Solving Problems in Education Using Quality Tools

Matthew Barsalou, Germany, email matthew.barsalou@gmail.com

The purpose of this white paper is to explain the use of quality tools to educators. There are many quality tools available and a small selection are presented in detail for educators to choose from when addressing problems. In addition to providing tools, this paper also presents the A3 report as a problem solving process.

It is the tenth paper in a series of thoughts collected, organized, and promoted by the Quality in Education Think Tank (QiETT) of the International Academy for Quality (IAQ).

The first paper addressed a broader scope of topics and put into perspective the overall field of "Quality in Education", which set a common ground for further reflection and guidance of QiETT activities. The forthcoming papers, such as this one, focus on more specific topics and delve deeper into particular topics based upon the collection of international inputs from quality and education experts.

To date, this collection of white papers comprises the following titles:

1-"Quality in Education: Perspectives from the QiETT of IAQ"
2-"Large Scale Training of Quality Professionals"
3-"Inclusive Quality of Education"
4-"Continuing Education in Quality Improvement for Healthcare Professionals and its effects on organizational improvement"
5-"Current Societal Challenges to Quality and Quality Management in Higher Education"
6-"Applying Quality Theory to Educational Systems"
7-"Training and Teaching Statistical Methods for Quality"
8-"Simple Hints to Help Trainers Improve Training Quality"
9-"Students Quality Circles – A Step Towards a Total Quality Society"
10-" Solving Problems in Education Using Quality Tools"

1. Introduction

The use of quality tools for problem solving may not be new to some teachers; Cleary tells us the affinity diagram is already used by teachers “for everything from planning parties to organizing historical data” (Cleary 2015 p. 1). This paper seeks to provide a tool kit of simple, yet powerful and easy to use quality tools for those educators who are unaware of quality tools. This paper also provides a PDSA (Plan Do Study Act) based process for quality improvement in the form of A3 reports.

Quality tools are the tools of quality professionals; however, their use is not limited to those engaged in the field of quality. For example Juran observed production workers in Japan applying basic quality tools to address quality problems in the 1960s (Juran 2005).

The use of quality methods in education is not new. As far back as the late 1970s, in the Carder Elementary School in Corning, New York, a Koalaty Kind program was deployed using PDSA. (LeRoy 1996). This program eventually included over 300 schools (Amos and Keely 2003).

The Winston Campos Elementary school in Palatine, IL used quality tools together with PDSA to increase the number of fifth graders meeting or exceeding the state’s standards in a standardized test. Quality tools used to analyze the situation included an Ishikawa diagram and a relations diagram. Insights form the analysis were used to create an improvement plan and the number of children meeting or exceeding requirements for the standardized test results increased from 59% to 95% (Jacobsen 2009).

2. Key Quality Tools for Educators

Data related to a problem should be viewed in a graph to identify features in the data that standout an may not otherwise be noticed. There are many types of graphs available and the exact type of graph depends upon the data available. Two simple, yet effective, graphs are the run chart and the histogram.

A run chart is well suited for displaying data that occurs in time order to identify potential changes (Tague 2005). For example, a run chart could be used to depict an individual student’s grades over time such as in the example shown in Figure 1. In this example, grades suddenly dropped in time periods six, seven, and eight and then increased afterwards. This graph could help to explain why an otherwise well performing student had a lower than anticipated overall grade. Perhaps the material was more difficult for time periods six through eight or perhaps the student was experiencing personal problems that affected their grades. Having identified where to look, an educator could then investigate further. A run chart is created by plotting values on the y-axis and time periods, such as dates, on the x-axis. Values would then be connected with a line.

