Implementation of quality tools in higher education process

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Abstract: The paper aims at examining the possibilities of enhancing the higher education process using quality tools, from the perspective of the number of passing exams, after introducing the Bologna process. One of the goals is modernisation of the teaching process by introducing e-learning. Several quality tools are used, such as: Pareto analysis, Statistical Process Control and Ishikawa diagram. After defining defects (seven basic types of waste) that have a negative influence on the final quality evaluation of higher education and how these defects can be eliminated, the Pareto analysis is done, which is used for establishing a vital minority of the exams that are critical for examination. SPC analysis is performed on the exams that are classified as a vital minority in Pareto analysis. Ishikawa diagram is applied in order to find the causes that effect on a small number of passed exams.

Keywords: Pareto analysis; SPC analysis; Ishikawa diagram; higher education process.


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1 Introduction

The higher education process at faculties and universities is faced with constant challenges to ensure a well-organised and high-quality development of the education system. It represents one of the main conditions to form a knowledge-based society capable of providing good employment of the population. These circumstances strive for the harmonisation of the education system as a consequence of greater competition for resources, stronger opposition from new providers of higher education, and significantly reduced public funding. The contemporary requirement placed on educational organisations is to conduct constant research into market needs and to keep a close check
on the service quality. Quality must not represent just one of the subjects in plans and programs of certain faculties, but also a way for reaching a competitive advantage. This is the reason why introducing quality management is important for the future university development (Tribus, 2005).

In order to achieve the best possible quality of services in the educational process with the lowest costs, one should apply the Lean Six Sigma method. Combining Lean and Six Sigma increases the efficiency and effectiveness of processes. Lean enables simplifying and speeding up the process by reducing or eliminating waste. On the other hand, Six Sigma reduces the variation in the process and reduces or eliminates defects from the process (Bhuiyan and Baghel, 2005).

The aim of this paper is to show the possibility of implementing the Lean Six Sigma method in an educational process and to present the results after applying the Lean Six Sigma method in the first academic year in Faculty of Mechanical Engineering, University of Niš in Serbia.

For the purpose of determination of root causes of the small number of passed exams, the survey including 120 students of the first and second academic year, has been conducted.

2 Lean Six Sigma methodology in higher education

Combining the Lean and Six Sigma methodology increases the efficiency and effectiveness of the process. Lean enables simplifying and speeding up of the process by reducing or eliminating waste. On the other hand, Six Sigma reduces the variation in the process and reduces or eliminates defects from the process. The application of the Lean Six Sigma methodology in the educational process may be very challenging since industrial processes are mainly based on this method. In order to improve service quality in an educational process, it is necessary to define the quality first. Some authors defined the quality of education as “the ability of student’s knowledge to satisfy stated requirements” (Karapetrovic and Willborn, 1997). Many authors agreed that the major difficulty in improving quality in education process lies in the definition of a ‘customer’. The students at Wright State University recognised themselves as the customers in a higher educational process (Helms and Key, 1994) in the conducted survey. Not only those faculties disregarded the fact that students could be presented as customers, but they also often saw students as raw material (Ewell, 1993). Students can also be classified into groups as the raw material, customers, or even as employees. Students classified as raw material are those that are going through the process and that are becoming the final product. Students classified as customers are purchasing the service of education. In addition, students classified as employees are those that should be involved in their studies, they should be motivated to act and they are evaluated at the end of the process (Savoia et al., 2016). It can be assumed that the quality of a student’s performance should be important for a university in the same way in which the quality of an employee’s performance is important for a company.

The most challenging way is to apply industry techniques to an educational process, which points out the general problem. The quality tools used in industrial environment mainly begin with studying the market, or with the question “What are the real customer’s needs?”. Afterwards, the focus is on the quality of the process to meet these needs. On the other hand, the education process is characterised by different motives of
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The major problem occurs in the part of education itself and then in the supplementary or administrative areas of the educational process. Some authors stressed that “the primary activity of educational institutions is not a business one, it implies teaching and learning” (Quinn et al., 2009). It can be said that the educational process cannot be divided into teaching on the one hand and learning on the other.

