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A New Method for the Science Teaching: 6-Sigma Method

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Abstract
Today, in order to increase the academic achievement of the students, new methods are investigated in the field of education and many studies are done on their effectiveness. In this article, 6-Sigma method implemented recently in different areas is introduced and it is aimed to discuss the applicability of the 6-Sigma method in science teaching. In this framework, the study was carried out by using phenomenographic research method. Semi-structured interviews were conducted on the opinions of six science teacherswho voluntarily applied the 6-Sigma method with DMAIC process in their classes.
Keywords: Six Sigma, DMAIC, Science Teaching, Heat and Temperature

1. Introduction

The changes and progresses that have come up with the new requests in education indirectly affect the methods and techniques applied in teaching. This situation updates the education systems of the countries and sometimes leads to drastic changes even in educational policies in order to adapt to the age. Education systems require a groundbreaking support tool that helps improve the quality of education (Mohmand, 2016). In this context, countries are exploring new methods of teaching in order to improve their education and training activities and testing the applicability and effectiveness of these methods. When the relevant literature is searched, it has been understood that one of the new methods used in different areas is the 6 Sigma method (Antony, Gijo, Kumar and Ghadge, 2016; Chakrabartyi and Tan, 2007; Hadidi, Bubshait and Khreishi, 2017; Joghee, 2017; Matthew, 2013; Özkan, Rubio, Hassan and Davis, 2017). However, no research evidence was found to claim whether this method is effective or not to increase student achievement in teaching.

Six Sigma, which we want to introduce and promote as a new teaching method, was developed by Motorola in 1986 and is used by a large number of companies, particularly in the manufacturing and finance sectors (Paul, Nordstrum and Cudney, 2017). Six Sigma refers to the proportion of defects or errors in a process (Godfrey, 2002). In another definition, Eckes (2003) describes 6 Sigma as a continuous improvement, understanding and reducing undesired variations; the collection of data and the use of statistical methods for problem solving to improve the processes. According to Park (2002), 6 Sigma is a measure of the statistical measurement of the quality level of the process and is a sign how well the process depicts performance and improvement. Initially, 6 Sigma focused on reducing defects throughout the process of large companies, while focusing on creating goals, strategies, practices and value (Patil, Kamlapur and Dhore, 2006). In education, 6 Sigma can improve students' thinking, writing and presenting skills (Patil, Kamlapur and Dhore, 2006).

Six Sigma uses a five-stage approach (Kanigolla, Cudney and Corns, 2013), which is a continuous improvement effort, defined as DMAIC (Define, Measure, Analyze, Improve, and Control) to improve productivity and customer satisfaction. The DMAIC process is important in the implementation of this method. DMAIC can also be briefly defined as improving overall performance (Patil, Kamlapur and Dhore, 2006). The DMAIC route map is the same as in Figure 1.