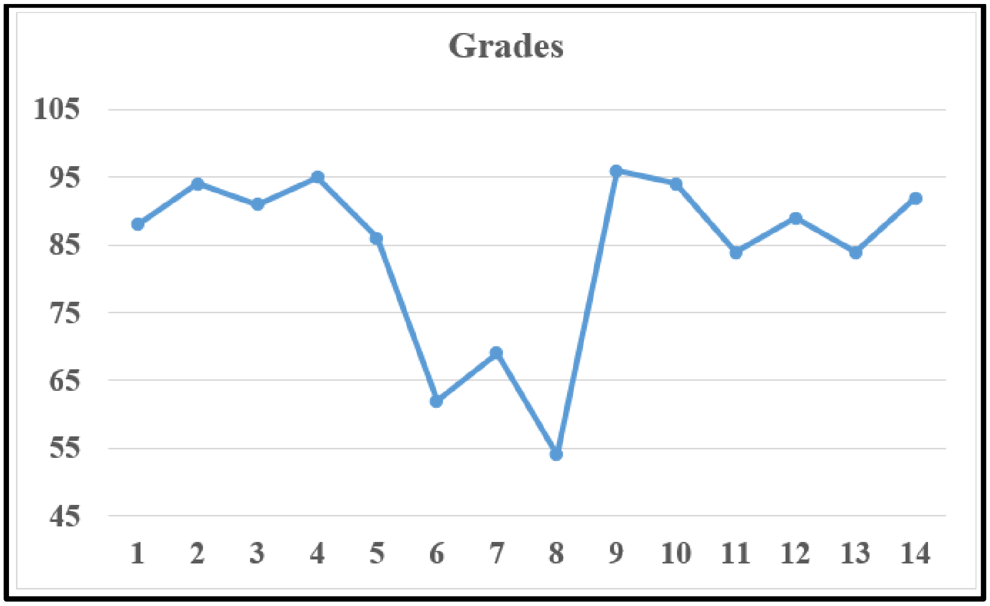

Figure 1: Example of a run chart of an individual's grades over time

Not all data is collected in time series. For such data a histogram can be useful for displaying the distribution, or spread, of the data (Borror 2009). The histogram in Figure 2 depicts the spread of grades for 25 students. The width of the bar represents a range of values, which are listed on the x-axis. The bars are called bins and the number of bars is equal to the square root of the number of items in the sample. In this example, there are 25 students; therefore, there are 5 bins. The number of bins should be rounded up or down to a whole number if the square toot is not a whole number. The range of values in a bar is known as the bin size and can be calculated by subtracting the lowest value from the highest value and dividing the number of bins by the difference. In this example, that would be 5/(98–68) = 6; therefore, the bin size is six. The x-axis depicts the number of items in a bin. Suppose there were four students with grades between 68 and 73; the count would then be four.

