Journal of Education and Practice
ISSN 2222-1735 (Paper) ISSN 2222-288X (Online)
Vol.5, No.25, 2014

Introducing Effective Problem Solving Culture in Higher Education Institutions in Nigeria: Methods and Tools

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Abstract
This paper introduces the concept of effective unconventional problem solving culture that is uncommon to the culture practiced in the educational institutions. The Six Thinking Hats, Devil's Advocacy and Root Cause Analysis methods and the Fishbone (Cause and Effect) and Pareto Analytical tools other than the conventional research methods and tools used were identified and introduced. The concept of brainstorming in teams as problem solving data collection mechanism was also elaborately discussed and introduced. Hypothetical instances were cited as demonstration of the methods and tools application in problem. This paper attempts to recommend these methods and tools and many more in wide application in the industries to the higher educational communities in Nigeria where most of the methods and tools were originated. This is expedient following the fact that the education at all levels generally and specifically at higher education levels is fast assuming commercial status where accountability, competitiveness, value for money, all outputs and outcomes factors of modern day are drivers of business.
Keywords: Problem, Problem-solving, attitude, methods and tools

Introduction

Hubbard (1915) ones said: when life gives you lemons, make lemonade! The two halves of this statement can be figuratively referred to as problem signifying the sour lemon taste, and the sweet success reflecting the ingenuity of a problem solver respectively. Individually or collectively, varying nature and degree of problem(s) assail us, some minor and some very serious which can be solved in a way that is satisfactory to everyone involved or sometimes unsatisfactory, but the fact remains that, the solution situation would better than the problem situation. In the same way our attitudes to solving problem vary from one problem solver to the other. The Family, Career and Community Leaders of America, FCCLA outlined some of such attitudes as follows: "ignore the problem, get someone else to solve the problem by acting helpless, procrastinate in making decision, blame others for the problem, get angry and do foolish things without really thinking about the consequences, make a joke of the situation or let someone else decide by giving into group pressure, etc... However, a completely different attitude could be: thinking about the problem, consider information and choices, talk to others involved, and solve the problem, adding also that problems don't go away on their own but by taking a positive approach and come to the rescue to solve problems"

The recent transition to the information age has focused attention on the processes of problem solving, management, decision-making and continuous improvement (Boland and Collopy, 2004; Stice, 1987; Nickerson, Perkins and Smith, 1985; Whimbey and Lochhead, 1982). In fact, Gagne (1984) considers the strategies used in these processes to be a primary outcome of modern education. Although there is increasing agreement regarding the prescriptive steps to be used in problem solving, there are fewer commonalities on specific techniques to be employed at each step in the problem-solving and decision-making processes for continuous improvement.

All problems are not equally important and their relative significance should be kept in perspective. Many employers have long regarded problem solving, critical thinking and the ability to work on teams as critical workforce competencies (Secretary's Commission on Achieving Necessary Skills, SCANS, 1991). Despite the importance of problem solving, many educational analysts and industry representatives report that students leave higher education with an underdeveloped ability to solve open-ended problems (Commission on Accountability in Higher Education, CAHE, 2005). In part, this arises because instructors of undergraduate courses prefer students to construct knowledge through single-answer analytical problem solving before they address more complicated open-ended problems that require higher levels of knowledge. Where analytical problem-solving tends to invoke cognitive skills primarily, open-ended problem-solving involves significant social and affective dimensions.

Good problem solving skills empower students in their educational, professional, and personal lives. Nationally and internationally, there is growing recognition that if education is to produce skilled thinkers and innovators in a fast-changing global economy, then problem solving skills are more important than ever. The ability to solve

problems in a range of learning contexts is essential for the development of knowledge, understanding and performance. Requiring students to engage with complex, authentic problem solving encourages them to use content knowledge in innovative and creative ways and promotes deep understanding (Crebert, Patrick, Cragnolini, Smith, Worsfold and Webb, 2011).

Problem solving as a culture is a common place in the industries in the process of profiteering, customer satisfaction, safety, security, etc. In the schools, there is often a misconception between problem and exercise. In the real world, exercise and problem differ in many diverse ways. The former usually have predetermined solutions, with "a well-defined route to the solution and students must simply follow the formula". Whereas, the latter, is often fuzzy, open-ended, unstructured and 'one-offs,' with no predictable outcomes (Woods, 1985).