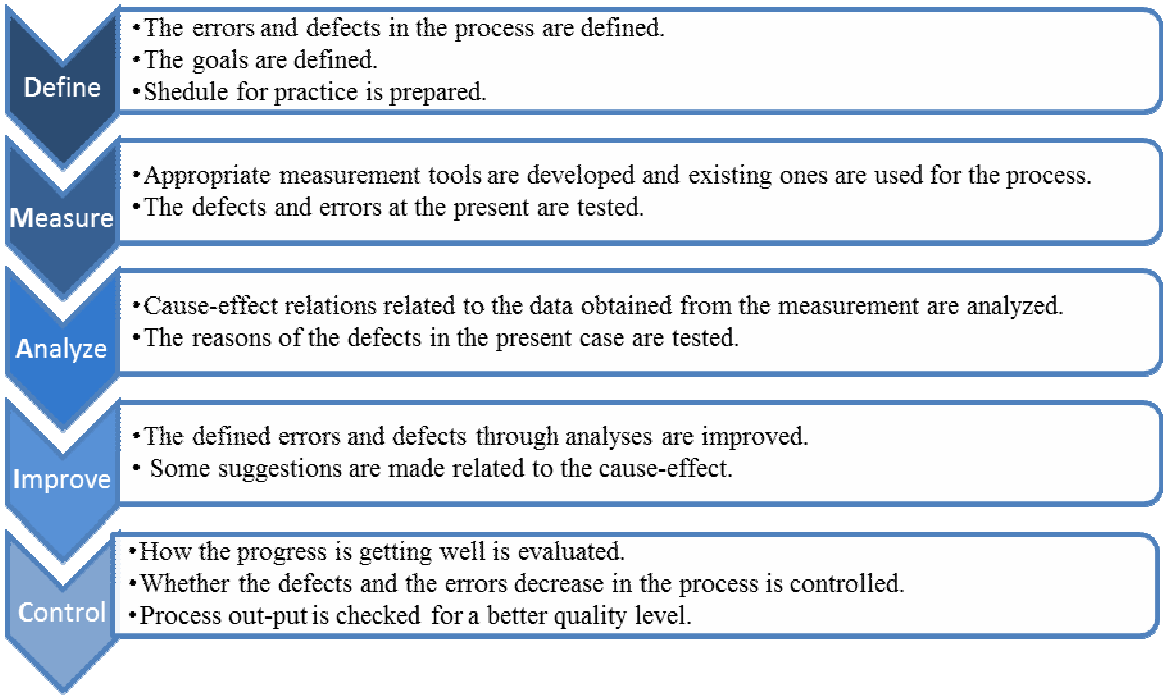

Figure 1. DMAIC process in 6-Sigma.

Six Sigma has recently begun to appeal the attraction of academic world. Especially, 6-Sigma has taken its place as an important application in the business world (Antony and Banuelas, 2001; Hopen and Cudney, 2016; Pande, Neuman and Cavanagh, 2000; Soković, Pavletić and Krulcc, 2006; Weinstein and Castellano, 2008) and in engineering (Babajide and Moore, 2015; Downing and Bryan, 2010). However, 6-sigma applications are fairly newin the field of education. When the literature is examined, it is possible to see some researchers at the level of higher education related to the 6 Sigma method (Kanigolla, Cudney and Corns, 2013; Kukreja, Ricks and Meyer, 2009; Mohmand, 2016; Zhao, 2005). For example, Kukreja et al. (2009), present a case study for the accounting department to analyses the academic performance of the students using the Six Sigma process improvement methodology. Zhao (2005), on the other hand, has developed a theoretical approach using the Six Sigma method to improve the quality of higher education. As mentioned above, there were no studies in which the 6-Sigma method was implemented in teaching.

Students are experiencing some difficulties in understanding science subjects and especially in the subjects of physics. One of these topics and concepts is heat and temperature. In this research, we will refer to the correct teaching of heat and temperature in a formal way. The reason why heat and temperature is chosen as the topic of the research is that students have misconceptions about the topic and they have difficulty to understand the concepts about heat and temperature. As a matter of fact, it has been determined in the researchers carried out from the past to the present that students have difficulties in terms of heat and temperature (Adamczyk and Willson, 1996; Aydın, 2007; Carlton, 2000; Hitt and Townsend, 2015; Kesidou and Duit, 1993; Zacharias, Georgios and Marios, 2008). This study is a guideline for science teachers for 5th grade students since the first application of heat and temperature starts at the 5th grade in secondary schools. Therefore, in this article, which introduces the 6 Sigma method, it is aimed to discuss the applicability of the 6 Sigma method in science teaching with an improved activity on heat and temperature at secondary school level.

2. Application of 6-Sigma – DMAIC Methodology

In this section, the application process of the 6-Sigma method on the subject of heat and temperature in the 5th grade science class in middle school planned according to the DMAIC process is mentioned.

