

Creating Potential Problems: Knowledge, Experience and Critical Thinking

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Abstract: Problem finding is a critical stage in the entire thinking process: without problem finding, there would be no problem solving. However, while people continuously try to find ways to be more creative in problem solving and have published volumes of studies on the subject, very few theoretical or empirical studies have focused on problem finding. Moreover, among the three general levels of problems, that is, existent, emergent and potential, the least amount of attention has been placed on the last. While industries are increasingly concerned about creating (or inventing) potential problems in order to develop new directions and opportunities, it is worth putting more effort into how to nourish this capability. By reviewing different perspectives on the topic, this paper first illustrates the definitions of problem finding, and the situations and levels of problems. It then discusses the current problems in problem finding. Through a case study examining the experiences in problem finding of a group of part-time engineering and product design students in Hong Kong, this paper indicates that developing the capability of problem finding, especially of creating (or inventing) potential problems, requires three crucial elements: a wider knowledge, rich experiences and a critical mind.

Key words: *Problem Finding, Potential Problem, Critical Thinking*

1. Introduction

In recent years, more researchers and thinkers have considered the quality of thinking. While the focus has been placed on problem solving, problem finding as an area in the thinking process has relatively been less considered. One reason for this may be that, compared with problem solving, problem finding seems less relevant to the final outcome of the thinking process. In fact, as early in 1938, in his book *The Evolution of Physics*, the great scientist and inventor, Albert Einstein, had already asserted that "The formulation of a problem is often more essential than its solution, which may be merely a matter of mathematical or experimental skill. To raise new questions, new possibilities, to regard old problems from a new angle, requires imagination and marks real advance in science" [1]. In 1959, in *Productive Thinking*, Wertheimer had also already pointed out that the function of thinking is not just the solving of actual problems but the discovering of new one. He further pointed out that envisaging and formulating the productive question is often a more important and greater achievement than finding the solution to a set question. Similarly, in *Originality*, Mackworth declared that an activity like problem finding would seem to be close to the heart of originality in creative thinking [2]. In addition, in

Creativity's Compass, Jay and Perkins stated that the act of finding and formulating a problem is a key aspect of creative thought and performance in many fields, an act that is distinct from and perhaps more important than problem solving [3].

Few would dispute that a person who is good at generating creative solutions to defined problems is a creative thinker. However, if neither this person nor any other can find any problem for this "creative" person to solve, his or her creative as well as critical thinking talent would never be expressed. In other words, without people who discover problems, there would be no creative solutions. Thus, the act of discovering the problem is the first step in knowing [4], and the first step in creative activity and problem solving [5]. Also, a good thinker can be a person who is able to solve problems creatively, but equally one who can critically find problems using his or her initiative.

2. Problem Finding

2.1 Definitions of Problem Finding

The terms related to problem finding are varied. Some people prefer to call it problem identification, while some may call it problem sensing, problem invention, problem creation, problem formulation, creative problem discovering, problemizing, etc. [6-10]. Problem finding can be understood in various ways. It entails sensitivity to needs or an awareness of possibilities in a given situation. It may demand focusing and clarifying a problem or analyzing data to determine a broad issue underlying several seemingly disparate situations. It may also include an evaluative component, selecting which problems are worthy of pursuit and further development [11].

2.2 Situations of Problems

In his numerous studies of creative thinking, problem finding and creative achievement, Getzels has argued that there are two main types of problem situations in terms of the degree to which the problem, method, and solution are already known: that is, *presented* and *discovered* problem situations [12-14]. For example, different from industry, which most of the time is required to discover new problems to gain profits, many school problems can be considered presented problems. This is because, in general, teachers already know the methods and solutions of the problems presented to the students. On the other hand, creative activity in art and science would exemplify some degree of discovered problem situation. That is, the central question becomes "How is a new problem discovered?" rather than the more usual question "How is an existing problem solved?"

2.3 Levels of Problems

By considering different degrees of the existence and nature of related activities, Dillon distinguishes problems into three levels: *existent*, *emergent*, and *potential*. An existent problem is evident: a problematic situation exists [15]. The key appropriate activity is to recognize the situation and solve it. This level of problem needs little or no problem finding. The problem is obvious and demands a solution. For example, there is little need to engage in problem finding when faced with a provided mathematics question. Although there may be some redefinition of the problem, the general problem is obvious and evident.