Six Sigma emphasises three factors, essential for an organisation’s success, and they are: customers, processes and employees (Banuelas et al., 2005). Customers should be the centre of an organisation, because they dictate quality. They except a certain level of product’s or service’s performances, competitive pricing, just-in-time delivery, maintenance. Considering previously mentioned issues, the processes should be observed from customers’ perspective. Due to that, every enterprise should discover what customers want, and what do they really get. This kind of information will enable an enterprise to increase value by improving its processes. Considering that people make results, it is necessary to motivate employees to direct their knowledge, skills and abilities towards the satisfaction of customers’ needs. Therefore, the quality must be an assignment and a responsibility of each and every employee in an organisation (Goh, 2010; Raisinghani et al., 2005).

Implementation of Six Sigma is grouped into five phases which make the results of their implementation superior (Hwang, 2006). The aim of this methodology is to improve the quality of process outputs by identifying and eliminating causes of defects (faults) and minimising the variability in production and business processes (Linderman et al., 2003; Stoiljkovic et al., 2010). Application of DMAIC, which is part of Six Sigma methodology, in higher education process has been proved to be an example of good practice in problem-solving in Malaysia Higher Education Institutions (Paramasivama and Muthusamy, 2012), as well as the continuous quality improvement (CQI) (Basri and Box, 2009).

The Lean methodology represents a group of methods and techniques that are focused on the continuous elimination of waste so that each process, task or activity adds value to the product (Womack et al., 1990; Holweg, 2007). The value is defined as an action or a process that a user would be willing to pay for. In fact, the Lean is focused on creating a value with less work (Hampson, 1999).

The highest goal of the Lean methodology is to eliminate waste. Waste is all that adds costs or consumes time without adding any value. Each activity consumes certain resources that can always be converted into currency. Toyota has identified three general forms of waste (Shah and Ward, 2007) and they are: Muda (basic waste), Muri (overburden) and Mura (unevenness).

Waste, which may be categorised into seven basic types (Womack and Jones, 2003; Hines and Rich, 1997), can be identified in all the processes. Identified waste within the education process at the Faculty of Mechanical Engineering is shown in Table 1.

Lean production is inspired by the Kaizen, the Japanese strategy for the continuous improvement (Glover et al., 2013). The word Kaizen consists of two Japanese words: Kai – literally meaning to isolate and Zen – meaning to fix (Peitz and Shin, 2013). As the words themselves explain, the problem should be isolated, analysed, solved, and the solution must be implemented. Kaizen is based on Deming’s philosophy and his quality circle plan-do-check-act (PDCA). This actually leads to the conclusion that these two concepts, Six Sigma and Lean, have similar or even the same roots (Shan et al., 2008; Hu et al., 2008).
Table 1  Seven basic types of waste in the education process

<table>
<thead>
<tr>
<th>Waste</th>
<th>Definitions</th>
<th>Elimination of waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defects</td>
<td>Wrong teaching plan and classroom schedule, mistakes upon registering for exams, failed exams, withdrawing from exams, incomplete or incorrect information</td>
<td>Create a checklist to define ‘what is good’ in the curriculum, announce student requirements, following an application of modern curriculum in the world, classroom schedules and timetable must be displayed and accessible to students and professors in a visible place</td>
</tr>
<tr>
<td>Buffer stocks</td>
<td>Students who are left back, great variation in the number of passed exams in different exam periods, taking the same courses again for not receiving the signature at the end of the previous term, students who failed or withdrew from taking the exam, unnecessary and redundant parts of curriculum</td>
<td>Regular student attendance at lectures and practise classes, introducing obligations and manner in which exams are taken to students at the beginning of each semester, taking exams during the semester through mid-term tests, project tasks, and term papers</td>
</tr>
<tr>
<td>Motion</td>
<td>Students moving from classroom to classroom, not getting the information on: taking exams and mid-term tests, exam periods and registration, mistakes upon registration, at the right place at the right time</td>
<td>Conducting teaching in a single classroom, designing web portals and displaying information regarding exams and mid-term tests in one spot and on one notice board</td>
</tr>
<tr>
<td>Waiting</td>
<td>Information (in exams, mid-term tests, exam periods), waiting to enrol in the next year, students and professors being late for lectures and practise classes, waiting for and replacing equipment necessary for teaching</td>
<td>Faster information update, implementation of the Bologna Process, regular student and professor attendance at lectures and monthly checks of student attendance, student surveys in the work of professors and assistants</td>
</tr>
<tr>
<td>Transportation</td>
<td>Students passing from year to year, information transfer from the student service to the notice board regarding exams and mid-term tests</td>
<td>Designing web portals and displaying all information in one spot and on one notice board, complete implementation of the Bologna Process</td>
</tr>
<tr>
<td>Over-processing</td>
<td>Re-taking exams, re-enrolment, re-taking classes</td>
<td>Implementation of the Bologna Process</td>
</tr>
<tr>
<td>Overproduction</td>
<td>Excessive number of students who did not find a job within six months of graduation</td>
<td>Cooperation of the Faculty with organisations and companies, giving presentations – career days, organising employment fairs</td>
</tr>
</tbody>
</table>

