# COMPLEX PROBLEM SOLVING TRAINING

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## ABSTRACT

*Surveys conducted between 2012 and 2020 have established conclusively that there is a substantial need internationally for generic skills and one of the most important of these skills is problem-solving, especially complex problem-solving (CPS.) However, two recent surveys conducted by this author of numerous problem-solving training courses advertised online show that there is almost no focus on CPS in these courses. Also, there is a lack of a common understanding of what mental processes constitute effective problem-solving. There appear to be two main schools of thought; those who understand problem solving to be a mental process that stands on its own and those who understand it to be made up of various modes or ways of thinking.*

*Considering the complexity of the problems facing the world and that complex problem-solving is usually a collaborative and team effort, it is clear that there is a need for a common conceptualisation and understanding of CPS. Consequently, the CPS framework proposed by Hunter (2019) is reviewed in this article and the application of the elements of this framework to the training of CPS is discussed in some detail.*

**Keywords:** Problem-solving, Training, Problem-solving skills, Complex problem-solving, CPS, CPS training, Generic skills

## ABBREVIATIONS

APA: American Psychological Association; CEO: Chief Executive Officer; CPS: Complex Problem Solving; KSAVs: Knowledge Skills Attitudes and Values; NRC: National Research Council; OECD: Organisation for Economic Co-operation and Development; PISA: Programme for International Student Assessment; UK: United Kingdom; WEF: World Economic Forum

## INTRODUCTION

### The need for problem-solving skills

Between 2012 and 2020 extensive surveys were conducted internationally to investigate the need for the main skills that are, and will be required in the foreseeable future. The main surveys that were conducted during this period are as follows;

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- National Research Council (NRC) Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st Century (2012)

- World Economic Forum (WEF) The Future of Jobs: Employment, Skills and Workforce

- Strategy for the Fourth Industrial Revolution (2016)

- World Economic Forum Future of jobs report (2018)

- Hewlett Foundation 21$^{st}$-Century Competencies and Their Impact: An Interdisciplinary Literature Review (2016)

- Bloomberg Job Skills Report (2016)

- Pearson Survey report The Future of Skills: Employment in 2030 (2017)

- UK Department for Education Employer Skills Survey Report (2018)

- Brookings Institute survey report, Education system alignment for 21st century skills (2018)

Hunter (2019, 2020) analysed the findings of these surveys and found that the main skills indicated by them are,

1. Problem-solving (including complex problem solving),

2. The ability to learn,

3. Critical thinking,

4. Analytical thinking and

5. Systems thinking.

In addition to the above reports, the WEF Future of Jobs Report of 2020 lists the top five skills indicated by its latest survey as follows:

1. Analytical thinking and innovation,

2. Active learning and learning strategies,

3. Complex problem-solving,

4. Critical thinking and analysis and

5. Creativity, originality and initiative

**Problem-solving training courses**

The surveys mentioned above clearly indicate that there is a substantial need for problem-solving skills, especially complex problem-solving skills and the question arises as to what is being done to train people in these skills. Consequently, during 2019 Hunter conducted a survey to investigate problem solving courses advertised online (Hunter, 2019, 2020.) In March 2021 he conducted a similar, survey to determine whether any changes had taken place since 2019.

**Method**

The sampling method used in both surveys was to select the first usable advertisements for problem-solving courses available online. The main aspects covered by each course were recorded on a spreadsheet and analysed.

**Results**

**Table 1** lists the four most frequent aspects of problem-solving dealt with by the courses in both surveys and shows the number of these courses that focused on each of these aspects. The number of courses analysed in each survey was 107.

**Table 1:** Number of courses focusing on aspects of problem solving.

| ASPECTS OF PROBLEM-SOLVING | 2021 | 2019 |
|---|---|---|
| Steps in the problem-solving process | 62 | 52 |
| Analytical thinking | 62 | 69 |
| Creative thinking | 58 | 69 |
| Critical thinking | 27 | 34 |

*Source: Author processed from spreadsheet of results.*

Note that **Table 1** shows that the number of courses focusing on the steps in the problem-solving process increased from 52 to 62. Other notable changes between the two surveys are that;

- Courses offered by universities decreased from 50 to 5,

- Courses offered by private institutions increased from 57 to 102,

- In-Person courses decreased from 96 to 69

- Virtual courses increased from 11 to 40.