Table 1. Application plan for 'heat and temperature' unit according to DMAIC process

Step/Phase	Explanation	Tools Used
Define	To define the aim and scope of the course, to identify the problems related to heat and temperature, to reveal the necessary outputs, to determine the requirements of the students related to the subject and to plan the process.	Required assessment techniques such as student interviewing, observation, resource search, formative evaluation (for the identification of student preliminary information)
Measure	Processes such as making an assessment of the problem state of heat and temperature, measuring, testing the accuracy of the measurements, determining the misconceptions about the existing heat-temperature.	Alternative assessment techniques such as three-tier test, concept map, analogy and diagnostic tree, and pre-test success test.
Analyze	In the measurement phase, an analysis process is carried out, such as determining the root cause of the problems, arranging the students to remove the existing problems about the heat-temperature topic, and creating a sequential list to determine which developments have more influence on which situations.	Three-step test, descriptive analysis for concept mapping and analogy techniques, SPSS data analysis program for analysis of success test.
Improve	Identify the solution options for identified problems, approve the proposed applications/activities/changes, and finalize the implemented applications/activities/changes.	Working papers on the concepts of heat and temperature, daily living associations, experiment and activities to organize to distinguish between heat and temperature concepts
Control	To control the improvement/development work done in the previous stage, to determine whether the difficulties experienced by the students in terms of temperature and temperature are continuing, to follow a process such as applying a control plan and evaluating improvements/developments.	Final-test success test, concept map, observation and student interview, reliable and valid heat and temperature success test.

Figure 2. Lessonactivity on heat and temperature

3. Methodology

This research was conducted by using phenomenographic method. In the study, semi-structured interviews were carried out for the science teachers who applied the 6-Sigma method in their courses to figure out how the method works.

3.1 Teacher Opinions about 6-Sigma Application for 'Heat and Temperature' unit

The process of the application plan in Table 1 on "heat and temperature" was explained by a face-to-face interview with eight science teachers. Teachers were coded A, B, C, D, E, F, G, and H, D and F teachers indicated that they did not fully understand the application plan. Therefore, they would not participate in the interview. The other six teachers voluntarily described 'heat and temperature' in their lessons by applying the DMAIC process within the scope of the 6-sigma method. The demographic information of the teachers who implemented 6-Sigma in their courses is given in Table 2.

Table 2. The demographic information of the science teachers

ScienceTeachers	Gender	Experience(years)	Education Level
A	Male	8	BEd.
B	Male	7	BEd.
C	Male	5	BEd.
E	Male	8	MSc.
G	Female	12	BEd.
H	Female	15	MSc.

The practice of each teacher lasted about four lesson hours, consisting of approximately 40 minutes. After the application, the teachers' opinions about the practice were taken with the questions in the prepared interview protocol (Annex-1). Face-to-face interviews were recorded with a voice recorder and each interview lasted 20-30 minutes. The analysis of the data was carried out by content analysis method. In this analysis, it is tried to categories the similar expressions to make them more understandable. The data obtained from the interview analyzes related to the implementation process of the 6-sigma method are presented in Table 3 under three categories as the effectiveness of the method, the appropriateness of the subject and the difference from the other methods.

Table 3. Teachers' views about 6-Sigma method

Science Teachers	Effectiveness of the method	Appropriateness of the subject	Difference from the other methods
A	The most important effect of the method is learning deficiencies in the determined subject and mistakes in the teaching process.	With this method, the problem of mixing heat and temperature concepts has been removed.	In 5E and quantum learning models, the subject to be taught is handled together with the students in the framework of the determined events and phases of the models. In the six-sigma method, after the teaching of the determined subject, there is a focus on solving the parts of the learning process that the student has difficulty in learning and cannot fully comprehend.
B	It can be ensured that challenging topics are taught better in a short time. The concept that exists in the students can be used to solve the misconceptions.	The method is appropriate because the students are having difficulties in using the heat-temperature concepts because these concepts are intertwined. With this method, the concept of heat and temperature can be grasped better.	With this method, students are probed prior knowledge about concepts of heat and temperature. There is a solution in this method for the subjects that are not fully learned or misunderstand.
C	It is an effective method of teaching abstract concepts and subjects, such as heat and temperature, matter, electricity, which are difficult to understand.	This method can solve the problem of using the concepts of heat and temperature interchangeably. This is an appropriate method.	In the 6-sigma method, it is more important that the learning difficulties in the subjects such as heat and temperature that students have difficulty in learning are removed while 5E and 7E, it is important to know how to process (how to handle the issue, and in what order)
E	It is influential in the formation of a better teaching by eliminating the previous misinformation that students related to science teaching bring to the learning environment.	The concepts of heat and temperature are abstract concepts. Students are having difficulty in understanding these concepts. With this method, the problems are determined and analyzed, so it is suitable for the subject.	Unlike other methods, the 6-sigma method can be used to determine problems in science teaching, such as students having difficulty learning or misunderstanding in everyday life, and it is possible to control whether these problems have risen in the meantime.
G	It is effective in determining a problem related to the course and in solving this problem.	I saw that this method is applicable to heat and temperature. Because this topic contains important science concepts that students have difficulty in understanding.	The 6-sigma method differs from other methods in that it overcomes these deficiencies by focusing on subjects and concepts that the students cannot learn or mix.
H	With this method, the problems of students in science subjects can be determined and their solutions can be realized.	There are problems such as the use of heat and temperature concepts on the subject of 'heat and temperature', misunderstanding about these concepts in informal environments. These problems can be solved by this method. Method is suitable for this topic.	The main difference between this method and the other methods; 6-sigma method errors, omissions and defects is focused.

