ANALYSIS OF PROBLEM SOLVING MODELS IN ENGINEERING EDUCATION

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Abstract
Engineering education emphases deeply on problem-solving, nevertheless several instructors impart content besides formerly assume learners to always solve problems deprived of being exposed the method involved. Our situation is that a strong analysis of problem-solving plans and problem-solving proposals must remain involved in each engineering gathering, Problem-solving is careful to be a vital movement of an engineering exercise, the writers analyzed some of the problem-solving models rummage-sale by engineering learners to solve problems that need continuously remained a portion of engineering teaching. Numerous of the new current problem-solving models described in the engineering education training are analysis, divided and related in this paper. This of Analysis indicated that Wankat & Oreovicz, the problem-solving model is overall sufficient to put up most of the essentials (but, not essentially completely) of the other models. As soon as correctly applied, this model likewise donates to the growth of the supplementary thinking skills, motivation skills, innovation and problem-solving skills required of engineering educationalists.

Keywords: *Problem-solving Models, Problem-Solving, Engineering education.*

1.0 INTRODUCTION

Problem-solving as a procedure might be embodied in numerous methods, wherever research itself is basically a typical problem-solving model (Wang & Chiew, 2010). Problem-solving interrelates through several other cognitive procedures such as concept, searching, knowledge, decision making, implication, analysis, and synthesis on the foundation of core knowledge representation. Problem-solving is a "cognitive-affective– behavioral procedure over which an individual or group efforts to categorize, determine, or formulate effective means of handling with problems come across in normal living (Schacter, Gilbert, & Wegner, 2009). Problem-solving is mostly observed as the most vital cognitive movement in the daily and specialized setting; greatest societies are essential to and satisfied for solving the problem. Nevertheless, knowledge to resolve the problem is too rarely required in proper learning situations in part since our thoughtful of its procedure is partial (Jonassen, 2000).

Problem-solving models are "information level" useful or theoretical structures that define the cognitive method of specialists as soon as solving problems in their domain. These models need newly drawn considerable care as an applied instrument for conducting strong and well-organized knowledge founded schemes progress. This approach is particularly helpful for very large applications where there is a lot of knowledge to be gathered, as well as for modeling difficult problem-solving tasks such as design or diagnosis (Ramparany, 1992). In academic settings, students often encounter problem solving as little more than a systematic application of scientific and technological knowledge to well-constrained problems but are expected to graduate with the

ability to solve complex open-ended problems that require consideration of a broad range of problem constraints including "economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability (Singer & Smith, 2013).

Most educators agree that problem solving is among the most meaningful and important kinds of learning and thinking. However, the most taxonomies of learning and instructional design models do not even acknowledge it as a learning outcome. After abandoning problem-solving by name in his earlier taxonomy later regarded problem-solving as the synthesis of other rules and concepts into higher-order rules, which can be applied in a constrained set of situations. Problem-solving would require a combination of analysis and synthesis skills, though it is not specifically identified (Jonassen, 1997).

Among various learning strategies, problem-solving has been recognized as an effective strategy for helping students make reflections and experience in-depth thinking (Hwang, Hung, & Chen, 2014). Some authors identify critical and creative thinking as core skills that are applied to problem-solving (Bransford & Stein, 1993). Define problem-solving as the primary skill with critical and creative thinking as components (Frenseh & Funke, 2014). Problem-solving skills exist without subject context. Be all of that as it may, to be considered effective problem solvers engineering educators should be able to draw upon a wide range of analytical, synthetic, and evaluative thinking tools, problem-solving heuristics, and decision-making approaches (Bardach & Patashnik, 2015).

When given a problem to solve, they should be equipped to identify the goal and put it in context; formulate a systematic plan of attack that incorporates a suitable blend of analysis, synthesis, evaluation, and problem solving heuristics; locate sources of information; identify main ideas, underlying assumptions, and logical fallacies, and evaluate the credibility of the identified sources; create numerous options and classify and prioritize them; make appropriate observations and draw sound inferences from them; formulate and implement appropriate measurable criteria for making judgments; develop cogent arguments in support of the validity or plausibility of a hypothesis or thesis; generate new questions or experiments to resolve uncertainties; and monitor their solution process continuously and revise it if necessary (Kim & Hannafin, 2011).

