory during a transition crisis. The model determines how to reallocate manpower in order to allow the facility to operate in an alternative transient steady state if the facility is short-staffed due to a disruptive external event. This methodology is illustrated using a representative case study of an instant coffee plant. The results show that, in the case of a reduction in available labour, labour is allocated to the more critical areas and productivity can be maximised by minimising interaction with less critical departments. The P-Graph is a mathematical framework for solving PNS problems, originally in the field of chemical plant design, but more recently for a wide range of problems characterized by common structure (Tan et al., 2018). The P-Graph also allows the definition of a maximal structure, which is different from the structures used in many process integration (PI) problems because it is generated with mathematical rigor, which eliminates the risk of human error (Friedler et al., 1993). The P-Graph model can generate alternative HR plans to be considered for implementation, with the final plan selected providing a benchmark or targets for staff recruitment and reallocation aligned with the strategic goals of the HEI (Aviso et al., 2019). P-Graph has been successfully applied to solve problems with a similar structure to PNS, such as chemical reaction pathways (Fan et al., 2002) economic systems and human resource planning (Aviso et al., 2019), and workforce allocation (Aviso, 2017b).

Based on the literature review it can be concluded that the P-Graph methodology was used less frequently for process analysis, especially in a public service context before. But based on the literature it can be stated that this is a valuable method for this purpose. The goal of this research is to introduce the P-Graph methodology as a new analytical process in the domain of public administration processes, showing how this novel approach can be used to gain deeper quantifiable results and understanding in comparison to other methods used earlier to analyse these processes, to provide more detailed improvement suggestions.

2. Materials and Methods

The P-Graph methodology was developed in the early 1990s for the optimization of complex chemical production systems (Friedler et al., 1993). This method systematically generates mathematical models based on input parameters. It is formally proven that these models contain the optimal solution to the problem. Since then, the P-Graph methodology has been continuously improved and is now able to successfully solve a wide variety of tasks, such as decision support models for human resource expansion at a university (Aviso et al., 2018b). For the initial process mapping and visualisation of the examined enrolment process first the Business Process Modeling (BPM) methodology was applied to better understand the details and behaviour of the process. Business Process Modeling consists of four basic components: flow objects, connector objects, floats, and artifacts. Kazemzadeh et al. (2015a) outline three different triggers for events in BPM: at the start of the process (initial event), at mid-process occurrence (intermediate event) and at the climax (end event). Activities are represented in BPM diagrams as rounded rectangles that represent tasks that can vary from simple to complex or specialized, to the extent that they resist breaking down into further smaller steps (Kazemzadeh et al., 2015a). Diamonds within BPM diagrams represent gateways that allow processes to diverge or converge, and each type is distinguished by internal labels (Kazemzadeh et al., 2015a; Kazemzadeh et al., 2015b).

In order to implement the P-Graph methodology first observations were conducted about the admission process and in-depth interviews were carried out with both the administrators and the supervisor of the administrative office to understand the details and steps of the process. This data collection was revealing the nature of the process, its inefficiencies and anomalies, such as the insufficient time, inefficiently organized process steps and unsatisfied stakeholders (administrators and students), which all justifies the need of a more complex and better organized solution. As it can be seen based on the results, even with one third of the average amount of the incoming students the process cannot be carried out in time, leading to overtime work and higher turnover rates. This highlights the necessity of overall process improvement for which the P-Graph method is highly useful tool, leading to more practical approaches, effective techniques and efficient strategies.

The university enrolment process consists of two major parts. After successful admission, the university has immediate access to student data and documentation from the central admissions database. After that, the university administrators initiate the processing of these documents, sending additional data requests to the students if the data turns out to be inaccurate or missing. The primary goal in this phase is to ensure that all student records are accurately entered into the database for simplified course administration. This crucial step must be taken within 2-3 weeks for all students, prior to the official signing of the contract in the framework of the centrally organized mass meeting. In addition, during the meeting, in addition to signing the contract, additional papers are also collected from the students in physical form.