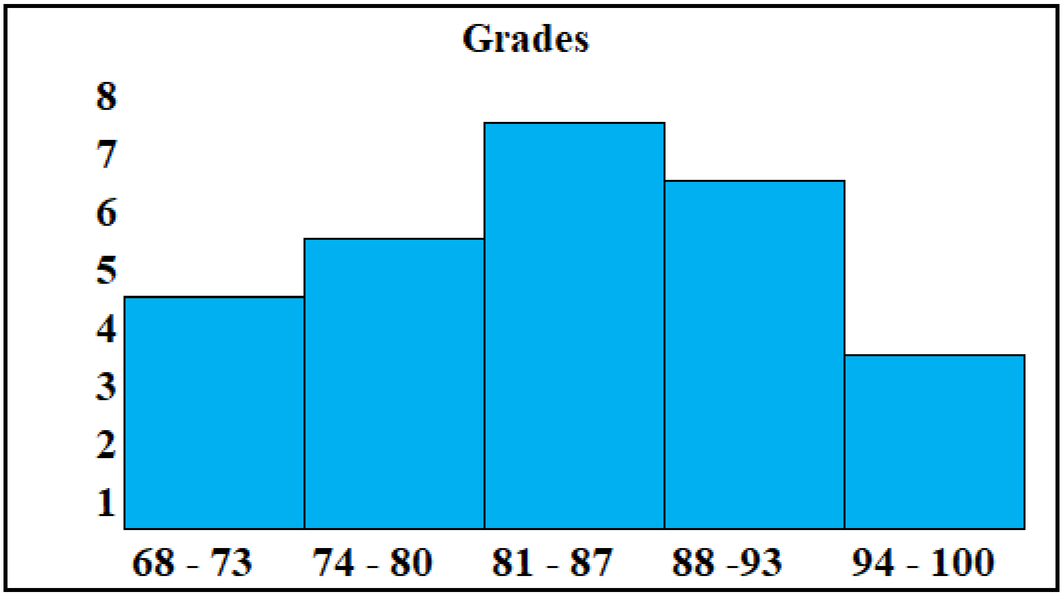

Figure 2: Example of a histogram for the distribution of a class's grades

The cause or causes of a problem must be found when attempting to solve a problem and an affinity diagram is a useful methods to assist in brainstorming to generate a list of potential causes. An affinity diagram is used for organizing a collection of ideas (Brassard 1996) and is created by having each team member write ideas on a piece of paper. This can be an index card, moderator card, or even blanks pieces of paper cut into four quarters. The objective is to generate many ideas. These ideas are then clustered into comparable groups. Figure 3 depicts un-clustered note cards for an affinity diagram.

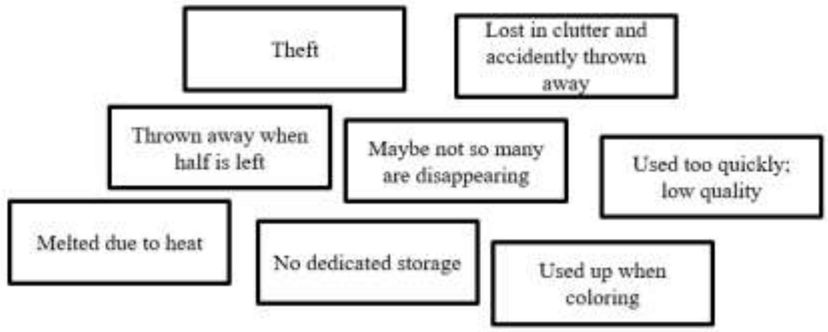

Figure 3: Example of affinity diagram note cards after brainstorming

Typically, one card is selected from the cluster to use as a category heading. Alternatively, a new card could be used to create a title that summarizes the cards in a cluster. Another option is to use category names based on the “6Ms” consisting of milieu (environment), machine (equipment), measurement, method, man (people), and material. The 6Ms are typically used for creating an Ishikawa diagram, but can be useful for an affinity diagram as well. Figure 4 shows note cards clustered based on labels from the 6Ms. Naturally, these labels can be changed and customized as needed.

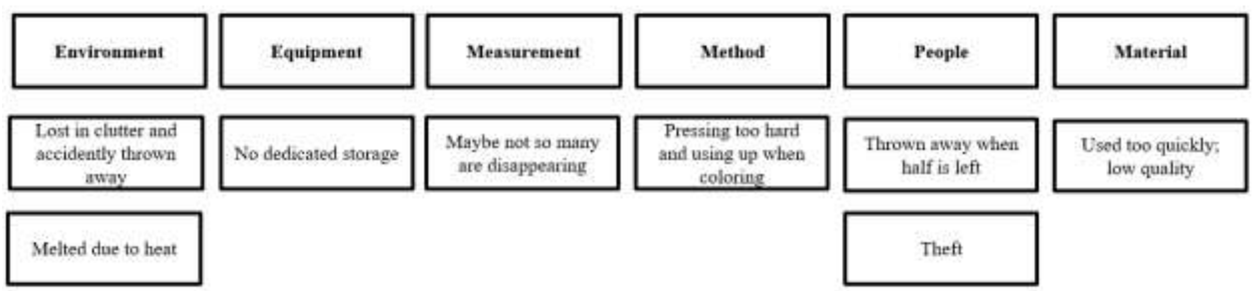

Figure 4: Example of an affinity diagram clustered using the “6Ms”

The ideas generated while creating an affinity diagram should be copied into an Ishikawa diagram, also known as a cause and effect diagram, which is a graphical depiction of potential causes leading to an effect. Another name for an Ishikawa diagram is fishbone diagram due to the shape resembling the bones of a fish (Figure 5). An Ishikawa diagram is useful for organizing potential causes and helping the team to generate new ideas (Hutchins 2019).