2.0 Analysis of problem-solving models

Engineering education is a grand challenge that will have an impact on all of the other engineering grand challenges. Competencies of the future global engineer should be as follows: (1) technically adept, broadly knowledgeable, a lifelong learner, and culturally aware; (2) exhibits an entrepreneurial spirit, innovative, and understand world markets; (3) knows how to translate technological innovation into commercially-viable products and services; and (4) is professionally nimble, flexible, and mobile (Froyd, Wankat, & Smith, 2012). Henceforth, uncertainty we stand to solve the problem, our determination wants to improve employing, maintenance, and student perseverance to graduation.

Engineering education and engineering profession presently face dual problems: (1) we do not have adequate learners joining in and graduating from engineering programs, and (B) graduates are not sufficiently ready to train present engineering. In many countries engineering institution admissions initiated to fall in 2001 based on statistical analysis, United states engineering colleges are among the countries that admission was drop in 2001 and require revealed not at all sign of

rotating about. Alike tendencies are obvious in further nations through the world (Anderson & Taraban, 2013). Problem-solving is an act takes a wide range of mental procedures and skills when reached the correct conclusion. An individual with progressive problem-solving abilities can successfully use knowledge and can easily solve the problems encountered (Özsoy-Güneş, Güneş, Derelioğlu, & Kırbaşlar, 2015).

Numerals of engineering and science instructors have expressed "problem-solving" models founded upon collective experience and research-based on student surveys and interviews. The most general of these models discourses the issues raised above by encouraging in-depth reflective thinking to obtain both technical and theoretical knowledge. Even though there are modifications among the models, selected cover essentials that others do not have, there are also several connections. A careful contrast of these models might formerly yield a general model that contains the elements needed to address the issues currently faced by engineering education (Diefes-Dux & Salim, 2012).

2.1 The Wankat & Oreovicz, problem-solving model (Motivation).

Meanwhile, the concern can be the main disadvantage to problem-solving; it is beneficial to effort the learner's self-confidence. The wankat & Oreovicz might need to evade being understated when first working on this step. It is also valuable to impart learners a few humble reduction exercises, commitment is definitely encouraged by self-reliance which is also the determination of the I Can step (Wankat & Oreovicz, 2015). The define step is frequently assumed slight care by learners. Learners want to list the unknowns and known, draw a figure, and perhaps draw an abstract figure which displays the essential associations (recall that greatest individuals choose visual education). The statistics remain critical meanwhile an improper number nearly assurances an inappropriate solution. The constraints and criteria for a result should be undoubtedly known, this step can hence contribute to learners persevering over the curriculum asserted that "engineering education emphases deeply on the problem (Anderson & Taraban, 2013).

The explore be situated initially omitted since the approach but was additional when its significance toward skilled problem solvers developed strong (Woods et al., 1979). This stage can also be titled "Think about it. Through this step, the expert makes inquiries and explores all dimensions of the problem. Is it a routine problem? If so, the specialized will solve the problem speedily in an advancing way. If it is not repetitive, what side are current? Which of these parts is repetitive? What are unobtainable figures possible to be required? What are the alternate solution approaches, and which is probably to be most suitable and correct? Prepares this problem certainly must to be solved, for an added significant problem? A lot of specialists agree to guide solutions to see if an added full solution is certainly vital. Meanwhile, learners are often uninformed of this stage; they want reassurance to enhance it to their range. In the plan step, proper reasoning is used to agree up to the steps of the problem. For extended problems, a flowchart of the steps may be valuable. The suitable equations can be solved and written deprived of numbers. This is extremely hard for learners in Piaget's actual operational step. This step is easier for overall intuitive and thinkers, which means that sensing individuals and serial thinkers need more exercise (Tiwari, et al., 2010).

Do it, step 4, include essentially placing in ideals and manipulative a response. This is the step which learners need to the domain. Even properly skilled problem solvers frequently need to combine steps 3 and 4 and not advance a solution in the representative procedure. The parting of the plan and do it stage makes for well problem solvers in the extended run. Unraveling these stages sorts it easier to check the outcomes and to generalize them meanwhile placing in new ideas is easier. Identifying learners are likely to be well at doing the real calculations (Wankat & Oreovicz, 2015).

Checking the outcomes must be a reflex portion of the problem-solving approach. Checking needs internal checks for mistakes in number crunching, both mathematical manipulations then it contains assessment through outward standards. A very suitable plan of skilled problem solvers is to like the answer to the bounds resolute in the explore step, the response must similarly remain related to "common sense." This stage needs assessment besides several learners' determination not remain practiced at it (Adams, Kaczmarczyk, Picton, & Demian, 2010).