The second pivotal stage of the process begins with the management of paper-based documentation to incorporate additional student information into the database that was previously omitted. This phase involves a hybrid approach that combines digital and paper-based methods, requiring extensive, iterative corrections by administrators. This stage is characterized by its bureaucratic nature, complexity and non-transparency and presents significant challenges. Administrators work under tight deadlines and must finalize preparations before the semester begins. Additionally, approximately 60 % of enrolled students have difficulty completing the paperwork accurately on the first try, leading to multiple additional data requests per student. As a result, administrators are often forced to work overtime to ensure the process is completed on time and manage the enrollment of all students. The total number of students of the investigated Hungarian university is 14,000 people, during a year approximately 4000-6000 students enroll in the fall and spring semester together. The data have been relatively consistent over the past 6-7 years and do not show significant fluctuations. The challenge is not so much the fluctuating changes in enrollment numbers, but rather the staff's ability to adapt to varying levels of stress and workload. According to data collection the staff turnover is high, around 20 % turnover in the first two years, although those who make it tend to stay longer. Weekend work often becomes necessary, which increases the stress level of those involved. Effective administration requires a minimum of 1-2 years of experience, which is hindered by significant turnover.

3. Calculation

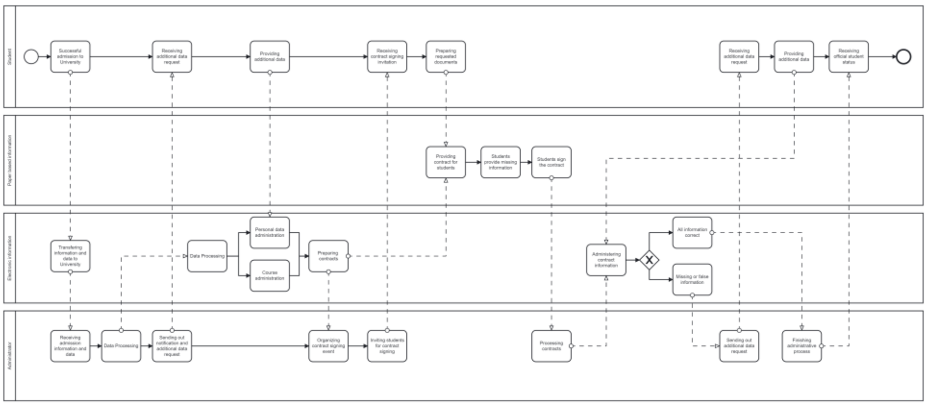

Figure 1: Business Process Modelling representation of the enrolment process

On Figure 1. the Business Process Modelling can be seen representation of the process. At the start of the admissions process, students must provide data and documentation, which administrators then collect and review through various stages. In case of contradictions or incomplete information, further clarification requests are sent to the students. These procedural steps are essential to register students in the university system and begin course administration. A formal contract will be entered into at a later date, which will require further requests for information and documentation to move the administrative process forward. It may become necessary to clarify additional information until the process is completed, which ends with the transfer of official student status to the university's students. Figure 2 shows a P-Graph representation of the university enrollment process, depicting the resources, operational units and intermediate operations generated by the P-Graph Studio software. In this context, administrators, their capacity and students are identified as resources of the process. In the initial stage, the administrators either undertake to process the documents submitted by the student, or request additional information in case of inaccuracy or incompleteness, and then process the obtained data. Entering the second stage, administrators follow a parallel process pattern to manage the paper-based documentation presented at the signing of the contract. However, there is a separate time allocation for each stage, and the processing of paper-based documentation requires longer time compared to its electronic counterpart. It is noteworthy that students often encounter errors in each section, which necessitates several rounds of additional data requests. In addition, the overall time constraints of the entire process should be properly considered in both stages independently.

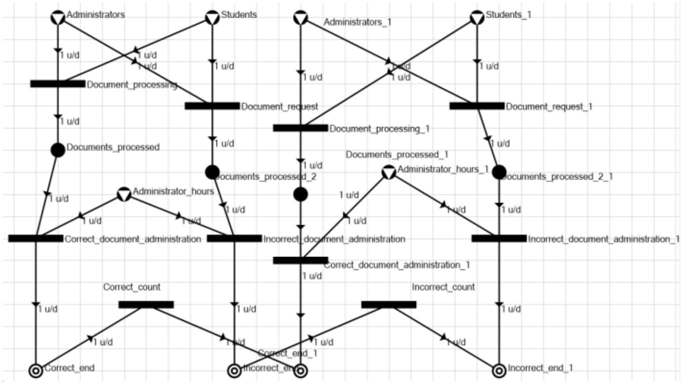

Figure 2: P-Graph representation of the enrolment process

4. Results

To operate the P-Graph representation of the process it is necessary to define input resources and constraints first. The first input resource is the available administrative human resource (A_n) itself which can be calculated based on the number of available administrators, working hours per day and working days per week, keeping in mind that administrators have only three weeks to complete the first stage of the process once the enrolment started in order to be ready for the contract administration, for which they will have an additional two weeks. In this process, there were 17 administrators (N_a) at our disposal, each working 8 hours a day (H), 5 days (D) a week (W). Our goal is to maximize the output of the process, with the finished documentation process as the final product. On average, the study works with the assumption of NS=4,200 students who provide input documentation and enroll within the specified time frame. The formulas used for the calculations are from the study by Eisinger and Buics (2024).