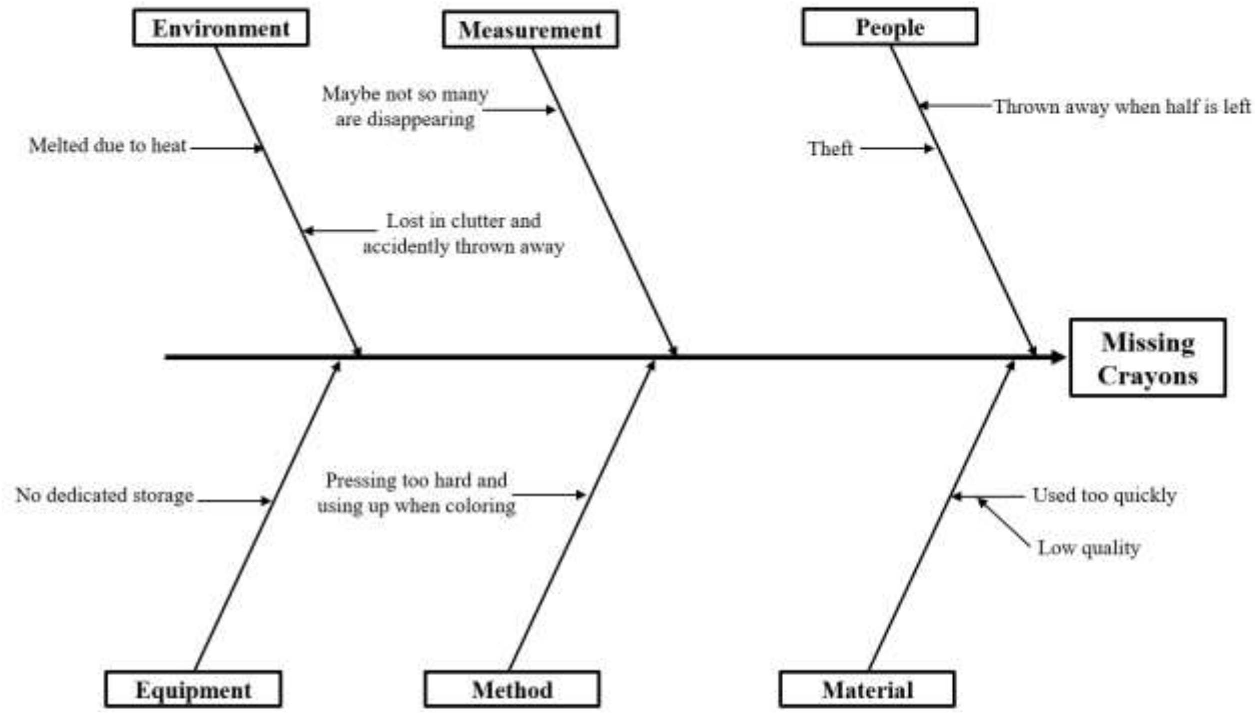

Figure 5: Example of an Ishikawa diagram

A horizontal arrow points towards a box with the name of the problem listed. Angled arrows are referred to as branches and point from the branch label towards the horizontal arrow. If used, labels from the affinity diagram can be copied to the branch labels. The 6Ms are a good starting point for an Ishikawa diagram's branch labels; however, there is no requirement to always use the 6Ms. They may be modified or even replaced with completely different top branch category names. For example, Flushman *Et al.* looked at reasons people transitioning from teacher preparation to their first year of teaching may be unsatisfied with their job, perform less well than they could, and may leave teaching. The authors created an Ishikawa with top branch names consisting of limited mastery, perception versus reality, transition skills, new teaching context, uncoordinated / ineffective support, misaligned teaching philosophies / priorities, and school climate (2020).

