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21st Century Skill “Problem Solving”: Defining the Concept

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Abstract: Only knowledge is not sufficient to make students succeed in the world. Students need to attain 21st century skills like problem-solving, creativity, innovation, metacognition, communication etc. to endure in the modern world. Problem-solving skill is one of the fundamental human cognitive processes. Whenever students face a situation where they do not know the way to complete a task, the problem occurs. Problem-solving is a process, which involves systematic observation and critical thinking to find an appropriate solution or way to reach the desired goal. The framework of problem-solving consisted of two major skills: observation and critical thinking skill. Observation skill refers to collecting data, understanding and interpreting the meaning of the information using all the senses. Critical thinking involves the individual's ability to do the following: conceptualizing, logical reasoning, applying strategy, analytical thinking, decision making and synthesizing to solve any problem.

Key words:

21st Century skill, Problem-solving, Critical thinking, Observation skill, Cognitive process, Analytical thinking, Divergent thinking



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Introduction

Today, in the modern world, the education system is going through some massive changes. As it is proofed that in every 5.5 years scientific knowledge is getting doubled (Nash, 1994), and it raises one question in everyone's mind at the beginning of the 21st century [1]. What knowledge and skill our children need to survive the speedy changes seeming in all expanses of life? If we prepare our children only for existing prospects, their knowledge and skills will be obsolete by the time they have to use them in

their private life and in the world of work [2]. Therefore, children have to gain more knowledge about different subject areas to live a successful life in this fast-moving world. At the same time, they have to achieve some crucial skills, which will help them to survive the fast-changing world. In recent years a new concept has emerged focusing these prospects, which called 21st-century skills.

The term 21st-century skills mean an extensive set of knowledge, skills, work habits, and character traits that are most essential to lead a perfect life in today's world, particularly in academic life and future careers. According to Binkley et al. (2012), ten 21st century skills, which could be identified in four groupings [3]:

➤ *Ways of Thinking*

1. Creativity and innovation
2. Critical thinking, problem-solving, decision making
3. Learning to learn, Metacognition

➤ *Ways of Working*

4. Communication
5. Collaboration (teamwork)

➤ *Tools for Working*

6. Information literacy
7. ICT literacy

➤ *Living in the World*

8. Citizenship – local and global
9. Life and career
10. Personal and social responsibility – as well as cultural awareness and competency

Problem-solving is inescapable in human life and is crucial for human survival [4]. It is one of the fundamental skills of 21st century skill. Problem-solving is the most important skill needed by today's children

everywhere, including both in school and out of school learning and achievement. Recent research in problem-solving suggests that educationalists, trainers and policymakers are reviewing curricula to include incorporated learning environments which focus students to use analysis, evaluation, synthesis etc. type skills, and especially, problem-solving skills as new learning theory has evolved and professional standards have been changed which created demands of the new workplace [5].

What is the Problem?

People involve some sort of problem-solving in their daily activities. But all problem solving is not alike. There are problems that are familiar to us, which can be solved with a few mental steps. However, there are problems that we have never encountered before, which require extensive thinking. Some problems have very distinct objectives, and some problems have ambiguous and indistinct goals.

According to Mayer (2003), a problem happens when in any given situation, a goal or objective state needs to be fulfilled, and there is no predictable or regular method of solution available [6].

A *problem* is considered to occur, “when a living creature has a goal but does not know how this goal is to be reached. Whenever one cannot go from the given situation to the desired situation simply by action, then there has to be recourse to thinking” [7]. Dörner (1976) emphasized that a problem is barriers “between the given situation and the desired goal state, i.e., the lack of knowledge, can be further classified according to the amount of (a) ignorance of the means/operators applicable, and (b) lack of concreteness concerning the goal state” [8].

In simple language, problem can be defined as any state in any area of life where a person wants to reach a destination or complete a task within a certain amount of time but doesn't know how to reach that desired location or reduce the gap between their current condition and where they want to reach in an efficient way.

The concept of Problem-Solving

For most of the twentieth century, educationalists have dedicated their full concentration to trying to describe and illuminate problem-solving skills. In the initial 1900s, problem-solving was regarded as a machine-driven, methodical, and frequently intellectual (decontextualized) set of skills, like those used to crack puzzles or mathematical equations. These problems usually have correct answers that can be reached based on rational solutions with one right answer. This is also known as convergent reasoning.