$$A_n = N_a \times H \times D \times W \tag{1}$$

Because of the time constraints in the first stage the process will have A1=2040 hours of human resources and in the second stage A1=1360 hours of human resources. The third input resource is the required labor hours (L_n) per documentation. According to administrators, the average processing time for a documentation is 30 minutes per student in the first digital stage (P_1) and 45 minutes in the second paper stage (P_2). Considering that administrators have other daily tasks, the research assumes that they can spend only 55 % (σ) of their time on the enrollment process. Administrators have a capacity of L1=2244 working hours in the first stage and a capacity of L2=997 working hours in the second stage, which serves as a constraint.

$$L_n = \frac{N_a \times H \times D \times W \times (1-\sigma)}{P_n} \tag{2}$$

In this scenario, an additional limitation applies to the administrators' schedule. The research assumes that all admins work daily and the remaining 45 % are available for other duties, breaks and business hours. Also, although administrator experience indicates a 50-60 % error rate in documentation in the second stage, this model initially assumed a moderate error rate of 10-20 % for this scenario. Table 1 shows the three scenarios that are considered in this setting. First the model assumes an average of 4200 enrolling students, then 2100 students (half of the average amount), and finally 1400 students (third of the average amount).

Table 1: Input resources of the scenario in the model

Name	Admin_resource_1	Admin_resource_2	Admin_Hours _1	Admin_Hours _2
Max. flow	2040 u/d	1360 u/d	2244 u/d	997 u/d

According to the model results, in scenario one administrators could process 1,787 documents during the first stage and 744 documents maximum during the second stage, far from the initially considered 4, 200 student documents. In the second scenario with 2,100 enrolling student documentation administrators are able to process 1886 documents in the first stage and 843 documents in the second stage, resulting in a much higher efficiency, but even in this scenario they are not able to process all documentation in time. In the final scenario the model considers even less enrolling students. With an amount of 1400 applications administrators are able to achieve 93 % efficiency in the first stage and 64 % in the second stage (Table 2).

Table 2: Scenario results in the model

Scenarios	Results	First stage	Second stage
Scenario 1	Completed documentation	1,787	744
	Efficiency	43 %	18 %
Scenario 2	Completed documentation	1,886	843
	Efficiency	90 %	40 %
Scenario 3	Completed documentation	1302	899
	Efficiency	93 %	64 %

5. Discussion and conclusion

In the present case study, the enrolment process at a university was investigated, where it was observed clearly from the in-depth interviews that the employees were overworked and consequently frustrated, leading to high turnover. The workers have a total of 5 weeks to complete the enrolment process, but this is a short period of time to adequately work the 40 hours per week. Office workers have other tasks in addition to those related to enrolment, so in the model it is estimated that on average workers can spend 55 % of their working time on this task. The study concludes that managing an average enrollment of 4,200 students is inefficient for administrative employees, leading to high overtime rates that harm staff well-being. As a result of these problems, three scenarios were set up in which the number of students was varied to see how many employees could efficiently manage the enrolment of the students. The results of the scenario analysis show that scenario 2 (2,100 students) and scenario 3 (1,400 students), with the lower number of students, are still overloaded. By default, the system operates at 30.5 % efficiency, which would be 65 % efficiency for 2,011 students and 78.5 % efficiency for 1,400 students. Even with a third of students (scenario 3), it is not possible to manage the available resources within the working time. Our suggestion to address the present problem would be mainly to allow administrators longer time to complete the process, and it may be worthwhile to hire and involve more administrators during the period under study, so reducing the overload of other employees. However, these solutions could raise further issues, as training new staff would also require a large amount of resources, but would reduce turnover in large cases. The whole enrolment process would need to be modified to allow for the other tasks to be completed within the timeframe. This P-Graph implementation would also have negative impacts, such as increased costs and possible employee resistance to the change, but these effects could be mitigated by highlighting the long term benefits for all stakeholders. The main change which can be seen is that would increase the efficiency of the current process is that paper and digital record keeping should not run in parallel, but it would be sufficient to keep the enrolment digitally. There are examples of this method in Hungary, saving a lot of capacity and resources. Making processes more efficient could not only increase the satisfaction of administrators but also contribute to the sustainability of the organization.

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