Potential causes are listed on the branches. These are the hypotheses that seek to explain the problem. Individual branches may have lower level branches or multiple sub-level branches. Five whys can be helpful when creating an Ishikawa diagram. The question "why" is asked five times for each hypothesis. Five is a good rule of thumb; however, it is possible to go more than five levels deep and there may at times be difficulty in going five levels deep. The objective is to get to the underlying cause of the problem by asking why until the underlying cause is found.

There is a difference between five whys for a product failure and five whys for continuous improvement. For an RCA for a failed manufactured product, the root cause will be often one, or potentially two, causes linked to other causes such as a part that fails due to a dimension that was incorrectly machined caused by a set up error resulting from a lack of documented set up instructions. There may be many contributing causes when performing an RCA as part of problem solving for continuous improvement. For example, suppose the problem was students returning late from lunch. This may be due to a combination of factors such as a short lunch time and long wait for food, students spending more time talking than eating, and some students needing to go much farther than others to get to their classroom. Each why in five whys for product failure must be investigated to determine if it is happening. For continuous improvement, the whys may be more theoretical.

It may be advantageous to create a tracking list to assign hypotheses to team members to investigate. If used, a tracking list should include the hypothesis from the Ishikawa diagram, prioritization, the name of the person responsible, the action to be taken, a due date for results, and a brief summary of the results (See Figure 6).

Hypothesis	Priority	Responsible	Action	Due Date	Results

Figure 6: Tracking list

3. Other Quality Tools

Data should be graphed when possible and a list of potential causes should be created when attempting to solve a problem. A histogram or run chart are ideally suited for most problems where data are available and affinity diagrams and Ishikawa diagrams are well suited for generating and displaying potential causes. However, there are many other quality tools available and these should also be considered, as needed.

For example, a simple checklist can be useful for collecting data to analyze (Westcott 2013). A check sheet is a list of problems with a tally mark used for each occurrence of the problem. The information in a check sheet can be especially useful in determining which problems occur the most and should therefore be addressed first. Figure 7 depicts a check list listing types of trash found in a classroom.

Type of trash	**Quantity**
Soda bottle	I
Water bottle	II
Candy wrapper	~~IIII~~ II
Chewing gum wrapper	II
Candy bar wrapper	III
Chips bag	I

Figure 7: Check list for data collection

A variation on the check sheet uses a graphical depiction of an area or object with a mark identifying the location where failures have occurred (Juran 1999). Here, a sketch is made of an area and the location of problems is marked on the sketch. The location where problems are concentrated can then be identified such as in the example in Figure 8.