In addition, some of the teachers' answers to the questions are presented below without changing the teacher's expressions. These statements include; the effectiveness of the method, the appropriateness (suitability) of the subject and the difference from the other methods are given in order of two examples for the categories.

D: *"...I think that this method can be applied in science teaching more often in the following years ..... As far as I understand the mistakes and misconceptionsin every discipline can be removed from the process by using the problem-solving steps consisting of 5-step successive steps."*

E: "...In this method, the problems of the students in learning troublesome science units and misconceptions can be removed. As a result, this method is effective in science teaching."

A: "...Particularly, students confuse 'heat and temperature' concepts and cannot fully understand the characteristics of these concepts. With this method, the concepts of heat and temperature can be grasped better...."

F: *"...The 6 Sigma method is a nice, non-complicated method consisting of five steps that can be applied to the science class. With this method, the problems that students have are identified and there are certain stages to be solved. I think this method is an effective method in science teaching...."*

D: *"...While other methods are similar to each other, this method seems different to me from other methods. In other methods it is clearly stated what activities are done at every stage of the teaching process but in 6 sigma method the learning difficulties of the students are removed and better learning is achieved...."*

E: *"...The most important difference of this method is not only the problem can be determined but also the steps are taken to find out a solution to the problem..."*

When summarizing the interview data; Six Sigma method is effective in science teaching and it is stated that students can remove the misconceptions and difficulties they experience about heat and temperature and by implementing this method, it is possible not only to determine the problem but also to improve better solution about it.

4. Discussion and Conclusions

It has been argued in this study that it is possible to use the 6-sigma method in teaching in order to solve the problems that students experience during the course. In this context, firstly, an implementation plan prepared according to the 6-sigma method was developed. Each step of the 6-sigma method is explained in the implementation plan and suggestions for appropriate data collection tools are provided at this stage. Later, this application plan was shared with science teachers and their views on the 'heat and temperature' applications were taken. The concepts of heat and temperature that help us realize the events in daily life are two concepts that are very common in everyday life or in informal learning environments. In everyday life, the use of the concepts of heat and temperature without being taught sufficiently can cause confusion or misconception that is difficult to change later on (Jara-Guerrero, 1993; Madu and Orji, 2015). When the literature is examined, it has been determined that the students attending to different class levels have difficulties in distinguishing the difference between heat and temperature concepts (Schönborn, Haglund and Xie, 2014; Yeo, and Zadnik, 2001). The researchers found out those students of secondary school level (Bayram, 2010; Sarı Ay and Aydoğdu, 2015; Schönborn, Haglund and Xie, 2014), high school students (Aydoğan, Güneş and Gülçiçek, 2003; Yeo, and Zadnik, 2001) The students at the university level confused the concepts of heat and temperature (Alwan 2011; Aydoğan, Güneş and Gülçiçek, 2003; Damlı, 2011; Luera, Otto and Zitzewitz, 2005; Madu and Orji, 2015; Yavuz and Büyükekşi, 2011) and they could not learn these concepts properly. Therefore, it is important for students to learn the concepts of heat and temperature through correct methods starting from the early age and not to encounter such difficulties about them in following years. Through interviews with science teachers, teachers agree that using 6-Sigma method in science classes is an effective method in teaching difficult subjects.