The preceding stage, simplify, is nearly not ever complete by learners except they remain clearly expressed toward do it. Whatever has been knowledgeable almost the content? In what way might the problem be solved greatly more professionally in the forthcoming? For example, was one term very small so that in the forthcoming it can be carefully ignored? Were tendencies linear so that in the forthcoming appropriate rare ideas want to be calculated? If the problem was not solved properly, what would have been done? Learners want to be powerfully fortified to study response and then resolve improper problems (Anderson, 2010).

Wankat and Oreovicz, note that learners have a habit of being worried, take information planned addicted to minor bits, do not recognize whatever information is significant in the problem, aim from insincere problematic facts, jump to ends about what the problem is requesting, do not analyse the problem into portions, frequently do not draft the problem, use a trial and error strategy, do not check their solutions and ignore corrective response. Specialists, on the other hand, are naturally assured, establish information into "shares," see whatever information is applicable in the problem, reason from important values, take time to express and redefine the problem to themselves, examine the problem into parts, look for familiar patterns in the problem, spend considerable time drawing the problem, apply strong tactics, checked their solutions, and study from mistakes (Taraban et al., 2007).

2.3 Gray et al. extant an organized method to problem-solving.

The concern of this method as a beneficial one to learners all over their occupations. They established this method in reaction to learners' use of a "jumble of actions" to solve dynamics and statics problems, nevertheless respect the technique as capable to monitor learners toward the solution of the problem they come across in mechanics. Presentation of their technique as "commonly appropriate" also suitable meant for learners as initial as mechanics' level of sophomore (Gray, Constanzo, & Plesha, 2005).

The Define-Road Map-Problem Representation component is essentially a technical stage meaning frequently followed in a style of linear thru the learner. It inclines to be rotation with the

learner following approaches adopted by the instructor. Gray, et al. (2005), has recognized the developed instruction of cognitions (complete resolution approach, understands the problem deep structure, and constructs a mental model that occurs throughout this stage. Nevertheless, the numerous cognitions itemized in the second row of Table 1 are mainly routine and can be realized by learners through the first stages of their knowledgeable progress based the learner's intellectual development (Gray et al., 2005).

Gray et al (2005), suggested that in solving exercise and assessment problems, learners involve in "design matching" of the problematic to calculations they recognize "approaching up with several equations in unknowns." In their planned method, they afford a set of basic equations as of which learners can develop the equations the requirement for an exact problem. Gray at al., extent a planned method to issues solving. Gray at al., respect the method because it is a valuable one to learners through their livelihoods. They established this method in response to learners' use of a "hodgepodge of tricks" to solve dynamics and statics problems, but then favor the way by means of able in the direction of monitor learners to the resolution of in the least problem they come across in mechanics. They present their technique as "collectively valid" and suitable for learners at first as a sophomore level mechanic (Taraban, 2008).

2.4 The Litzinger, problem-solving model (investigation as a critical component in problem-solving).

The Litzinger remained concerned in problem investigation as a critical component in problem-solving. Founded on an analysis of the works of many researchers, they recognized several features that were thoroughly connected towards rational skills, capability to implement problem solving procedures content understanding in the field of the problem, knowledge of and, and the ability to interpret among representative systems, mostly interpreting among a oral problem narrative also a illustrative representation of the problem, similar a free-body illustration. In their Combined Problem-Solving Model, these aspects remain divided interested in different proportions of problem-solving, to successfully solve a problem, an individual requires to be able to participate the procedures of these dimensions (T. Litzinger, Van Meter, Wright, & Kulikowich, 2006).

Litzinger et al remained worried with fundamental cognitive developments related with problem investigation and the creation of a free-body illustration who described that their student's participants normally needed excellence understanding, they unsuccessful to remember previous information, and they did not distinguish values that beneficial in the direction of the problems that they remained solving. (Carberry & McKenna, 2014). For Litzinger et al., effective translational processes across representative systems – verbal to diagrammatic to mathematical – are essential apparatuses of positive problem solving, The Litzinger, et al model is still being investigated and may be extended as new discoveries are testified. (T. Litzinger et al., 2006). Litzinger, et al., and Gray, et al., require recognized certainly developed instruction of cognitions that happen through this stage. Nevertheless, the numerous cognitions itemized in the second row of Table 1 are mainly technical and can be applied by learners throughout the initial stages of their knowledgeable progress (Taraban, 2008).