Mourtos, DeJong and Rhee (2004) were of the opinion that "while the exercises make an important first step in helping students bridge the gap between theory and application, they do not provide the depth and complexity necessary to master problem-solving skills... Students who train mostly in exercise solving tends to develop serious handicap. They rely heavily on solutions they have seen before, rather than working from first principles. Thus a problem with brand new context presents a formidable challenge to them." Therefore, problem solving involves error and uncertainty and even if your students are eventually successful, it is likely they will feel uncomfortable, as they come to terms with the problem solving processes they will encounter in the workplace (Ryan, 1996). Whatever forms the problem takes and whatever approach is used to help students develop their problem solving skills, it is important to recognize and make students aware of the differences between solving exercises and solving problems as shown in table 1 below.

Table 1: Difference between Exercise solving and Problem solving

Exercise solving	Problem solving
A process used to obtain the one and only right answer for the data given.	A process used to obtain a best answer to an unknown, subject to some constraints.
The situation is well defined. There is an explicit problem statement with all the necessary information (known and unknown).	The situation is ill-defined. There may be some ambiguity in the information provided. Students must define the problem themselves. Assumptions may need to be made about what is known and what needs to be found.
The student has encountered similar exercises in books, in class or in homework.	The context of the problem is brand new (i.e. the student has not encountered this situation before).
Exercises often prescribe assumptions to be made, principles to be used and sometimes they even give hints.	There is no explicit statement in the problem that tells the student what knowledge/technique/skill to use in order to solve the problem.
There is usually one approach that gives the right answer.	There may be more than one valid approach.
The usual method is to recall familiar solutions from previously solved exercises.	The algorithm for solving the problem is unclear.
Exercises involve one subject and in many cases only one topic from this subject	Integration of knowledge from a variety of subjects may be necessary to address all aspects of the problem.
Communication skills are not essential.	Requires oral and/or written communication skills to convey the essence of the problem and present the results.

Mourtos, DeJong Okamoto & Rhee (2004)

Definition of Problem and Problem Solving

The following are some scholarly views on the definition of a problem. Duncker (1945) defined a problem as situation when a living creature has a goal but does not know how this goal is to be reached, when one cannot go from the given to the desired situation simply by action. Newell and Simon (1972) defined problem as some blockage in a gap that prevents a person from immediately seeing a course of action and if there is no blockage, then the situation is an exercise, not a problem. Alıcıgüzel (1979) defined problem as the difficulties faced by individuals and communities that need to be resolved in order to achieve success. Ritz, Deal, Hadley, Jacobs, Kildruff and Skena (1986a) defined a problem as a need, which must be met. Türer (1992) was of the opinion that if there is no any purpose then there is no problem, in other words, the desire to fulfill a need to achieve a purpose and the difficulties objecting these are the main conditions of a problem. For Erden and Akman (1998), problem is a new trouble faced by the individual that the individual does not know how to surmount. Woods (2000) viewed problem to be challenges we focus on to solve where there is no immediately apparent procedure,

idea, or routine to follow. From the foregoing, problem has been defined to mean so many different issues to so many different individuals and organizations.

However, the fact remains that problem is still a problem as long as there exists, a reason or a need for improvement. That is the gap between the current situation and a desired situation. Attempt(s) at bringing about the desired is referred to as problem-solving. To different scholars, problem-solving like problem is viewed differently. According to Stones (1994), problem solving includes integration of concepts and skills to get over the unusual complete situations. Krulik and Rudnick (1996) viewed problem solving as one of the primary skills that students must take with them when they leave the classrooms and enter the real world. In the views of Candelaria and Limjap (2002), the development of critical thinking skills essential for problem solving does not necessarily require direct instruction. Students may acquire the skill as they interact with their environment in the school and at home, thus honing their creative skills as well. In a later publication, Mayer and Wittrock (2006) define problem solving as cognitive processing directed at achieving a goal when no solution method is obvious to the problem solver.