An emergent problem is implicit. This means that this kind of problem must be discovered before it can be solved. The appropriate activity is to probe the data for a hidden, unclear or incipient problem or solution. Emergent problems are important to persons dealing with complex situations and data. For example, a technician must discover "what the problem is" when he or she examines an out-of-order machine before setting out to solve it. Also, as Treffinger states, in dealing with emergent problem, a problem finder is necessary for exploring,

searching and examining all of the data in a given "mess", to identify problems to address. Different from existent problems, in emergent problems problem finding is necessary before problem solving can take place [16].

A potential problem does not yet exist as a problem. Its elements exist and may strike the problem discoverer as an unformed problem, interesting situation, or idea worth elaborating upon. As stated by Starko, perhaps potential problems are most clearly seen in the process of invention process [17]. In short, by examining the elements, the problem discoverer can create (or invent) a problem where no problem previously existed. As with an emergent problem, problem finding is necessary for potential problems.

3. Current Problems in Problem Finding

There are several problems in the current practice of problem finding. First of all, few people recognize the importance of problem finding [18-20]. This results in the unbalance development of different stages in the entire thinking process. Simply, as mentioned in the introduction, without problems to identify, there would be no investigations, analyses, solutions or evaluations. This is also the crucial problem that industries nowadays face. Many directors of corporations, for example, electrical and electronics corporations, agree that they do not lack people to carry out good investigations and accurate analyses on collected data, and to produce feasible solutions for some well-defined problems. What they really lack are people who can critically bring new directions to development — new problems to solve — which can push the corporations to reach further business goals and new market profits.

Due to shortcomings in experience and research, studies and training on problem finding can easily lack focus and direction. In detail, problem finding includes different elements and activities such as conceiving a problem, defining a problem statement, and formulating a problem [21]. However, when we review the current systems of education and professional training, we cannot deny rarely do curricula and programs stress these different areas.

In addition, as discussed above, problems can be categorized into three levels. Today, the focus is always put on *recognizing* existing problems and *discovering* emerging problems. For example, in current school education and in-service training programs, the emphasis is always on requiring students or trainees to recognize a problem so that they can solve it, or on requiring them to examine data that has been provided and discover a problem to solve. However, less attention is put on how to reinforce the capability to create potential problems.

4. Case Studies in Hong Kong

Since the mid 1990s, several studies have been carried out in Hong Kong on the problem finding capabilities of design, technology and engineering students, and on industry's need for this capability [22-25]. Regarding the nature of the subjects and the characteristics of their future careers, these types of students are, in fact, supposed to be good at problem analysis and solving, or to have been trained to be so.

4.1 New Industry Requirements

The study findings indicate that there have been changes in the job requirements in the design and engineering industry, especially the latter [26]. In the past, designers were only required to use their creative minds to generate ideas to solve problems that had been provided while engineers was only required to solve problems based on their technological and engineering knowledge and experience. Today, designers and engineers are more often

required to initiate directions for design and production, even when they do not work at the supervisory level. In current post-industrial societies, such as Hong Kong's, characterized by a high degree of competitiveness and rapid changes in the direction of development, employees are more often required to show initiative in the area of "What should be done?" rather than of "How should it be done?"

4.2 Weakness in Problem Finding

However, the study's findings further indicate that students (the graduates) nowadays are weak in problem finding, although they have good analytical skills and some are creative in problem solving. The results also indicate that the major cause of this weakness is that the educational system, which always emphasizes the results rather than the process, provides little opportunity for students to gain experience in problem finding, from the elementary levels of education to in-service training. Although curriculum or program planners always emphasize the importance of preparing students or trainees to be more creative, the focus is still mainly on training students or trainees to generate solutions to predetermined problems. Most of the time, the only problems addressed at school or in places of training are those that have already been defined, so that problem finding behavior is not likely to emerge there (Figure 1).