- Blended (in-person combined with virtual) courses increased from 0 to 11.

Only 6 problem-solving courses included systems thinking in the 2019 survey and none in the 2021 survey. However, systems thinking courses were advertised separately. Another relevant finding of both of these surveys is that the duration of most of the courses was two days.

## THE CONCEPT OF PROBLEM-SOLVING

The APA Dictionary of Psychology defines problem-solving as,

"The process by which individuals attempt to overcome difficulties, achieve plans that move them from a starting situation to a desired goal, or reach conclusions through the use of higher mental functions, such as reasoning and creative thinking."

The higher mental functions relating to complex problem-solving are referred to in this article as modes of thinking, of which a number have been referred to above. It is clear from the skills surveys and both the training course surveys that there is a substantial variation in the concepts of problem-solving. For example, the WEF Future of Jobs reports list problem-solving and various modes of thinking such as systems thinking and critical thinking separately, which implies that those modes of thinking are not considered to be part of problem-solving. On the other hand, all the problem-solving courses focused on a few specific aspects of problem-solving such as the steps and one or two

modes of thinking, which implies that, in relation to training, these aspects were considered to be an integral part of problem solving. However, the problem-solving courses differed substantially in the aspects of problem solving on which they focused.

The question therefore arises as to whether complex problem-solving (CPS) is a mental function that stands on its own or whether it is made up of various modes of thinking and, if so, which modes constitute CPS.

Frensch & Funke, (2014) state, "According to our definition, CPS occurs to overcome barriers between a given state and a desired goal state by means of behavioural and/or cognitive multistep activities." They also explain that the state of the system in which a complex problem exists is dynamic and there is a lack of transparency in the sense that the relationships between the various elements of the problem cannot be easily detected. They point out that CPS involves the problem solvers' "cognitive, emotional, personal and social abilities and knowledge."

Also, the 2016 WEF Future of Jobs report defines CPS as, "The ability to generate or use different sets of rules for combining or grouping things in different ways."

Hunter (2019) summarizes the main aspects of CPS reported in the research literature as follows;

● A complex problem exists in the context of an environment.

● A complex problem can be defined as the gap between the current state and the desired or goal state.

● There are a number of goals that could be in conflict with each other.

● The goal state is achieved by means of multi-step activities.

● The CPS process involves systems thinking.

● The CPS process and the skills, abilities and knowledge involved should be viewed and studied holistically.

● The CPS process is influenced by the solver's cognitive, emotional, personal, and social abilities and knowledge.
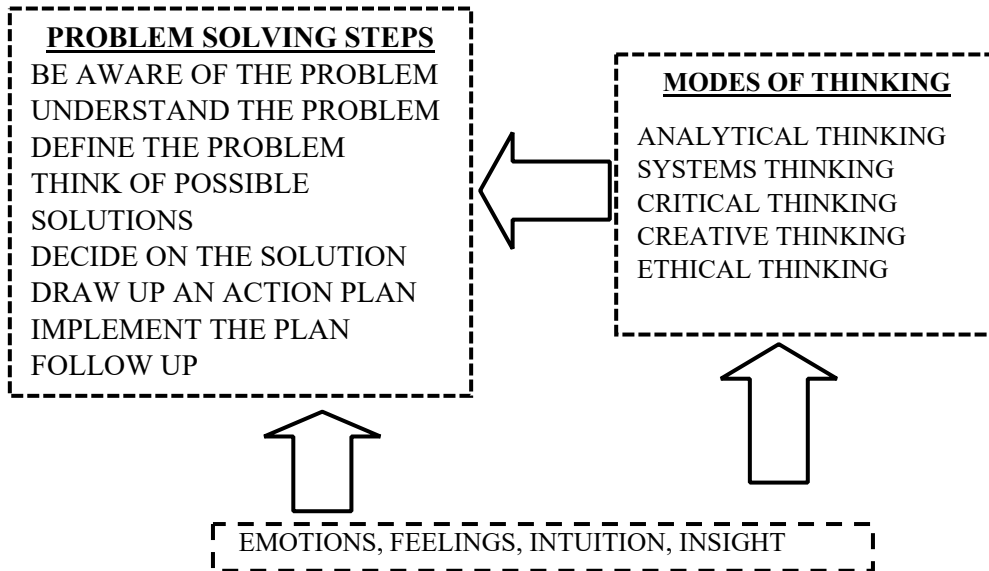