Problem Solving Methods

Many problem-solving methods have developed and published in different literatures (Jensen, Kurtz, Spencer and Reum, 1992; Krulik and Rudnick, 1996; Myrvaagnes, Brooks, Carroll, Smith and Wolf, 1999; Woods, 2000). Some of these include Plan-Do-Check-Act, PDCA technique (Robbins and Langton, 2003); Problem-Objectives-Alternatives-Tradeoffs, PROACT technique (Hammond, Keeney and Raiffa, 1999); Define-Measure-Analyze-Improve-Control, DMAIC technique (Chieh, 2010); The Collaboration technique (Gorski, 2006); etc. Three fun-based, contemporary, innovative and creative problem solving methods discussed in this article are: The Six thinking Hats Method (de Bono, 1986), Devil's Advocacy Method (Hartwig, 2010) and Root Cause Analysis (Gano, 2007).

Six Thinking Hats Method (de Bono, 1986)

Edward de Bono six thinking hats method has a completely different approach to problem solving; it is originally referred to as a game. Six Hats of different colours with each hat representing a perspective, or way of thinking. In this method, the problem solver is expected to put on the different hats in a sequence to encourage them to adopt different perspectives. The aim of this strategy is to get the problem solver broaden their horizons. This is a very powerful method with wide applicability.

Table 1: Edward de Bono's Six Thinking Hats

Hat	Explanation	Characteristic statements
White	White is neutral. While wearing the white hat, ignore arguments and proposals. Instead, examine the facts, figures and information. Identify what information is needed and how it might be acquired.	What information do we have here? What information is missing? What information would we like to have? How are we going to get the information
Red	Red is for feelings, hunches and intuition. It permits people to put forward their feelings without apology or justification. Intuition may be a composite judgment based on years of experience, and it can be valuable, even if the reasons behind it cannot be spelled out.	My gut feeling is that it won't work. I don't like the way this is being done. My intuition tells me that this process won't be sustainable.
Black	The black hat is for pessimism and logical negativity. It is the hat of caution and critical judgments. It is the most used hat, and perhaps the most valuable hat. However, it is very easy to overuse the black hat and stifle creative ideas with early negativity.	The policies will prevent us from doing that. We do not have the resources to do this project. The team doesn't have the necessary project management experience.
Yellow	The yellow hat is for optimism and the logical positive view of things. It looks for feasibility and how something can be done. It looks for benefits, but they must be logically based.	That might work if we rearranged the timeline. It's possible the team could take this further in a second project. We have the resources to make this work.
Green	The green hat is for creative thinking, new ideas and additional alternatives. This is where lateral thinking and other creative techniques are engaged.	We need some new ideas here. Are there any other alternatives? Could we do this in a different way? Could there be another explanation?
Blue	The blue hat is the thinking overview, or process control hat. It is generally used by the chairperson of the meeting, as it sets the agenda for thinking, suggests the next step, and asks for summaries, conclusions and decisions.	We have spent far too much time looking for someone to blame. Could we have a summary of your views? I think we should take a look at the priorities.

Devil's Advocate Method

This method allows for constructive criticism without providing alternatives. Method was known to be first used in recorded history by the Catholic papacy in the process of canonization of saints in the 1600s (Herbert and Estes, 1977). United States of America Presidents Kennedy during the Cuban nuclear threat and Johnson during Vietnam War employed this method of problem solving during difficult times in office when strategic decision making was necessary (Schwenk, 1984). Devil's advocacy has received substantial attention, primarily from scholars studying management, organizational behavior, and business communication (Valacich and Schwenk, 1995a; Schwenk and Valacich, 1994; Schwenk and Cosier, 1993; Murrell, Stewart and Engel, 1993; Schweiger, Sandberg and Rechner, 1989; Schwenk, 1988; Schweiger, Sandberg and Ragan, 1986; Chanin and Shapiro, 1984).