When the cognitive learning theories emerged, the meaning of problem-solving skill changed. It became a complex mental activity comprising of a variety of cognitive skills and activities. Problem-solving encompasses higher order thinking skills like "visualization, association, abstraction, comprehension, manipulation, reasoning, analysis, synthesis, generalization—each needing to be 'managed' and 'coordinated'" [9].

Problem-solving is also defined as a cognitive process that focused on accomplishing an objective for which the students do not primarily know a solution technique. This meaning contains four key features [10, 11]:

a) Cognitive-Problem solving occurs inside the student's cognitive system. It can only be inferred incidentally from

the student's behaviour or perspective which includes students biological changes, self-analysis, and activities throughout the problem-solving.

- b) Process-Problem-solving contains intellectual calculations. This involves applying some actions to an intellectual representation so that it creates a new intellectual representation.
- c) Directed-Problem-solving is intended to accomplishing an objective.
- d) Personal-Problem-solving influenced by the previous knowledge of the students. Therefore, a problem sometimes becomes a problem for one person and sometimes that's not a problem for a person who already knows how to solve it.

Problem-solving is an intellectual process of the brain, which explores the explanation to a specified problem or discovers a technique to comprehend the given goal [12]. The brain uses the maximum cognitive functions like analytical thinking, generalization, and synthesis in problem-solving, which involves features such as the scientific way, critical thinking, decision-making, and reflective thinking [13, 14].

PISA (2012) defined problem-solving competence as [15]:

"...an individual's capacity to engage in cognitive processing to understand and resolve problem situations where a method of solution is not immediately obvious. It includes the willingness to engage with such situations in order to achieve one's potential as a constructive and reflective citizen".

Problem-solving starts with identifying a problem state and forming an understanding of the nature of that condition. It needs the children to recognise the specific problem(s)

to be solved, design and execute a solution, and observe and assess progress throughout the activity. Unlike a simple task, a problem is a non-routine state or condition for which no regular solution approaches are easily available [11]. Therefore, Problem-solving needs logical reasoning to process certain information in a way that can be used to solve the problem effectively and efficiently.

Observation skill for Problem Solving

Observation skill is an integral part of the problem-solving skill. Observation is the main intellectual skill (Millar, 1994) and also the first natural science skill a kid develops in his or her life [16, 17]. Observation is more than just looking (Millar, 1994; Johnston, 2011) [16, 17]. It includes the use of all five senses, recognising similarities and dissimilarities between things, observing patterns in things and occurrences, recognizing sequences and events in the world, and understanding observations [17]. Observation helps to remember details of an inquiry and assistances problem-solving (Grambo, 1994), as it is a vital element in other scientific skills [18-19].

Observational skills are the basic tools of problem-solving. It is the first step to solve any types of the problem around us. It provides children with the chance to emphasise more clearly on the procedures of seeing, systematically and empirically, and by means of that procedure to develop their skills to comprehend what they observe [20]. Observing is a broad activity, not only using the sense of sight to collect data, but also using other sensory devices such as hearing, smell, taste, and touch [21]. Additionally, Johnston (2009) found that kids observe by means of their five senses, by observing details,

organizing, combining and classifying things or sequencing events [22].

Observing skill is as well as an important part of the science process skills, which is a series of activities to collect data about an object using all the senses. According to Watson, Goldsworthy and Wood-Robinson (1999), there are six categories of scientific investigation [23]. They are

- (i) classifying and identifying,
- (ii) fair testing,
- (iii) pattern seeking,
- (iv) investigating models,
- (v) exploring, and
- (vi) Making things or developing systems.

All of these have a basis layer of observation as well as skills of designing, quantifying, the breakdown of data and assessing processes [24]. Stone (2014) suggested that observing skill is the most basic skill that bonds the mastery of higher-level science process skills [25]. Basic science process skills are (BSPS) observing, classifying, measuring, and predicting. These skills provide the mental foundation in scientific inquiry, such as the ability to sequence and define natural things and events [26]. The ability to use BSPS refers to the ability to perform practical inductive reasoning or Piagetian concrete operational reasoning [27]. BSPS are the primary skills for solving any problems. When children get opportunities for observations in the early age, they have stable grounding for concept development, extending their understanding level (Harlen & Symington, 1987) and better theorizing in future phases of academic learning and investigating [28, 29]. Therefore, observation skill must be cultivated in

children so that they can use it effectively in solving any problems of life.