## THE PROPOSED CPS FRAMEWORK

The proposed complex problem-solving framework explained below is mainly derived from:

• The findings of the skills surveys conducted by the WEF and other organizations,

• The definitions of CPS by Frensch & Funke (2014) and the WEF Future of Jobs report (2016),

• The main aspects of CPS reported in the literature (as listed above),

• The results of the online training course survey conducted by Hunter during 2019 and

• The practicality of training and applying the elements of the framework.

It is proposed that CPS consists of the steps in the problem-solving process, five modes of thinking and the problem solver's emotions, feelings, intuitions and insights.

The problem-solving steps form the core of the framework and the other elements feed into the process where appropriate. The arrows do not indicate direct causal relationships between the various elements but that they can be integrated in numerous ways depending on the nature of the problem and the step in the problem-solving process.

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┌─────────────────────────────┐        ┌──────────────────────────────┐
│  PROBLEM SOLVING STEPS       │        │                              │
│  BE AWARE OF THE PROBLEM     │        │    MODES OF THINKING         │
│  UNDERSTAND THE PROBLEM      │        │                              │
│  DEFINE THE PROBLEM          │        │   ANALYTICAL THINKING        │
│  THINK OF POSSIBLE       ⇐   │        │   SYSTEMS THINKING           │
│  SOLUTIONS                   │        │   CRITICAL THINKING          │
│  DECIDE ON THE SOLUTION      │        │   CREATIVE THINKING          │
│  DRAW UP AN ACTION PLAN      │        │   ETHICAL THINKING           │
│  IMPLEMENT THE PLAN          │        │                              │
│  FOLLOW UP                   │        │              ⇑               │
└────────────⇑────────────────┘        └──────────────────────────────┘
         ┌───────────────────────────────────────┐
         │  EMOTIONS, FEELINGS, INTUITION, INSIGHT │
         └───────────────────────────────────────┘
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**Figure 1:** The proposed Framework for Complex Problem Solving (Hunter, 2019.)

A big advantage of the proposed framework is that each of its elements is extensively researched both theoretically and practically. As discussed above, many of the elements of the framework are already dealt with in various combinations in existing problem-solving training courses so a certain amount of integration is already taking place. The following are brief explanations of the five modes of thinking, emotions, feelings, intuition and insight. The steps are then explained in the context of applying the proposed framework for the implementation of a CPS training programme.

## THE MODES OF THINKING

### Analytical Thinking

Wilson (2016) explains that analyzing is, "Breaking materials or concepts into parts, determining how the parts relate to one another or how they interrelate, or how the parts relate to an overall structure or purpose." This has been the main approach to understanding and solving problems for hundreds of years and has formed the basis of the scientific method that has resulted in thousands of amazing inventions and technologies.

### Systems Thinking

There are two main ways of thinking about a system: as a transformation process and as an open system. From a process point of view the main components of a system are the inputs to the system, the process that transforms the inputs, the outputs from the system, the goals of the system, the feedback of energy and information into the system and the subsystems. The subsystems work synergistically to achieve a common goal or a set of goals for the system as a whole.

Systems are open in that they constantly interact with their environment. So, to understand how a system works one also has to understand how it is affected by its environment and how it affects the environment.