Hartwig (2010) published a model of devil's advocacy method he used in Motivating Academic Schools to Set and Publish Accurate Course Rotations in a Timely Fashion Utilizing a Facilitation Technique: The Devil's Advocate Approach: a problem solving session he facilitated in 2006. The model is presented as follows:

Table 2: Hartwig's Devil's Advocacy Model

Whole group split into 2		
Sub-group 1 makes recommendation	⇩	Sub-group 2 critiques recommendations
Talks and develops recommendations	Round 1	Talks and develops critiques
Presents recommendations		Critiques Recommendations
Taking round 1 critiques into account, talks and develops recommendation	Round 2	Taking round 1 recommendations into account, talks and develops critiques
Presents recommendation		Critiques recommendation
Subsequent rounds develop and present recommendations until both groups agree	Round n+1	Subsequent round develop and critique recommendations until both groups agree
Evaluation of agreed and critiqued recommendations		

Root Cause Analysis, RCA

According to Gano (2007), RCA is a problem solving method attributable to the Apollo Space Exploration regime, where it was used in risk assessment studies. RCA is reactive in its mode of application because it is used only when the problem had already occurred. However, Gunning (2011) has the view that, a sound culture of RCA in an organization could make RCA a proactive problem solving method as RCA could be used to forecast a problem before it even occurs in order to proffer preventive and corrective measure to mitigate repeated occurrence.

Different types of RCA techniques are known and in use today, some of these include failure modes and effect analysis, FMEA (Haq and Lipol, 2011), 5-Whys (Senge, 1999), others include Management Oversight and Risk Tree (MORT) Analysis, Human Performance Evaluation, Kepner-Tregoe Problem Solving and Decision Making, events and causal factors analysis, fault tree analysis, storytelling, Change Analysis, Barrier Analysis (USA, 1992; Gano, 2007). Steps to conducting effective RCA include the following:

- Define the problem.
- Data collection.
- Identify the root cause of the defined problem through effective brainstorming, why-why analysis, Pareto analysis, etc.
- Identify corrective action(s) that will prevent recurrence of the problem.
- Implement the corrective action(s).
- Observe the corrective actions to ensure effectiveness else go back to collect fresh data.
- Identify preventive action(s) that prevent occurrence.
- Evaluate the RCA, if necessary.

Similarities in the Various Problem Solving Methods

All problem solving methods discussed in this paper and others not discussed have overtly or covertly the following steps as presented in table 3 below.

Table 3: Stages in the Problem Solving Process

SN	Steps	Description
1	Identify the problem	Either present a defined problem or ask students to identify their own.
2	Define the problem	Ask students to represent the problem in their own words, defining the key words, terms and concepts. Students should ask themselves questions such as: • What do I know already about this problem or question? • What do I need to know to effectively address this problem? • What resources can I access to determine a proposed? In this stage, a very focused problem statement is needed, though that statement will go through a series of changes as new information is accessed and processed.
3	Collect, evaluate and organize information about the problem	Determine what information will be relevant, useful and absolutely essential for solving the problem; retrieve information from print, web and other sources; classify and categorize relevant information.
4	Create/select a strategy to resolve the problem	Ask students to collect examples of similar problems and the strategies used to solve them.
5	Allocate resources to solve the problem	Encourage students to develop timelines, action plans, progress reports and role allocations to ensure the problem is satisfactorily resolved.
6	Monitor the problem solving process	Ask students to submit regular progress reports or updates to ensure deadlines are met; require submission of reflective documents on process issues as part of their assessment.
7	Evaluate the final solution	Ask students to evaluate their final solution to the problem from multiple perspectives (e.g., an accountant; a manager; a researcher; an end-user; an advertising agent) to test its validity in a range of contexts.

Methods of Data Collection: Brainstorming:

Brainstorming is a common strategy applicable to all problem solving tools. It is one sure channel of idea generation. It is a common knowledge that if want the best ideas generate lots of ideas out of the probability of extracting the best. To run a group brainstorming session effectively, two approaches are applicable, structured approach where every group member has equal opportunity in an orderly manner and the unstructured approach where every group member shouts out his ideas at random. Either way the following guidelines apply:

- Team formation. Optimum team membership is between 4-10.
- Find a comfortable meeting environment, and set it up ready for the session.
- Appointment of an ideas recorder on a flipchart, white or blackboard.
- Recording of all ideas generated and clearly.
- Homogenization of members' mindset by the use of an effective warm-up exercise or **ice-breaker.**
- Define and clearly state the problem to be solved and lay out any criteria to be met. Make it clear that that the objective of the meeting is to generate as many ideas as possible.
- Give people plenty of time on their own at the start of the session to generate as many ideas as possible.
- Ask people to give their ideas, making sure that you give everyone a fair opportunity to contribute.
- Encourage people to develop other people's ideas, or to use other ideas to create new ones.
- Encourage an enthusiastic, uncritical attitude among members of the group. Try to get everyone to contribute and develop ideas, including the quietest members of the group.
- No criticism or evaluation ideas during the session. Criticism introduces an element of risk for group members when putting forward an idea. This stifles creativity and cripples the free running nature of a good brainstorming session.