2.5 Mettes et al. Problem-solving model (cognitions).

Mettes et al., characterized the several cognitions by figure somewhat than name as showed in Table 1. Designate an efficient method of problem-solving teaching. By means of a chart format, they are existing, the flow of issues solving stages inside their Organized Method to Problems Solving. From an educational viewpoint, the writers accept a positive tactic to education: that is, they give emphasis to that learner's necessity do their own learning and that teachers can only enable that education. In constructivist relations, education is a lively development over which the apprentice concepts his/her own sense; the sense is not only conveyed as of instructor to learner motivated on awarding the vital fundamentals for good instructional put into practice (Mettes, Pilot, Roossink, & Kramers-Pals, 1980).

Table 1: Summary of Problem solving models

Wankat & Oreovicz	**Gray et al.**	**Litzinger et al.**	**Mettes & Roossink**
I Can Motivation			
Define List known and unknowns. Draw figure. Identify criteria and constraints for a solution.	**Road Map** Givens. Concise statement what needs to be found overall solution strategy.	**Problem Representation** Construct a mental model. Determine involved principles. Understand the problem deep structure. Identify givens. Determine what to solve for.	**1.** -read the problem **2.** draw the system write down system boundaries characteristics of an unknown estimate answer
Explore Explore problem dimensions. Is it routine? What data is required? which basis most convenient. What are the alternative solution methods	**Modeling** Assumptions to make the problem tractable	**Problem Framing** Draw a physical diagram. Map givens onto the problem. Apply appropriate principles. Monitor process / detect errors.	**3.** Is it a routine problem? **4.** Write down possible key relations (key equations) **5.** check key relations for their validity to the problem

Plan Set up the problem using formal logic Write equations and solve numbers	**Governing Equations** All the equations For a solution. Verify that n of unknowns n= equations	**Problem Synthesis** **E**xecute plans Evaluate solution Monitor process and detect errors	**6. W**rite down the unknowns Write a valid equation (key relation) in which unknown occurs. Replace general quantities with specific quantities
Do It (Execute) Put in values and calculate solution	**Computation** Manipulation and solution of equations		**7.** If not solvable check for lost key relations or use alternative procedures **8.** carry out calculations
Check Check calculations Reconsider problem limits. Apply common sense	**Discussion & Verification** Verify solution is correct. Consider solution's physical Meaning. Consider the role of assumptions in Solution.		**9.** check the answer for sign, magnitude, dimension **10.** check for mistakes on estimation, setting up the scheme, writing down key relations, calculations
Generalize (Reflect) Ask what has been learned about content Consider how to solve More efficiently			

3.0 Discussion.

Every cell in this table characterizes single model component by way of recognized over the original writers in bold kind. The several cognitions described by the authors inside both model elements are similarly itemized in the table cells.

The Wankat and Oreovicz, model contains the greatest essentials or steps even though the others need fewer stages. The Litzinger, et al model is still actuality investigated and will be extended as new discoveries are testified. To each cell in this table characterizes one model component as recognized by the inventive writers in the bold sort. The several reasoning's described thru the writers surrounded by respectively model component are also itemized in the

table cells. Mettes, et al characterized the several perceptions by means of number slightly than heading as specified in Table 1. The Wankat & Oreovicz model is the only one that contains I Can step or motivational part. So far, this will be the greatest critical stage for the reason that it creates the learner's sureness in existence talented to solve the problem and recognize the importance of the problem. (Besterfield-Sacre, Atman, & Shuman, 1997), has described that many first-year learners leave engineering because they "lost interest in it."

The motivation step of this model can consequently be used to discourse learner retaining by connecting to the engineering problem run through in that way providing learners extra vision interested in the career. (Stage, 1988) observed the over-all student populace and initiate that assurance is maybe the only most vital limitation in forecasting learner completion. Commitment is positively encouraged by sureness which is also the determination of the I Can step (Wankat, Felder, Smith, & Oreovicz, 2002).

This stage can consequently guarantee to learners continuing the curriculum. The Define-Road Map-Problem Characterise component is essentially a technical stage that is frequently followed in a linear fashion by the learner. It leans towards to be honestly rote with the learner following approaches adopted by the instructor. The Explore-Modelling-Problem Bordering component is mainly a theoretical, deep thinking exercise that can also embrace certain practical actions. In this stage wherever learners reveal on their classification, explore other solution approaches, choose what wants to be measured, whatever can be rejected, and picks suitable values to apply to the problem. There is a many of resemblance among the four models we choose for this specific step in the problem-solving procedure. Here is a likewise specific connection between this stage and the Define step. The significant fact is that there is a countless agreement of resemblance among the different cognitions used by learners through these two steps of the procedure (Litzinger et al., 2010).