In this study, we propose a framework that can be used as a guide to apply 6-sigma to the concepts of heat and temperature in the field of physics in which students have difficulty in learning. We think that this framework will be useful for science and physics teachers and the mostly to the important academic environment as well.

5. References

Adamczyk, P., & Willson, M. (1996). Using concept maps with trainee physics teachers. *Physics Education*, *31*(6), 374-381.

Alwan, A. A. (2011). Misconception of heat and temperature among physics students. *Procedia Social and Behavioral Sciences*, 12, 600–614.

Antony, J., & Banuelas, R. (2001). A strategy for survival. *Manufacturing Engineer*, *80*(3), 119-121.

Antony, J., Gijo, E. V., Kumar, V., & Ghadge, A. (2016). A multiple case study analysis of Six Sigma practices in Indian manufacturing companies. *International Journal of Quality & Reliability Management*, *33*(8), 1138-1149.

Aydoğan, S., Güneş, B., & Gülçiçek, Ç. (2003). The misconceptions about heat and temperature. *Gazi University Journal of Gazi Educational Faculty,* 23, 111-124.

Aydın, Z. (2007). *Misconception encountered in heat and temperature unit and using concept maps to remove these misconceptions,* Master Thesis, Yüzüncü Yıl University Graduate School of Natural and Applied Sciences, Van, Turkey.

Babajide, B., & Moore, T. (2015). Engineering University-industry projects: a design for six sigma framework. *Proceedings of the 2015 IEEE Frontiers in Education Conference (FIE)*, IEEE Computer Society, Washington, DC.

Bayram, A. (2010). *The effect of problem based learning on overcoming 5th grade students misconceptions about heat and temperature.* Master Thesis, Selçuk University Institute of Educational Sciences, Konya, Turkey.

Carlton, K. (2000). Teaching about heat and temperature. *Physics Education*, *35*(2), 101-105.

Chakrabartyi, T., & Tan, K. C. (2007). The current state of six sigma application in services. *Managing Service Quality*, 17(2), 194–208.

Damlı, V. (2011). *The effect of web based interactive instruction based on conceptual change approach for overcoming university students? Misconceptions about heat and temperature* Master thesis, Gazi University Institute of Educational Sciences, Ankara, Turkey.

Downing, C. G., & Bryan, A. M. (2010). Optimization of operational techniques using six-sigma principles. *Proceedings of the 2010 Industrial Engineering Research Conference*, Cancun, Mexico.

Eckes, G. (2003). *Six Sigma for Everyone*. John Wiley and Sons, Hoboken, NJ.

Godfrey, A. B. (2002). In the beginning. *Six Sigma Forum Magazine*, *1*(3), 46-49.

Hadidi, L. A., Bubshait, A., & Khreishi, S. (2017). Six Sigma for improving aesthetic defects in aluminum profiles facility. *Facilities*, *35*(3/4), 242-267.

Hitt, A. M., & Townsend, J. S. (2015). The heat is on! using particle models to change students' conceptions of heat and temperature. *Science Activities: Classroom Projects and Curriculum Ideas*, *52*(2), 45-52.

Hopen, D., & Cudney, E. (2016). Educators world: fostering individual, organizational, and societal success. *Journal of Quality and Participation*, *39*(1), 13-16.

Jara-Guerrero, S. (1993). Misconceptions on heat and temperature. *In the Proceedings of the Third International Seminar on Misconceptions and Educational Strategies in Science and Mathematics. Ithaca: Misconceptions Trust*.

Joghee, R. (2017). Control chart for high-quality processes based on Six Sigma quality. *International Journal of Quality & Reliability Management*, *34*(1), 2-17.

Kanigolla, D., Cudney, E. A., & Corns, S. M. (2013). Project based learning for quality and six sigma education. *Int. J. Six Sigma and Competitive Advantage, 8*(1), 51-68.

Kesidou, S., & Duit, R. (1993). Students' conceptions of the second law of thermodynamics-an interpretive study. *Journal of Research in Science Teaching*, *30*(1), 85-106.

Kukreja, A., Ricks, J. M. Jr., & Meyer, J. A. (2009). Using six sigma for performance improvement in business curriculum: A case study. *Performance Improvement, 48(2),* 9-25.