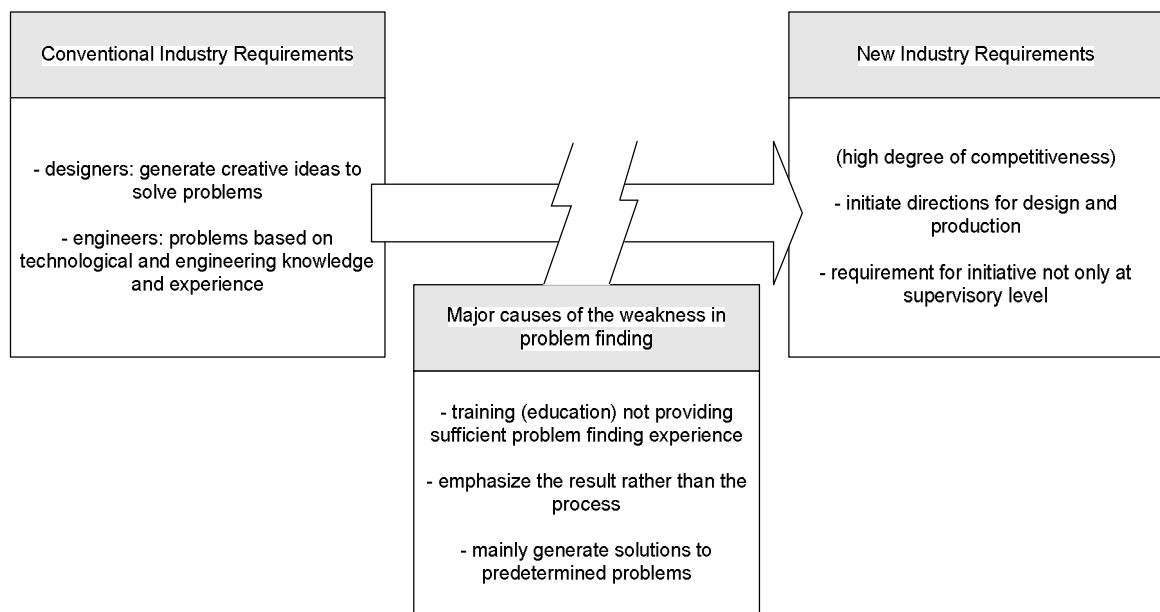


Figure 1. Changes of Industry Requirements, and Major Causes of the Weakness in Problem Finding

5. Study of the Capability of Problem Finding

One key suggestion of these studies is to explore how such a weakness might be remedied. For this reason, a study was carried out to examine the difficulties of problem finding, and how this capability could be nourished. In order to obtain more insights to benefit the industry, the samples for the study were part-time students, who had already completed a certain stage of their education and were working in the industry.

Since 2000, a part-time engineering and product design program has been offered to designers and engineers who work in the industry with different durations of working experience, that is, from one year to more than 15 years. In the program, all students are required to take a compulsory subject on design. Besides providing knowledge and experience to students on how design relates to cultural and social factors, another key objective of the subject is to motivate and help this group of working students develop a problem finding capability. The

students are required to tackle a project. Different from the common practice of project supervisors providing well-defined scopes, directions, topics or data sets, the students are required to identify problems on their own and then to propose solutions. Instead of simply recognizing existent problems, the students are encouraged to discover emergent problems and create potential ones.

In order to provide a great deal of freedom to students in problem finding as well in other kinds of thinking activities, the only guidelines provided to the students are that their project problems should be related to the daily life of Hong Kong people (that is, to meet the subject's objectives) and that the projects should be finished within the duration of the course, that is, thirteen weeks (excluding the last week for project presentation).

5.1 Method

A study of the design subject was carried out to evaluate the problem finding experience of the students (see Figure 2). During the first lesson of the subject, a survey was carried out of the whole group of students to understand their previous experiences in problem finding. A total of 19 students responded to the survey questions, 14 of whom were males and five females. The majority came from an engineering background, while three came from a design background.