- Let people have fun brainstorming. Encourage them to come up with as many ideas as possible, from solidly practical ones to wildly impractical ones. Welcome creativity!
- Ensure that no train of thought is followed for too long. Make sure that you generate a sufficient number of different ideas, as well as exploring individual ideas in detail.
- In a long session, take plenty of breaks so that people can continue to concentrate.

The center of the problem-solving cycle is the point at which students generate ideas for possible solutions. Managed well, this step can lead to creative and innovative solutions. It can be the most vividly remembered part of the process. Successful brainstorming depends on an environment that ensures a free flow of ideas.

Tools of Data Collection

The problem solving methods discussed above like numerous other one operate on the availability of valid and reliable data which can be collected with a combination of different well developed methods and tools for data collection and analyses. Two of such methods and tools are discussed; these are Fishbone analysis and Pareto analysis.

Fishbone Analysis (Cause and Effect) Method

This is a group problem solving method used in identifying causes of a problem. It is most effective when applied in a team setting. The product of this problem solving method is also called the ishikawa or cause and effect diagram that highlights all possible causes, major and minor alike of a particular problem of interest. It a presentation format of intense brainstorming exercises. Some tips:

1. Make a straight horizontal line arrow on a flipchart preferably A1 on landscape orientation. Place a box in the direction of the box and insert the problem statement in the box.
2. Decide on the categories of major problem on both sides, up and down of the arrow. Decision on the categories of causes can be made through, brainstorming or the 6Ms (management, man, method, measurement, machinery, material). The number of categories is not limited in anyway but it should be more than three but not too many to make the diagram readable.
3. Brainstorm for minor and sub-minor causes and insert them on the branches and if necessary on the main arrow. The final diagram should portray a sketch of fish-bone. Details about brainstorming are given below under problem solving tools.
4. Identification of the minor and sub-minor causes can be done randomly from where the major causes or bone can be derived or systematically where the major bones are already decided upon.

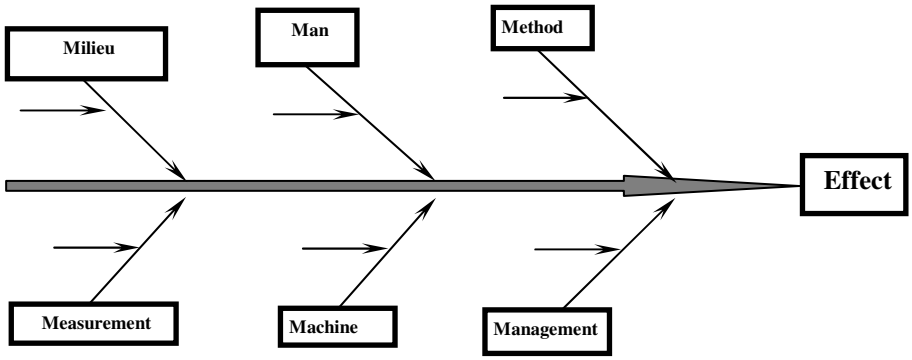

Fig. 1: A typical Cause and Effect (Fish-bone) Diagram

A variation of the method is the **Solution Effect Analysis Method** which in a reverse fashion in whereby the effect of the solution is what is evaluated first before any kind of commitment is made to the solution.