Critical Thinking and Problem Solving

Critical thinking is very essential in the case of problem-solving. Critical thinking and problem-solving skill are interrelated with each other. Sometimes these are used as synonym words.

Critical thinking and problem-solving skills comprise the skill of persons to a) reason efficiently, b) ask clear questions and crack problems, c) break down and assess alternative perspective, and d) reflect critically on choices and procedures [28]. Trilling and Fadel (2009) suggested that the capability to analyse, understand, evaluate, abridge, and generating new information are known as critical thinking [30].

The National Council for Excellence in Critical Thinking (1987) defines critical thinking as the “intellectually disciplined process of actively and skillfully conceptualizing, applying, analysing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action [31].

Cottrell (2005) identified critical thinking is a complex process of thought, which

includes a wide range of abilities and attitudes, such as [32]:

1. recognising other people’s situations, point of view, and conclusions;
2. assessing the evidence for alternative perspectives,
3. weighing up a contrasting point of view and evidence impartially;
4. being able to read between the lines, seeing behind surfaces, and recognising wrong or partial assumptions;
5. recognizing procedures used to make certain positions more appealing than others, and persuasive procedures;
6. reflecting on problems in an organized way, bringing rationality and reasonable, based on good evidence and functional assumptions;
7. drawing inferences about whether the argument is effective and reasonable, constructed on good proof and functional expectations,
8. presenting evidence in a planned, clear, well-reasoned way that satisfies others.

Similarly, Facione (2011) expressed that there are several cores of critical thinking skills [33]. They are (1) interpretation, (2) analysis, (3) inference, (4) evaluation, (5) explanation, and (6) self-regulation. The summary explanation of these core skills are described in the table 1 below:

Table 1. Core Critical Thinking Skills

Skill	Experts’ Consensus Description	Subskill
Interpretation	“To comprehend and express the meaning or significance of a wide variety of experiences, situations, data, events, judgments, conventions, beliefs, rules, procedures or criteria.”	Categorize Decode significance Clarify meaning

Analysis	“To identify the intended and actual inferential relationships among statements, questions, concepts, descriptions or other forms of representation intended to express beliefs, judgments, experiences, reasons, information, or opinions.”	Examine ideas Identify arguments Identify reasons and claims
Evaluation	“To assess the credibility of statements or other representations which are accounts or descriptions of a person's perception, experience, situation, judgment, belief, or opinion; and to assess the logical strength of the actual or intend inferential relationships among statements, descriptions, questions or other forms of representation.”	Assess the Credibility of claims Assess the quality of arguments that were made using inductive or deductive reasoning
Inference	“To identify and secure elements needed to draw reasonable conclusions; to form conjectures and hypotheses; to consider relevant information and to reduce the consequences flowing from data, statements, principles, evidence, judgments, beliefs, opinions, concepts, descriptions, questions, or other forms of representation.”	Query evidence Conjecture alternatives Draw conclusions using inductive or deductive reasoning
Explanation	“To state the results of one's reasoning; to justify that reasoning in terms of the evidential, conceptual, methodological, criteriological and contextual considerations upon which one's results were based; and to present one's reasoning in the form of cogent arguments.”	State results Justify procedures Present arguments
Self-Regulation	“Self-consciously to monitor one's cognitive activities, the elements used in those activities, and the results educed, particularly by applying skills in analysis and evaluation to one's own inferential judgments with a view toward questioning, confirming, validating, or correcting either one's reasoning or one's results.”	Self-monitor Self-correct

Source: Adapted from “Critical Thinking: A Statement of Expert Consensus for Purposes of Educational Assessment and Instruction. Research Findings and Recommendations.” [34].

In education, critical thinking can be found back to the work of Socrates, who used questions to inspire people in reducing the gaps and biases through logical reasoning, explain assumptions and provide evidence in their claims. The greatest well-known conceptualization of critical thinking originates in Bloom’s taxonomy.