### Critical Thinking

According to the American Psychological Association Dictionary of Psychology, critical thinking is a, "form of directed, problem-focused thinking in which the individual tests ideas or possible solutions for errors or drawbacks." Sternberg (1986) explains, "Critical thinking comprises the mental processes, strategies, and representations people use to solve problems, make decisions, and learn new concepts."

### Creative Thinking

The American Psychological Association Dictionary of Psychology defines creative thinking as "the mental processes leading to a new invention, solution, or synthesis in any area. A creative solution may use pre-existing elements (e.g., objects, ideas) but creates a new relationship between them. Products of creative thinking include, for example, new machines, social ideas, scientific theories, and artistic works".

In the CPS process creative thinking applies especially to the generation of ideas to solve problems, the implementation of these ideas and attempts to overcome barriers to achieving goals.

### Ethical Thinking

The OECD (2018) report, *The Future of Education and Skills*, states that;

"Acting ethically implies asking questions related to norms, values, meanings and limits, such as: What should I do? Was I right to do that? Where are the limits? Knowing the consequences of what I did, should I have done it? Central to this competency is the concept of self-regulation, which involves self-control, self-efficacy, responsibility, problem solving and adaptability".

Furthermore, Thagard, (2010) maintains that, "Ethical thinking should be both rational and emotional. Morality requires both thinking and feeling." Which brings us to the next group of elements of the CPS framework.

## EMOTIONS, FEELINGS, INTUITION AND INSIGHT

### Emotions & Feelings

Damasio (2010), a well-known neuroscientist, maintains that emotions are automatic, unconscious physiological responses of the body to external events and conscious thoughts. Examples of these responses are changes in blood

pressure, pulse rate and adrenaline production. According to him, feelings are how people consciously experience these responses. He points out that there is a very strong link between a person's emotions and that person's ability to think rationally. For example, he found that if part of a person's brain that controls emotions is damaged, he or she will have difficulty in making even simple decisions, which will make it difficult for that person to solve problems. It can be concluded therefore that emotions are critical for effective decision-making and problem-solving.

However, Goleman (1996) points out that high levels of emotions can have a negative influence on decision making so people should achieve a balance by managing their emotions. He refers to the ability to manage one's emotions as "emotional intelligence."

### Intuition

Intuition is a vague feeling that something is right or wrong, or different from the usual. This feeling appears to stem from unconscious memories of what happened in similar situations. According to Kahneman (2011), people often base their decision-making on their intuition but Kahneman (2011), Meyers (2002) and Thagard (2001) point out that intuition is often flawed and should be backed up with rational thinking. Thagard calls this approach, "informed intuition."

### Insight

Longman's dictionary of contemporary English defines insight as, "a sudden clear understanding of something or part of something, especially a complicated situation or idea." Insight usually occurs after a period of not thinking consciously about the issue (the incubation period). Insights can be especially helpful in understanding problems and generating solutions.

## TRAINING COMPLEX PROBLEM SOLVING SKILLS

In the light of the substantial need for complex problem-solving skills, senior and middle managers should review their training strategies and goals to ensure high levels of employee and organizational performance. One way to do this is to regard training as a complex problem (which it is) and apply the proposed CPS framework according to the steps as explained below. Training is a complex problem as it not only involves the steps that need to be applied but also has to take into consideration numerous factors such as the organizational strategic goals, the content of the jobs, the needs and motivation of the employees, their qualifications and experience, the cost of training, production pressures, and legislation.

In relation to the CPS framework, the systems approach to training is particularly helpful. For example, learners can be thought of from a process point of view in that knowledge and guidance are inputs they receive during training, they process that knowledge and their outputs are the knowledge, skills, attitudes and values they learn and demonstrate through their performance. From a learning point of view feedback to learners is important as it helps them to adjust their knowledge and behavior.

Also, learners are open systems because they interact in various ways with the other learners, the facilitator, the training technology, their managers, supervisors and co-workers and this interaction can help to reinforce what they have learned during training.