Pareto Analysis, PA

The Pareto analysis as a problem solving or decision making tool can be credited to Wilfredo Pareto, a 19th century Italian economist who conducted a study in Europe in the early 1900s on wealth and poverty (Juran, 1988; Haughey, 2000; Russel and Taylor III, 2003). He found that wealth was concentrated in the hands of the few and poverty in the hands of the many. The principle is based on the unequal distribution of things in the universe. It is the law of the significant few (20%) versus the trivial many (80%). The Pareto Principle is a rule-of-thumb, which states that, 20% of the problems have 80% of the impact. However, as quality management tool, the Pareto diagram was introduced as an instrument for the classification of the problems of quality. The Pareto diagram: Solves efficiently a problem by identification and hierarchization, according to their importance

of the main causes of the faults; Sets the priorities for many practical applications. Some examples are: process improvement efforts for increased unit readiness, customer needs, suppliers, investment opportunities; Shows where to focus efforts and Allows better use of limited resources. Pareto diagram can be constructed using the following steps:

1. Make a table of content for a typical bar chart. List the variables on the first column and the frequency of occurrence of variable against each of the variables in descending order of magnitude. Expand the table by making a cumulative frequency column in percentage.
2. Draw a bar chart with the cumulative frequencies (y-axis) against the variables (x-axis).
3. Draw in the cumulative frequency curve by adding the values of each successive variable together.
4. Add a scale of 0% to 100% on a secondary y-axis on the right hand side running from the x-axis to the top of the cumulative frequency curve.
5. Where the 80% level intersects the cumulative frequency curve, read down to the x-axis to identify the vital few variable.

The major advantage of Pareto Diagram is the fact that is easier to see on such a diagram the most important faults, and the main disadvantage is the hierarchical system of the faults, of non-conformities that frequently depend on the person that makes the diagram. Table 2 below represents hypothetical Pareto table of values after a brainstorming session or from a data collection instrument collation exercise.

Table 4: A sample format for Pareto diagram table of values

Variables	Freq.	Rel. Freq. (%)	Cum. Freq.	Cum. Rel. Freq. (%)
Seating Difficulty	42	27	42	27
Teacher-based learning	28	18	70	45
Congested classroom	21	14	91	59
Attendance regulation	19	12	120	71
Too difficult task	12	8	132	79
Teacher leadership	11	7	143	86
Teacher punctuality	6	4	149	90
Mastery of subject	5	3	154	93
Peer influence	4	3	158	96
Student-based learning	3	2	161	98
Attitude to attendance	3	2	164	100
Too easy task	1	1	165	101

The diagram is a typical bar chart. The diagram is plotted with cumulative frequency or the cumulative relative frequency against the variables. Below is typical Pareto diagram from the hypothetical values drawn from seeming problems of students' poor attendance to class.

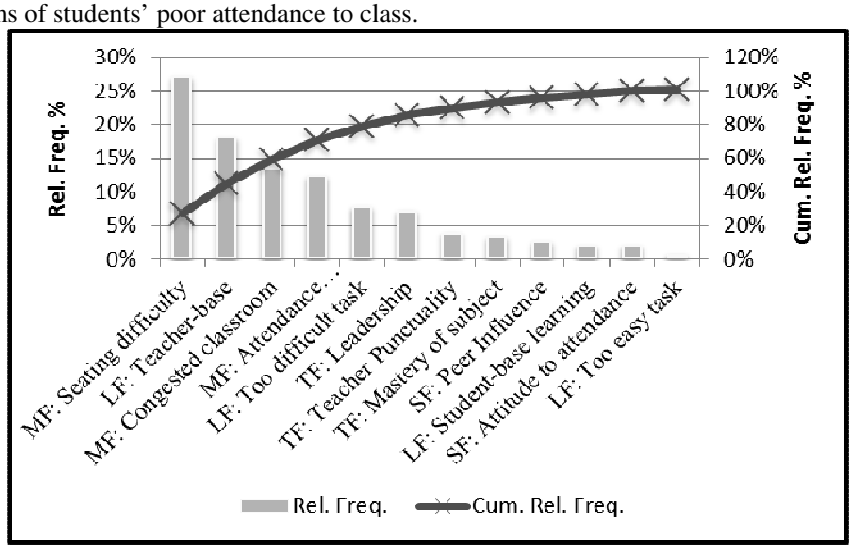

Fig. 2: Pareto Diagram for Problems of Students' Attendance to Class

Conclusion

From the foregoing, open or unstructured problems are the realities of our lives, when they present themselves, our abilities to surmount them is what make or mar us. However, the knowledge of numerous methods and tools now in scripts and practice has made life a lot more interesting with all the problems. The need to deliberately study or learn problem solving skills is imperative and so require application in schools, government, organizations, and even in the family.

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