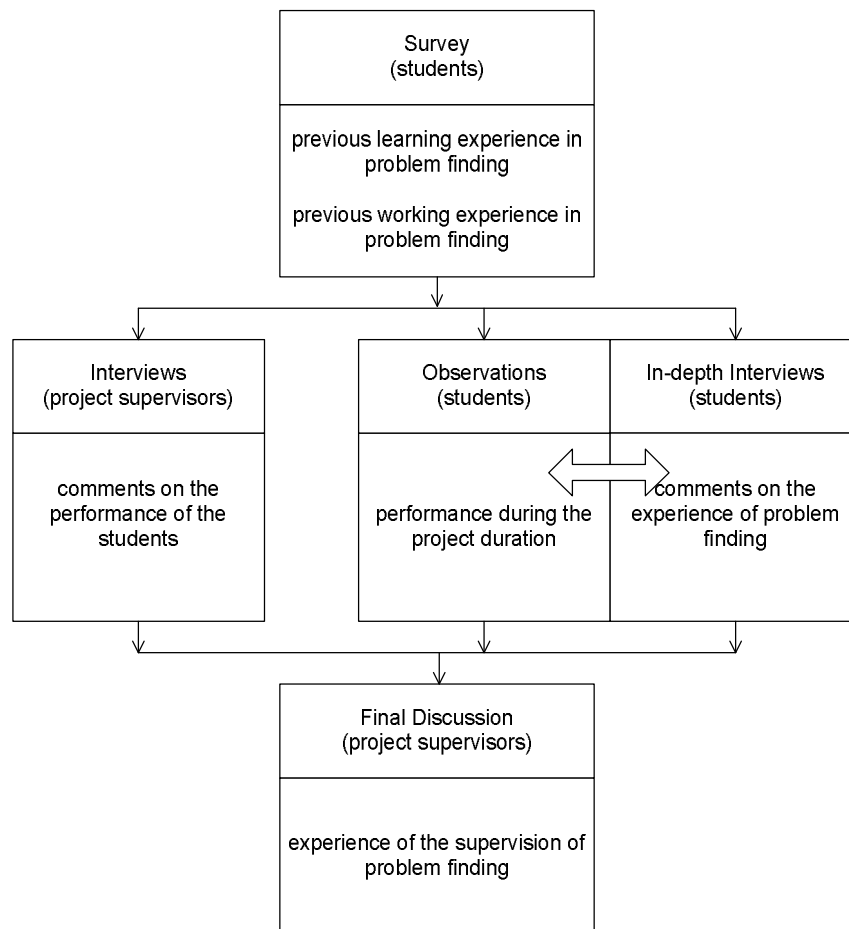


Figure 2. Study of Problem Finding Experience of the Students

The core activities of the study were observations of the students' performance during the project period and in-depth interviews of some students who had voluntarily participated in the study. Four of them were invited for the interviews. The reason for holding the interviews was to clarify the collected data and to seek more in-depth

data.

Apart from the subject professor (the author), there were two more part-time project supervisors who were product designers and who had rich experience and success business in product design and development. The part-time supervisors were asked for their comments on the performance of the students during and at the end of the project duration.

5.2 Results

Overall, there were no significant differences between the responses of male and female students in the survey and the interviews. There were also no significant differences in the project performance between male and female students.

The students with a design background had received experience in problem solving. When asked about the situations and levels of the problem finding in which they had been involved, they did not have any idea how to answer. After the terms and definitions were clarified, they agreed that they had only been involved in the problem finding activities related to existent and emergent problems. This means that, in their previous learning, their supervisors or tutors had provided them with a fixed project title or with a situation for which they were to identify a project and to solve it. Few of the students with an engineering background had got experience in problem finding (that is, project title/topic identification). Their experience was in tackling just one provided title or selecting a title from a set of titles. Several students had gained other problem finding experience only in extra-curricula activities.

Before the project started, most of the students in general had the perception that problem finding was not so difficult, or at least that it should not be more difficult than problem solving. Some also pointed out that this kind of capability could be gained when they went out to work. In fact, these kinds of perceptions can give some hints of why problem finding activities are so rare or of relatively less concern in school and in places of training.

Regarding the students' performance on the whole project experience, the supervisors noticed that nearly all of the students had difficulties in problem finding. The students, including those with a design background, did not have the confidence to find a problem on their own. The students always came to their supervisors to check whether the problem they had found was a good one. Regarding the time the students spent conceiving the problems and formulating the problems to the final project titles in a 13-week project, the mean value was five weeks. Two students needed to spend eight weeks formulating their project titles. During the project period, some agreed that problem finding was much more difficult than they had thought when they actually attempted to it.

