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Proposing a Learning Method to Deal with Ill-Defined Problems in The Real World According to The Characteristics of the Design Problem

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Abstract

The The real world is characterized by deep similarity and interdependence with ill-defined problems, observable in different contexts. Every day, thousands of ill-defined problems are analyzed by people in various sciences, and among the solutions, one is chosen for implementation. Addressing such questions requires a unique ability, and this feature creates a distinction between professionals and beginners in the relevant field. Therefore, the ability to identify such problems is very important, because solving these problems with a limited vision may lead to an inadequate and incomplete solution, which sometimes leads to irreparable consequences in various fields. For this purpose, educational design models were examined in this research. This study was conducted according to the characteristics of the design problem, with the aim of choosing a suitable model to address and solve ill-defined problems in different areas of the real world.

Keywords

Ill-defined Problem in the Real World, Instructional Design, Constructivist Learning Theory, Design Problem, Wicked Problems.

Introduction

Encountered across various fields, problems with inappropriate structures often involve elements that are ill-defined, lack clarity or adequacy in the problem description, and do not provide the necessary information for resolution. In simple, well-structured problem-solving scenarios, assessment is straightforward due to the presence of a single correct answer. However, in complex, ill-structured problems, assessing performance becomes more complex, often requiring collaboration among teams of experts and specialists over an extended period to achieve a viable solution. Unlike well-structured problems, where problem conceptualization and solution are separate processes, ill-structured problems intertwine these aspects, complementing and evolving in tandem (Chi & Glaser, 1985; Eseryel, 2006). Problem framing is pivotal in fostering knowledge and innovation, especially in the modern environment where problems are often ill-defined. Structurally ill-defined problems come in various forms that we encounter in our daily lives. They transcend specific content domains and their solutions are often unpredictable and non-convergent. These problems may necessitate the integration of multiple elements from diverse disciplines. For example, addressing issues like pollution may involve elements from mathematics, geography, political science, and psychology, potentially leading to numerous alternative solutions (Wood, 1983). Engaging with such problems as part of daily exercises can be both interesting and meaningful for learners as it helps them grasp the knowledge and skills required to define and address the problem effectively. These types of problems typically have vague or undefined goals and unstated constraints, making them prevalent in real-world scenarios involving both technical and societal issues. By tackling ill-defined problems, individuals can develop a deeper understanding of the complexities involved and cultivate the critical thinking and problem-solving skills necessary for navigating the intricacies of today's challenges (Batres, 2022; Wood, 1983). In such issues, it provides multiple solutions and different problem-solving methods, or it may not have any solution at all, and there is no consensus.

Flexibility is defined as the ability to assimilate information and concepts previously learned to create new solutions for new problems. This skill is vital for success in inappropriate domains where different concepts converge simultaneously to understand a complex issue. Having multiple criteria for evaluating solutions, the absence of initial conditions, and the presence of elements in various related domains are observed when dealing with such issues. Given their interactions and relationships, this is crucial (Rhodes & Rozell, 2017; Spiro, 1987; 1988). The ability to achieve this level of flexibility in effectively dealing with such problems is possible through proper training in various fields by employing a suitable and reliable educational model.

Examining the instructional design process leads to improvement in designing instructional models (Richards & Cameron, 2008). An active instructional design provides structured and designed learning experiences. A well-designed and tested instructional design creates opportunities for meaningful content areas to emerge (Major & Palmer, 2001; Reilly & Reeves, 2024) Given the importance of designing a good educational system in facing poorly defined issues in the real world, the significance of examining the existing methods in instructional design, their characteristics, advantages, and disadvantages at this stage is undeniable.

Instructional design is a field of human activity related to learning and performance improvement (Costa et al., 2022; Merrill, 2012). Various theories and models have been proposed for instructional design, including constructivist learning theory, situational learning, problem-based learning, narrative-based learning, subject-based learning, and user-centered design theory (Mogens Myrup & Niels Henrik, 1997). Each of these models has its own capabilities, but the concern of this research is, on the one hand, the selection and optimization of a suitable learning model for teaching how to deal with ill-defined problems in the real world, and on the other hand, considering that for years, the characteristics of design problems as ill-defined problems are studied and explored by theorists of design sciences, therefore, applying the characteristics of the design problem as a guide to propose.