Luera, G. R., Otto, C. A., & Zitzewitz, P. W. (2005). A conceptual change approach to teaching energy & thermodynamics to pre-service elementary teachers. *Journal of Physics Teacher Education Online*, *2*(4), 3-8.

Madu, B. C., & Orji, E. (2015). Effects of cognitive conflict instructional strategy on students' conceptual change in temperature and heat. *SAGE Open*, *5*(3), 1-9.

Matthew, J. L. (2013). Six Sigma in healthcare delivery. *International Journal of Health Care Quality Assurance*, *26*(7), 601-626.

Mohmand, S. (2016). Minimizing errors in education systems using six sigma and tqm tools. *International Journal of Scientific Research, 5*(4)*, 487-491.*

Özkan, B., Rubio, J. F., Hassan, M. K., & Davis, J. R. (2017). Six Sigma, stock returns and operating performance. *Management Research Review*, *40*(3), 331-351.

Pande, P. S., Neuman, R. P., & Cavanagh, R. R. (2000). *The Six Sigma Way: How GE, Motorola and Other Top Companies Are Honing Their Performance*. New York: McGraw-Hill.

Park, S. H. (2002). Six Sigma for productivity improvement: Korean business corporations. *Productivity Journal*, *43*(2), 173-183.

Patil, V. H., Kamlapur, S. M., & Dhore, M. L. (2006). Six Sigma in education: to achieve overall excellence in the field of education. *International Conference on Information Technology: New Generation*, 2-5.

Paul, G. L. M., Nordstrum, L. E., & Cudney, E. A. (2017). Six Sigma in education. Quality *Assurance in Education*, *25*(1), 91–108.

Sarı Ay, Ö., & Aydoğdu, C. (2015). The effect of conceptual change texts in the misconceptions identified removal in the unit of states of matter and heat. *Hacettepe University Journal of Education,* 30, 99-111.

Schönborn, K., Haglund, J., & Xie, C. (2014). Pupils' early explorations of thermoimaging to interpret heat and temperature. *Journal of Baltic Science Education*, *13*(1), 118-132.

Soković, M., Pavletić, D., & Krulcc, E. (2006). Six Sigma process improvements in automotive parts production.

Journal of Achievements in Materials and Manufacturing Engineering, *19*(1), 96-102.

Weinstein, B., & Castellano, J. (2008). Integrating six sigma concepts in an MBA quality management class. *Journal of Education for Business*, *83*(4), 233-238.

Yavuz, S., & Büyükekşi, C. (2011). Usage of concept cartoons in teaching of heat- temperature topic. *Karaelmas Science and Engineering Journal*, *1*(2), 25-30.

Yeo, S., & Zadnik, M. (2001). Introductory thermal concept evaluation: Assessing students' understanding. *The Physics Teacher*, *39*(8), 496-504.

Zacharias C. Z., Georgios, O., & Marios, P. (2008). Effects of experimenting with physical and virtual manipulatives on students' conceptual understanding in heat and temperature. *Journal of Research in Science Teaching*, *45*(9), 1021-1035.

Zhao, L. (2005). China's higher education quality management based on Six Sigma management principles. Proceedings of Artificial Intelligence, *Management Science and Electronic Commerce (AIMSEC), IEEE, Deng Leng*, 8-10 August 2011, 6559-6561. http://portal.psz.utm.my/sdi_senat/images/dmdocuments/2012/september%202012.pdf

Annex-1

Science Teacher Interview Protocol

[Record the name of the school, the teacher's name, gender, experience, level of education and interview date.]

I appreciate your participation into the interview. I would like to record our interview.

1. What do you think about Six Sigma method that you have used in your teaching sessions?

2. Can this method be used to solve the difficulties of students about heat and temperature concepts in science teaching? Explain Briefly.

3. What deficiencies can you remove from the science teaching? Can you give some examples?

4. Can this method be used considering the facilities of the school?

5. Can you achieve your teaching objective through this method? Explain Briefly.

6. What are the differences of this method compared with the other teaching methods or approaches? Please specify in detail.

[Thank you for your contribution.]