The detailed findings of the study can be summarized, as follows:

- Before the students had actually started their project, and even after the supervisors had clearly explained the situations and levels of problems to the students, some were still unable to distinguish *existent*, *emergent* and *potential* problems. In particular, some of the students wrongly understood emergent problems as potential problems. This situation began to change when the students began their problem finding and brought their found problems to the supervisors for discussion.
- The supervisors observed that most of the students were good in analytical skills. However, how to collect the related data or how to critically organize and select the data for consideration were two areas in which the students were weak.
- At the beginning of the project, the students had difficulty identifying problems. One of the major reasons was that the students, especially those who had studied engineering subjects, were seldom concerned

about subject matters and issues outside their disciplines. Many of them only considered matters related to "engineering" or "product/industrial design" as important for their study and career. In other words, they seldom tried to associate other things with their learning and work. This situation changed when the students followed the suggestions of the supervisors to explore more social and cultural issues and observe the daily happenings around them. At the project evaluation, the students agreed that these kinds of explorations and observations allowed them to widen their views and knowledge, and motivated them to explore things they had seldom been interested in. These kinds of explorations and observations further allowed them to come up with more data sets from which they could discover and create "interesting" and "new" problems to solve.

- Another major reason the students felt that problem finding difficult was that many of them had limited experience in problem finding, especially the students with an engineering background. The past project requirements of the engineering students mostly just required them to "solve" a pre-determined problem, or find out a problem from a set of provided data and then solve it.
- As to the problems (project titles/topics) finally found by the students, 10 could be categorized as potential problems, seven as emergent ones and two as existent ones. The fact is that, in the first three weeks, 15 out of the 19 students could only submit existent problems.
- During the project duration, some students pointed out that they had tried to discover an emergent problem or create a potential problem that was implicit. However, this "implicit" nature resulted in difficulties for them in ascertaining whether what they had discovered and invented "was a problem". Moreover, such problems were too implicit, which made it difficult for them to propose solutions. Some students agreed that, once they had found a problem, they would probably have difficulty proposing solutions to it (that is, to finish the project). They would then give up and try to find another more explicit problem, to which the solutions would also be more explicit.
- The students sometimes felt frustrated, since it was difficult for them to judge "critically" whether a problem was good (that is, correctly identified or defined) or not. In other words, there was no systematic way to allow them to judge whether or not a problem was good. The students agreed that, if it was difficult to judge objectively whether or not a solution was good, then judging a problem objectively should be even more difficult.
- The students also found difficulty in converting a problem or several problems to a project title. Borrowing Jay and Perkins' definitions, the students found difficulty defining and formulating the actual problem statement (or problem topic, title, brief) and carry out continuous problem reformulation [27]. This was the reason why some students always submitted several problems to the supervisors and requested their help in making a decision.
- Nevertheless, different from the beginning of the project when nearly all of the students had requested supervisors to provide them with a fixed scope or a clearly defined project title, in the end more than half of the students indicated that they would prefer to identify project titles by themselves in the future. Moreover, some students stated that finding problems by themselves provided them with more space to develop their thinking and imagination. They stated that if a problem (a project title or a set of titles) was determined by their teachers, the latitude for thinking would be narrower.

6. Conclusions

The issue of problem finding should be examined on two levels: the ideological level, which relates to people's perceptions of problem finding; and the practical level, which relates to the implementation of problem finding. That is, the crucial first step in strengthening a person's problem finding capabilities is to change his or her general misperceptions. Although some may not agree that problem finding is a more important and greater achievement than solving a set question, it seems quite inappropriate to hold the perception that problem finding is a "second class" or "may or may not be needed" stage in the thinking process [28]. To change a person's misperceptions of problem finding, one of the best ways is to allow and encourage him or her to have more practice and experience in the process. The study's findings indicate that the problem finding activity made the students (including those who had worked in the industry for a long time) change their perceptions and attitudes of problem finding. While the students gained more experience in problem finding, they had a better understanding of the difficulties involved. They recognized that problem finding was not an in-born or easy skill, as they had originally thought.

Second, problem finding involves conceiving and envisaging the problem, defining and formulating the actual problem statement and assessing the quality of the continuous formulation of the problem and its solution. All of these require an individual or a group of problem discoverers (or observers) to have a comprehensive knowledge of different areas, rich experience in problem finding and also a critical mind. Without comprehensive knowledge, problem discoverers may have a narrow perspective. This would make it difficult for them to be "sensitive" to their surroundings and to have sufficient knowledge to make judgments and carry out analyses. Without experience and a critical mind, problem discoverers will not have sufficient confidence to go further to define and formulate problems, and to make critical judgments on the collected data.

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