The following two steps of the problem-solving models are Plan-Governing Equations-Problem Mixture and Do It-Computation. These two steps are mainly technical and contain inscription the suitable equations designed for the problem model established popular the above phases besides solving those calculations. Selected deep thoughtful will happen through these steps mostly if the equations are improper, the several unknowns or there is also much evidence in the problem statement. Learners formerly naturally reappearance to the Define and Explore stages to define their model, review the expectations, and then remove unrelated facts. There is positively a deep, critical thoughtful performance which is instructors want to improve in their learners. Inappropriately, this is not constantly appreciated by one or the other the learner or educator consequently depriving the apprentice of emergent those abilities so vital to the professions.

Skilled problem-solvers checked the answers founded upon their knowledge, instruction of scale concerns, an element of physical checks, and other methods they need to be educated over knowledge. Learner problem-solvers do not require the growth of information wanted for these checks and consequently tend to evade in this stage, meanwhile, it can be period overriding and may enhance slightly to their ranking reward. Nevertheless, it is something that specialists organize and learners essential to acquire if they are to be developed critical, in-depth thinkers. Only the Wankat and Oreovicz model includes the Generalize step that involves reflective thoughtful.

As shown in several of the papers quoted at this point, this step is virtually certainly not completed by learners. It remains consequently hardly saw in inferior separation engineering apprentices that lone two of the four models obtainable in Table 1 include it (Gray, et al contain

certain deep behaviors in their Verification and Discussion step). Nonetheless, this is possibly the highest difference among the skilled and beginner problem-solver. Specialists usually analysis their solution seeing for comparable problems, further well-organized known for solving the problem, trainings that stand qualified by the problem, slightly simplifications which can be over almost the issues, in what way organises this problem associated with other problems they have solved, and the plan problem of how the many problem variables affect the response. This critical and regularly abandoned step in the solving problem process might be situated the single greatest significant step which learners can learn because it can constantly serve them well no substance wherever the career leads them. It is significant that engineering professors identify this and contain this step even in the very first developments if we are to graduate engineers that can adjust and adjust to the modifications that will happen throughout their careers.

An additional worldwide opinion of Table 1 shows there is significant settlement among the four models excluding at the onset and assumption of the problem-solving procedure. Completely, these models comprise virtually equal cognitive behavior's (though defined contrarily) and single disagree in wherever they happen through the procedure. Only one can accomplish that these behaviors are at the essential of the problem-solving procedure and befall unevenly in the instruction obtainable in Table 1. It must stand well-known because this may be the overall arrangement followed by learners, but then again, there can be significant repetition arising amongst the steps.

Learners regularly look advancing, step back, redefine, resume, and obstacle about amongst the many steps as they acquire to develop skilled problem-solvers. It is unacceptable on the way to see that the I Can and Generalize stages are individual involved in one model meanwhile they can be so significant to the knowledgeable improvement of the learner. These two steps are apparent as taking little value by learners whose aim is to attain a ranking which is frequently determined by in what way learners solved a problem somewhat than what did they acquire as of the problem. Thus, it is not unforeseen that they are not involved in the last three models which are derived from perceiving learner activities.

4.0 Conclusions

It is strong that there is significant arrangement among the many problem-solving models and that they only differ meaningfully at the conclusion and beginning of the procedure. Even though there is divergence around precisely when definite actions happen, there inclines to be arrangement around which actions do happen throughout the procedure. It also seems, with the exclusion of the Explore stage, that the popularity of the actions that do happen though solving problems are extra procedural than theoretical, deep thinking actions. Only the Wankat and Oreovicz model widely inspires higher-order thoughtful with its initial and last stages. This is similarly the further overall model obsessed by which the others can be charted and agrees to the added comprehensive cognitions existence named intended for by ABET also others. Problem-solving perception investigation remains and added to these developments will be recognized by this study. Furthermost possible, any innovative discoveries will be recorded into the seven basics of the Wankat and Oreovicz model of Table 1 because it is relatively overall if not all comprehensive. It is suggested that engineering educationalists use this model for curriculum improvement, and instructional media course, educationalists must also effort to include the I Can and Generalize stages of this model to improve the deep-thinking skills of engineering graduates and students.

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