3  Determination of vital minority

Pareto analysis, which is one of the seven basic quality tools, can be used in order to identify all the available resources for eliminating the causes of problems in the process. The Pareto method is named after Wilfred Pareto – it is the principle of 80% – 20%,
which states that there is a vital minority and trivial majority, i.e., that 80% of appearances are caused by 20% of the reasons (Grosfeld-Nir et al., 2007).

The Pareto analysis is based on the results of the exams that are not passed in the 2009/2010 academic year of the first year of academic study, obtained from the student service at the Faculty of Mechanical Engineering, University of Niš. Pareto analysis of the number of the exams that are not passed in 2009/2010 (Figure 1) shows that course Mechanics 1 – Statics make a vital minority, where the further analysis should be focused. The mentioned course is critical for the successful studying not only for the first year of academic study, but also for the entire education. One of the reasons is that the students of the first year have different background knowledge and different abilities to fit into the new environment.

The above-mentioned problem should be the focus of the faculty itself, the management and the professors, in order to increase the number of passed exams in this course and the level of quality of studies. This course represents the basics of techniques. In addition, the further upgrading of other courses would be inefficient. In the latest chapter measures for improvement are given in order to eliminate this problem.

Figure 1 Pareto analysis of the exams that are not passed in the first year of academic study (see online version for colours)

4 Variations in the process

Statistical process control (SPC) is an analytical tool for making decisions that allow you to see whether the process is functioning properly or not. SPC includes using statistical signals to identify the causes of variation, performance improving and maintaining productivity control at the high-quality level.

Upon the Pareto analysis being conducted and upon obtaining vital minority of courses that are critical for passing exams, SPC is applied. First of all, it is necessary to define certain parameters in the analysis, such as control points, target value, the upper and lower specification limits. Control points represent the measured values during a certain time interval for the sample observed, while the upper and lower specification
limits are the minimum values of tolerance fields outside of which the process should not vary.

Control points are the exam periods and there are seven of them: January, April, May, June, September, October I, October II and October III for the past three years: 2009/2010, 2010/2011 and 2011/2012. Mean value, the upper specification limits and lower specification limits depend on the number of exams that are not passed expressed in %.

According to the control chart of the observed course, it can be noted that the process varies a lot, and one part of the chart is outside the specification limits. Based on Figure 2, it can be concluded that the number of the exams that are not passed is very high in all exam periods except the last exam period – October III. The aim of the improvement of the educational process is to reduce this variation and to minimise the number of exams that are not passed, i.e., it is necessary that both the target value and tolerance field between the specification limits are as low as possible.

**Figure 2** Control chart for the course Mechanics 1 – Statics (see online version for colours)
5 Determination of relation between consequence and causes

Ishikawa diagram is a tool that helps in the identification, sorting, and displaying possible causes of a specific problem or quality characteristics. The diagram graphically shows the relation between specific consequence and all factors that influence the consequence (Ishikawa, 1982; Enarsson, 1998).

The diagram is constructed by starting from the consequence which is inserted in the right side of the diagram. A further step is drawing of the ‘fishbone’ diagram and attaching categories to it. The diagram is developed by considering all categories and asking WHY a certain category affects the result. For every cause, the same process of construction is repeated, and the question WHY is asked for every level. It can be concluded that the method for constructing Ishikawa diagram consists of considering all possible causes and their organisation into categories and subcategories.

Considered causes of the problem in production are usually divided into four categories and these categories are: Surroundings, Suppliers, Skills and Systems.

In this case, the considered consequence is Small number of passed exams (Figures 3–5).

The presented Ishikawa diagram is done also on the survey, which is taken by the most students in the first and second academic year. Students’ voice can be taken as very important information for further investigation, because it has the significant role for forming the future curriculum of the faculty. It is needed to reconsider not only individual point of view but also the socio-cultural view of the students and their environment (Scott and Leach, 2003).