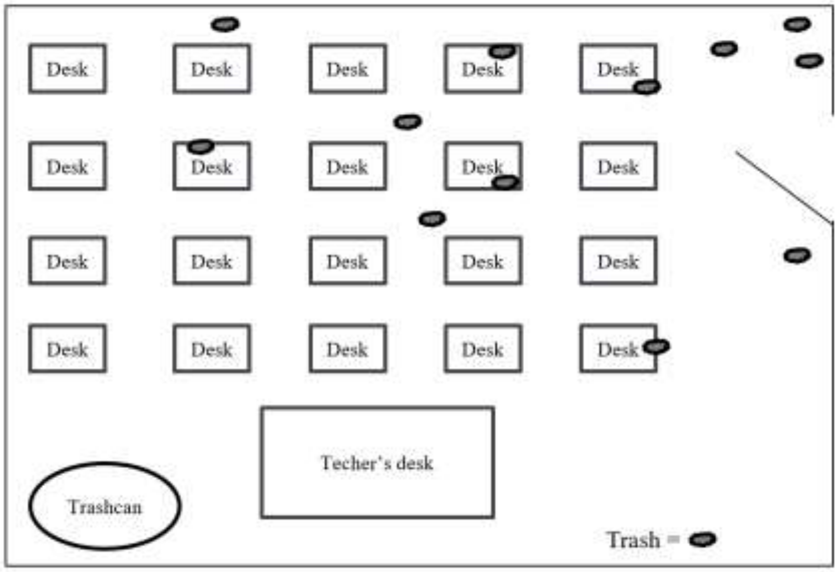

Figure 8: Check sheet for location data

Yet another variation on the check sheet is a check list, which is used to ensure actions are carried out (Ishikawa 1991). For example, a check sheet can be used to ensure certain cleaning activities are performed each day (see Figure 9). Such a check sheet also serves as documentation to show that actions were carried out.

Figure 9: Check list

4. The A3 Report as a Process for using Quality Tools to Solve Problems in Education

Quality tools can be used as standalone tools such as when two people create an Ishikawa diagram to explore and idea further or a small group of people are brainstorming and use an affinity diagram to assist in generating new ideas. However, an approach to quality improvement should be used when addressing complicated problems. This helps to ensure the necessary steps are taken and appropriate tools are considered.

Lean Six Sigma is one possible approach to quality improvement and problem solving. Lean Six Sigma brings quality tools together with statistical methods in a systematic process; however, Lean Six Sigma requires expensive training that typically takes two to four weeks and this may not be practical when rolling out an approach to many educators. Another potential approach is the 8D report, but the 8D report is better suited to investigating quality failures where steps such as containment actions may be necessary.

The A3 report is another approach to continuous improvement and it is well suited for use as an approach to problem solving and continuous improvement for educators. The A3 Report is based on PDCA (Plan Do Check Act) (Lenort *et. Al*. 2017), which uses cycles of studying the current situation and developing solutions, implementing solutions on a trial basis, checking the results to determine if the solution worked, and standardizing the solution if successful (Singh & Singh 2012).

The A3 report originated at Toyota Motor Company and gets its name from the European paper size A3, which is 297 by 420 mm or 11.7 by 16.5 inches, which is close in size to ABSI B paper (Matthews 2011). A3 reports are typically created on A3 sized paper; however, the size can vary, but should be large enough to contain all required information while being small enough to handle. Ledger or tabloid size paper could be used or a sheet of flip paper could be cut in half or even used whole.

An A3 report can also be created electronically. For example, a spreadsheet or presentation program can be used. However, some consideration should be given to printing the A3 report. An A3 report also serves as a communication method and should be displayed where team members and stakeholders can see it.

The content of an A3 report can very between organizations and authors with the names for the steps varying; however, the steps are generally close to the same regardless of what name or label is used. Figure 10 shows one example of an A3 report. This A3 report consists of eight sections:

- Problem name and team
- Current situation
- Target / Goal / Objective
- Root Cause Analysis
- Potential solutions and prioritization
- Implementation plan
- Results