Table 2. Taxonomies of Educational Objectives

Bloom (1956)	Anderson & Krathwohl (2001)	Marzano & Kendall (2006)	PISA (2000)
Evaluation	Create	Self-System Thinking	Communicate
Synthesis	Evaluate	Metacognition	Construct
Analysis	Analyse	Knowledge Utilization	Evaluate
Application	Apply	Analysis	Integrate
Comprehension	Understand	Comprehension	Manage
Knowledge	Remember	Retrieval	Access

Source: Adapted from “Skills for the 21st Century: What Should Students Learn?” [35].

However, many have taken the same concepts and defined them differently. An association of taxonomies explaining the educational objectives of evolution from lower level learning of knowledge, comprehension to various goals of critical thinking Table 2 (analysis, evaluate, create etc.).

Theoretical Framework of Problem-Solving Skills

Problem-solving is a procedure, which includes multiple skills like observation, understanding, logical reasoning, synthesis, evaluation etc. to solve a simple or complex problem. The theoretical framework of problem-solving skills is suggested based on the above discussion:

Problem-solving skill can be broken down into two core skills.

1. Observation Skill
2. Critical Thinking Skill

Observation skill refers to gathering information, understanding and interpreting meaning by identifying key points, pattern recognition and finding similarities and

differences of a problem or phenomena using all the senses.

Critical Thinking skills can be split into six sub-skills (Figure 1).

1. *Conceptualizing skill:* Conceptualizing means when a person has an idea or understand something completely. It means that learners will able to identify the topic and recognize the problem, which they are going to study. They will able to understand the investigating problem partially or completely. Therefore, conceptualizing skill is referred to as the as^{1st} step of critical thinking skill.
2. *Logical Reasoning:* Logic can be defined as the science of reasoning. The reasoning is a special mental activity by which someone makes or perform inferences. Logical reasoning is a process in which students will gather relevant information, interpret information and based on their interpretation they will formulate arguments. An argument is a collection of statements which will help in justification and draw the conclusion
3. *Application Skill:* Application skill refers to using knowledge in new or familiar

situations to resolve problems by means of the acquired facts, knowledge, principles and techniques. Students will be able to identify an appropriate strategy, carry out or effectively use a procedure for executing or implementing in solving the problem.

4. **Analytical Thinking:** Analytical thinking skills help students to collect information, articulate, visualize and solve complex problems in the fast information age of changing trend world [36]. According to Falcoine (1990), analytical thinking abilities include analysing an argument, claims, or evidence, making interpretations using inductive or deductive reasoning, Assessing or evaluating, and making decisions or solving problems [34]. The ability to think rationally, break down tasks or problems into its key parts and recognize cause and effect. Students will be able to make a list of actions and resources needed to solve the problem, compare and contrast the elements based on characteristics, classify information to recognize the pattern and drawing conclusion.
5. **Decision-Making Skill:** Decision-making means making choices, solving problems, selecting the best alternative. Decision-making skills enable a student to identify an appropriate assumption by evaluating the sources of evidence, use judgement to choose an appropriate and timely course of action. Students are able to judge the effectiveness of the solution and justify the solution process based on reasoned arguments.
6. **Synthesizing Skill:** Synthesis is the capability to combine parts of a whole in new and different ways. It needs children to think openly, relate knowledge from

several sources, determine alternatives, generalize ideas from explored facts and generate new ways to achieve a specified task. Synthesize enhances a higher level of intellectual thinking.



Figure 1. The framework of Critical Thinking skills

Conclusion

21st Century skill emphasis not only the main academic subject mastery but also skill-based learning outcome. Problem-solving skill is the most crucial ability demanded by our society and the vital element to enhance students' comprehending knowledge and prepare them to survive future challenges in life. To unlock the full potential of students we not only need to develop their problem-solving skills but also integrate our teaching-learning to satisfy the goal of 21st-century skills. We have to incorporate problem-solving skills in our curriculum to prepare our students adequately for the fast-moving future. The government, education policymakers and respective stakeholders must come forward to change our education system for creating individuals as a "problem solvers".

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