Figure 3 Categories skills and surroundings (see online version for colours)
The main causes that as a consequence have Small number of passed exams can be found in two categories: Skills and Suppliers. One of the major problems of the small number of passed exams, detected in Ishikawa diagram, is the outdated teaching plan for most of the courses. What is learnt in courses does not follow the trend of required knowledge in the market, which results in the problem that students after graduation cannot apply their knowledge on ‘real-life’ problems.
Another problem is a manner of presentation, which has implied so far that a professor teaches in large groups of students. In this way, professors are not able to answer students’ questions or clarify their lectures in details.

The absence of students from classes and failure to fulfil the pre-exam requirements (seminar papers, homework and project tasks) directly affect the consequence observed in this case.

6 Suggested improvements according to previous results

The vital minority of subjects that are critical for passing exams is determined by using the Pareto analysis. After determining a vital minority and implementing SPC analysis, it is necessary to determine the root cause of the small number of passed exams. Ishikawa diagram shows the root causes which should be eliminated using available resources that would increase the number of passed exams.

Besides from the fact that professors have to change their teaching plans, they need to change the manner of the presentation so that the courses become more interactive, where students will be more involved in the process of education. This means working with small groups of students where a professor will devote more time to students’ questions and their needs, i.e., professor and students will make an effective team. In other words, a professor and students will become ‘partners’ in the process of acquiring knowledge. These improvements will impact the elimination of another important problem which is the Lack of motivation of students and professors (Malik, 2010).

These are the reasons why the plan of improvement is determined. The improvement plan was made with the faculty management and professors of ‘critical subjects’ and was implemented immediately after these analyses. In the period when the improvement plan was made the Bologna process was in the early stage of implementation not only at this Faculty but also in the entire University.

By implementing the Bologna process completely in all courses and changing the mode of taking an exam, the above-mentioned problems will be solved. Examination procedure, which has so far consisted of written and oral part, and where students could take exams only after the semester has been finished, has been changed at present. Nowadays, during the course, students do their homework, seminars and project tasks. By fulfilling their obligations, students can take exams during the semesters. In this way students are active throughout the entire semesters.

During the summer break, all classrooms at the faculty were cleaned, renovated and equipped with new furniture. All unnecessary items, materials, tools and disused equipment were removed. Generally, now all rooms, machines, tools and equipment are more frequently cleaned, and as a result, we have a clean and safe workplace, where each next occurrence of a failure, hazard or anomaly can be easily detected and eliminated in time.

7 Discussion of results after applying lean Six Sigma methodology

As a result of the implementation of the Lean Six Sigma method in the education process and implementation of the improvement plan, there are more students who passed exams in 2012/2013 academic year. It can be noticed that not only the number of passed exams
is increased, but also there is a different redistribution of subjects that are passed successfully and that are not critical anymore.

Comparative overview of Pareto analysis of the number of passed exams in the examination period for 2009/2010 and 2012/2013 academic year shows the results after application of Lean Six Sigma method (Figures 6 and 7).

Figure 6 Pareto analysis of the number of passed exams in the first year of academic year 2009/2010 (see online version for colours)

Figure 7 Pareto analysis of the number of passed exams in the first year of academic year 2012/2013 (see online version for colours)

8 Conclusions

After locating and defining the problems in the higher education process, it can be said that the measures and actions proposed in this paper may be used to improve the quality
of teaching and students’ success in the exam periods. The implementation of the above-mentioned improvements represents just a beginning, and the full implementation would increase the pass rate of students even more while maintaining the quality of the curriculum. In addition, it is necessary to emphasise the importance of continuous monitoring of all parameters that affect the students’ success in the exam period and the quality of teaching process, and according to the results of the analysis, the adequate procedures for the improvement of these parameters should be identified and implemented.

Further analysis would involve a detailed students’ survey, so that an adequate information could be included in the analysis. Thus, both statistical data and subjective opinion of students will be considered in future research.

Implementing the Lean Six Sigma method requires some time, and it should be kept in mind that Lean Six Sigma is not a ‘final destination’ but the journey that should be continuous. Another important factor is a change of organisation culture, certain changes of the attitudes of professors and of students should be made as well as the way they communicate or cooperate. The application of methods and changing of the culture are necessary conditions for employees’ empowerment and commitment. The case study presented in this paper confirms how useful the implementation of the Lean Six Sigma methodology in a higher education process is.

References