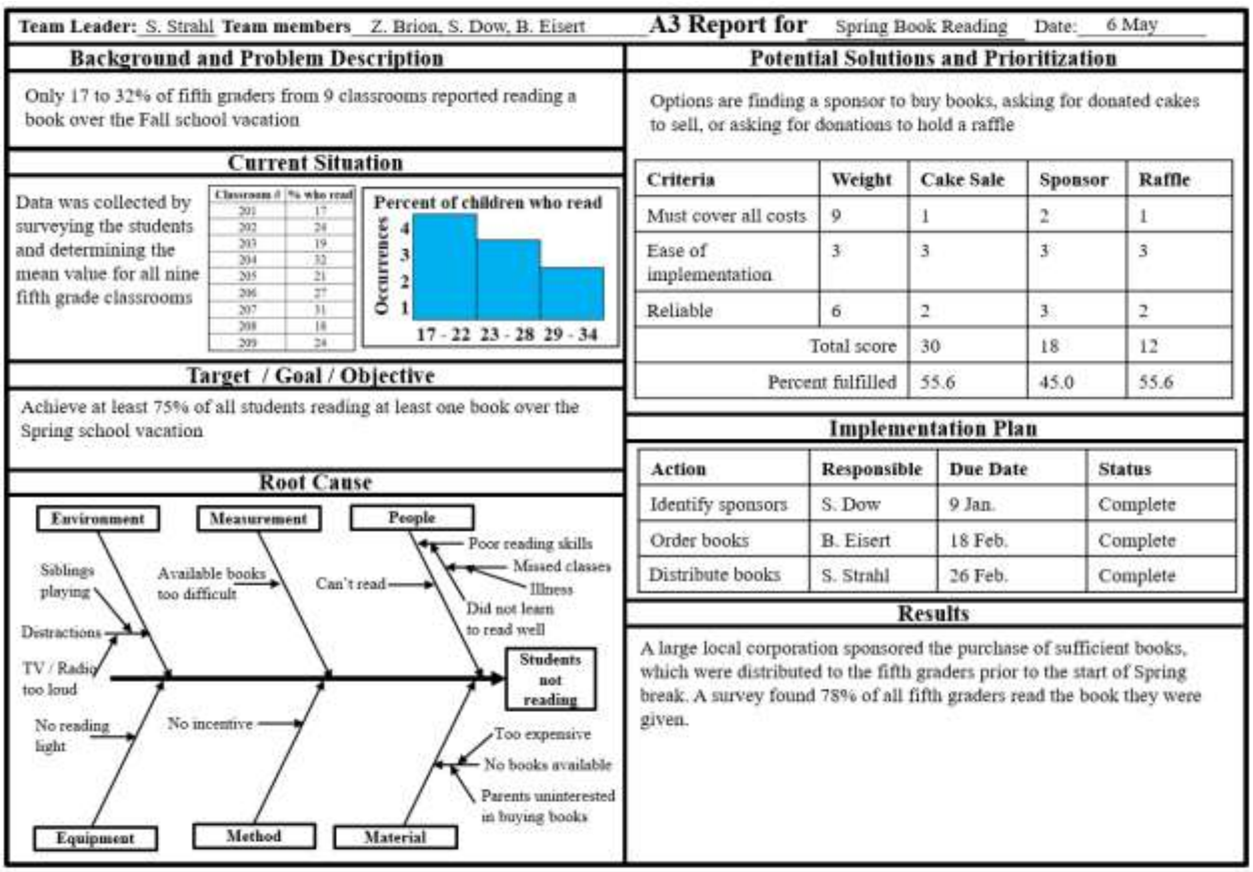

Figure 10: Example of an A3 report

The first step in using an A3 report is to identify a team and a team leader. The team leader should assume responsibility for any necessary coordination within the team and for updating the A3 report. The team itself may be as simple as three individuals who have come together to address a mutual problem.

The problem should also be given a simple name to make it easier to refer to the specific problem that is being addressed. Then the problem should be described and background information should be given. This is critical even if "everybody knows what the problem is" as it is possible that different people will have a different perception of the problem. Capturing the problem statement in a descriptive sentence will help to make the problem being addressed clear to team members and is also useful to communicating the problem outside of the team. The problem description should also be used as the scope of the project; new problems may be discovered, but should be addressed outside of this project to avoid attempting too many things at once. New problems should either be written down to address them later or a new project should be started.

The problem description should include data when available. It should also be updated as new information becomes available. For example, further investigation may show that the first numbers available were incorrect and the problem is better or worse than realized.

An understanding of the problem is needed so data should be collected and the current situation should be explained; ideally, with a graphical depiction of available data. It is possible that many graphs will be created and assessed; not all need to be displayed in the A3 report. A graph that summarizes key findings may be sufficient.