## THE STEPS IN THE TRAINING PROCESS

- **Be Aware of the Problem**

Being aware that a problem exists, or might exist, in an organization means that managers have to constantly monitor what is going on in the key areas of their business, their industry and economy. This requires relevant information to determine if there are any deviations from what is normally expected, i.e., from the standards and goals.

In general, complex problems in business organizations occur when there are major changes in the business environment, especially in relation to consumer needs for products and services, competition, supply chains, communication channels, technological changes and changes in work environments. A good example of this step is that managers should be aware that a shortage of problem-solving skills could exist in their organizations especially as a result of rapid technological changes.

- **Understand the Problem**

Assuming that managers are aware that such a problem exists in their organization they need to understand in detail where and when it exists, the extent of the skills shortfall, the causes, and the possible consequences. The problem has to be investigated in-depth and the information gathered has to be assessed in terms of whether it is factual, accurate and up-to-date.

Clearly, systems thinking, analytical thinking, and critical thinking are involved in this step but intuition and insight can also be involved when trying to determine the causes.

- **Define the Problem**

A problem is defined as the gap between the current state and the desired or goal state. In terms of a shortage of CPS skills, the actual and required CPS skills in the organization need to be determined. It is often difficult to clearly spell out the nature of the existing and desired knowledge, skills, attitudes and values (KSAVs) so a number of people usually have to be involved such as the potential trainees, their co-workers, supervisors and managers. The required KSAVs then become the goals that need to be achieved.

- **Think Of Possible Solutions**

It does not necessarily mean that training is the most appropriate solution because a more efficient and effective solution might be to change the people in the organization, such as through transfers, promotions, recruitment and selection. However, let's presume that training is the best way to solve the problem, in which case the solution could be a combination of training methods or techniques. The following are the main types of training techniques that could be considered;

## LECTURES

These would be used for explaining the knowledge content of the course, such as the elements in the CPS framework explained above. Lectures are generally boring so they should be interspersed with examples, Q and A sessions and audio-visual aids such as videos.

## GROUP DISCUSSIONS

A good way of running group discussions is to divide the learners into sub-groups of say five or six and assign problems for each sub-group to discuss. At the end of the discussions each sub-group should appoint at least one member to give a presentation on how the group dealt with their problem. The learners could then make comments and ask questions for clarification. The facilitator in this approach does not participate in the discussions but ensures that members actively participate and clarifies issues relating to the problems where necessary.

## CASE STUDIES

A case study consists of a detailed explanation of a realistic problem situation and could be used to train individual learners as well as groups of learners. The learners study the case, ask questions of the facilitator if necessary and, if in groups, they discuss the problem and give presentations as explained for group discussions.

## BUSINESS GAMES

Business games are similar to case studies but tend to be more practical in that the trainees become actively involved in running the business as a whole and deal with problems relating to the business. The games could be acted out in real life or could be computerized.

## PROJECTS

Projects are an effective problem-solving training technique as long as the trainees are interested in and stimulated by the project. One approach is to give a group of learners a real-life problem that they can work on during their own time and communicate online with each other either as a group or individually. On completion of the project, they could be asked to explain how they have worked through the elements in the CPS framework to arrive at their conclusions.

## ROLE-PLAYING

In role-playing the trainees take on specific roles depending on the nature of the complex problem they are working on. For example, it could be used in a situation that involves negotiating with various parties involved in solving a problem.

## PROGRAMMED INSTRUCTION

Programmed instruction is usually used to convey knowledge content and consists of the following main aspects;

● The learning material is broken down into self-contained and easily understood sections.

● The content to be learned is presented in progressive steps of difficulty ranging from familiar to unfamiliar content.

● There is frequent assessment of the learner's knowledge, which helps to ensure accurate learning.

● The learners are able to check the correct answers so there is immediate feedback as to whether they are right or wrong.

● Learners move through the material individually and at their own pace.

● There is no instructor but there is usually a facilitator available for assisting the learners where necessary.