The objective of the improvement activities should be clearly explained; ideally, with a measurable target or goal. This makes the desired end state clear to all and provides a means for knowing when it has been achieved. Next is the root cause analysis (RCA), which is the step where the Ishikawa diagram is created and then inserted into the A3 report. The cause, or causes of the problem are identified during this step of the A3 report.

Once causes are identified, potential solutions must be identified and prioritized if they can't all be implemented such as when there are insufficient resources available to implement all of them. A prioritization matrix is a useful tool to use here. The options and prioritization matrix can be displayed in the A3 report.

An implementation plan should be crafted for the selected improvement action or actions. This should include the action, the name of the person responsible, a due date, and the status of the action. The final step on an A3 report is the documentation of the results. Here, the implemented action or actions should be described as well a show that the improvement was verified to be effective.

5. Conclusion

Quality professionals do not hold a monopoly on quality tools; many are simple, yet powerful tools which can be used by educators who have no involvement with the field of quality. Quality tools used together with A3 reports results in a powerful tool kit together with an easy to use method for solving problems.

References

Amos, Allan, Suzanne Keely. 2003. "Quality's Positive Outcome in Education." *World Conference on Quality and Improvement*. 57: 107-109

Borror, Connie, M. (ed.) *The Certified Quality Engineer Handbook*. (3rd ed.) Milwaukee, WI: ASQ, Quality Press, 2009.

Brassard, Michael. 1996. *The Memory Jogger Plus: Featuring the Seven Management and Planning Tools*. Salem, NH: GOAL/QPC.

Cleary, Barbara A. 2015. "Educator's World: Using Tools to Support Design Thinking in the Classroom." *Journal for Quality and Participation* (Online Only Content). 38. No. 2: 1-3.

Flushman, Tanya, Sarah E. Hegg, Megan Guise, and Laura Flessner. 2020. *Journal for Quality Perspectives in Knowledge Acquisition*. 10.. No. 1: 18-28.

Hutchins, David. 2019. *Quality Beyond Borders: Dantotsu or How to Achieve Best in Business*. London: Routledge.

Ishikawa, Kaoru. 1991. *Guide to Quality Control* (2nd ed.). Translated by Asian Productivity Organization. Tokyo, Japan: Asian Productivity Organization.

Jacobson, Janet. 2009. "PDSA: A Road Map to Improved Writing Skills." Retrieved from http://asq.org/2009/09/continuous-improvement/pdsa-road-map-writing-skills.pdf

Juran, Joseph. 2005. “The QC Circle Phenomena” in *Juran, Quality, and a century of Improvement: The Best on Quality Book Series of the International Academy for Quality*. Vol. 15. (Kenneth S. Stephens. ed.) Milwaukee, WI: Quality Press.

Juran, J.M. 1999. “The Quality Improvement Process” in *Juran's Quality Control Handbook* (4th ed.). Juran, J.M., A Blanton Godfrey, Robert E. Hoogstoel, and Edward G. Schilling (ed.). New York: McGraw-Hill.

Lenort, Radim, David Staš, David Holman, and Pavel Wicher. 2017. “A3 Method as a Powerful Tool for Searching and Implementing Green Innovations in an Industrial Company Transport.” *Procedia Engineering*. 192: 533–38.

Matthews, Daniel D. 2011. *The A3 Workbook: Unlock Your Problem-Solving Mind*. Boca Raton, FL. CRC Press.

Singh, Jagdeep, and Harwinder Singh. 2012. “Continuous Improvement Approach: State-of-Art Review and Future Implications.” *International Journal of Lean Six Sigma*. 3 no. 2: 88–111.

Tague, Nancy R. 2005. *The Quality Toolbox* (2nd ed.). Milwaukee, WI: The ASQ Quality Press.

Walser, F. LeRoy. 1996. “Quality K-6 Education: Koalaty Style.” *Quality Engineering*. 8. No. 3: 475-479.

Westcott, Russell T. (ed.). 2013. *The Certified Manager of Quality/Organizational Excellence Handbook*. (4th ed.). Milwaukee, WI: ASQ Quality Press.