Regardless of whether this method is used or not, it is always advisable to start training with fairly simple problems and work up to complex problems.


## SIMULATION

This involves presenting the group with a problem that simulates or models a real-life situation, which they then have to deal with according to the guidelines. The problem situation could be one that physically replicates the real situation or could be a computer-based simulation (an advanced business game) of a hypothetical business such as Taylorshop, which involves hundreds of variables (Danner et al. 2011.) Taylorshop has been used mainly for researching how people solve complex problems and for assessing peoples' complex problem-solving skills but this type of simulation has the potential to be used for training purposes as well.

Leemkuil et al. (2000) present a very detailed discussion on the educational use of games and simulations for *"solving ill-defined or wicked problems."* They explain an instructional model that consists of six stages which are; describe the context of the problem, determine the constraints to solving the problem, develop case studies, decide on the knowledge base for the programme, provide an opportunity for the students to argue the various issues and finally, assess their learning.

### Learner-controlled instruction

In this method learners are required to investigate the topic by searching for information on their own using sources such as the Internet, libraries, company records and experts in the topic to build their knowledge of the subject.

● **Decide on the Solution/S**

In this step the training methods to be used are decided. A combination of training methods is probably the most effective for CPS training. For example, the training course could consist of;

o a video to explain the various elements of the framework,

o      a case study and

o      in-person, virtual or blended group discussions led by a facilitator.

- **Draw Up an Action/Training Plan**

A training plan or schedule should be drawn up indicating the venue, dates, content of each session, breaks, the audio-visual equipment needed, the duration of each session, the name of the facilitator, assessments and planned follow-up sessions.

- **Implement the Plan**

The people responsible for each aspect of preparing for and running the course should then implement the plan.

- **Follow-Up**

Follow-up is essentially checking whether the training programme is being implemented as planned and taking corrective action when necessary. Follow-up should take place during training (usually through assessments), at the end of the course or programme and some time (say one or two months) after the training programme to determine whether the training has resulted in improved performance. If it is found that further training is needed additional training sessions could be arranged.

## DISCUSSION

Although it has been well established that there is an international need for people who are skilled in solving complex problems, recent research shows that far more needs to be done to train people effectively in complex problem-solving skills. A significant number of problem-solving training courses have been on offer internationally over recent years but they tend to focus on specific aspects of complex problem-solving rather than treating it holistically by dealing with all the important aspects of CPS, such as those in the proposed CPS framework.

CPS is by definition complex, which means that adequate time needs to be allocated to training CPS. The duration of most of the courses analyzed in the training course surveys is two days, which may be adequate for teaching people to solve simple problems but it is unlikely that CPS can be trained adequately in two days. At this stage, it is not clear how much time should be allocated to CPS training courses but it is probably at least four days. The duration of a CPS course would depend on a number of factors such as the training techniques used and the capacity of the learners to absorb the concepts and develop the skills. Also, it should be kept in mind that learning a complex skill such as CPS will take a great deal of practice, which means that CPS training programmes should probably last months rather than days.

A matter of concern relating to the results of the two training course surveys is that the number of universities offering problem-solving courses decreased from 50 to 5 between 2019 and 2021. This was probably a result of the Covid-19 pandemic but hopefully when it is over universities will offer complex problem-solving programmes over an extended period.

## LIMITATIONS

The proposed CPS framework does not claim to be all-inclusive as it does not mention aspects such as collaboration, motivation and communication but these aspects could easily be incorporated into the training of CPS.

## CONCLUSION

It is clearly important that organizations investigate their need for CPS training and if they confirm that there is such a need they should design and implement effective CPS training programmes. CPS training should be a team effort involving CEOs, HR managers, training managers, line managers and possibly university academics and private training consultants. Furthermore, it is also important that a learning environment is created within the organizations so that designated employees are given the opportunity to learn CPS skills and are provided with the necessary support and encouragement to apply what they have learned.

## CONFLICT OF INTEREST

The author declares that there is no conflict of interest relating to this article.

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