An effective learning model is crucial in dealing with poorly defined issues in the real world. For this purpose, library research was conducted in order to examine the characteristics of the design problem, identify instructional design models, choose the optimal approach and improve it in dealing with ill-defined problems in the real world.

Methodology

Issues in the real world can be classified into two groups: well-defined and poorly-defined problems. Often, due to the lack of differentiation between these two groups, poorly-defined problems are formulated and solved using superficial methods, leading to irreversible consequences in the long run in the real world. Therefore, in this study, through a comparative and library study method, the nature of such problems in the real world and the alignment of the characteristics of such problems with inherently open-ended design problems were examined. It was proven that poorly defined problems in the real world and design problems can be classified into one group. The most important achievement of proving this fact was relating the characteristics of design problems to such problems in the real world to demonstrate the importance of solving such problems as a design problem. Given the importance of teaching how to deal with these issues, in the second stage, the perspective of a theorist on instructional design models in dealing with ill-defined issues in the real world was analyzed. Ultimately, based on the design of an effective educational system, solutions for teaching how to address open-ended problems in the real world were presented.

Poorly Structured Problems in the Real World

Problems that are unpredictable or do not converge to a solution, requiring the integration of multiple contents, Ambiguous or unspecified elements of the problem, Lack of a known degree of certainty (Wood, 1983), Unclear or unspecified goals and undisclosed constraints (Voss, 1987), Possessing multiple potential solutions, solution paths, or having no solution at all, Lack of agreement on the appropriate option, Multiple Criteria for Solution Evaluation, Having multiple criteria for evaluating solutions, Fewer Adjustable Parameters, Having fewer manipulable parameters, Uncertainty about Concepts, Laws, and Principles: Conceptual Uncertainty, laws, and principles for the solution or how to organize them. Inconsistencies in the relationships between concepts, laws, and principles. Lack of general rules or principles governing them: No explicit rules or general principles for them are provided or described. Lack of Explicit Tools for Determining: Lack of explicit tools for determining the existence. Ill-structured problems, by definition, are poorly defined. They represent real-world issues where there is disagreement, conflicting evidence, or contradictory opinions, and a single correct solution does not exist (Kitchner, 1983). Such problems are prevalent in international communications, characterized by multi-faceted decision-making heavily influenced by political issues, making finding the best solution rarely achievable. Instead, they usually have multiple possible solutions, each with its advantages and disadvantages, depending on the individuals involved and the situations in which they are applied. For instance, deciding on a new route on a highway in an urban area generates positive and negative perspectives, and there won't be a single solution. In this specific case, the objective is traffic flow, considering financial and political constraints, raising the question of whether a new highway should be constructed at all (Jonassen, 1997).

The search for scientific foundations to address social policy problems will remain unsuccessful due to the nature of these problems. They are *wicked* problems, while science has developed to tackle *tame* problems. Social policy problems cannot be definitively described. There is no concrete definition of shareholder rights. Policies that respond to social problems cannot be meaningfully right or wrong, and talk of *optimal solutions* for social problems is meaningless unless harsh conditions are first imposed. Furthermore, in the 21st century, there is a strong interest in the nature of wicked problems and the complex tasks of identifying their scope, implementing feasible solutions, and determining appropriate mechanisms and pathways for improvement.

This concern is timely, but over several decades, the perspectives of Rittel and Webber in conceptualizing wicked problems and the necessary political argumentation for their resolution have been beneficial (Crowley & Head, 2017; Head, 2022; Rittel & Webber, 1973).

Given the explanations in this section, the inherent indefinability, multi-content nature, presence of unclear objectives, unspecified constraints, and multifaceted nature of ill-defined problems in the real world have been demonstrated. If these issues are dealt with in a simplistic way and like issues with a specific definition, there will be irreparable consequences. (Proposing a learning method of dealing with these ill-defined problems in the real world using methods of solving design problems in a design process) is the extract of this research work. It should be noted that this research exclusively focused on the nature of the problem.

Instructional Design and Problem-Solving

The majority of experts in the field of education concur on the significance of problem-solving, recognizing that it necessitates a set of skills involving analysis and synthesis (Jonassen & Tessmer, 1996). Instructional design patterns can be categorized into two main approaches: systemic approaches and constructive approaches. Instructional activities are carried out sequentially and precisely, following a linear and chained process, indicating a systemic approach to education. Traditional, systematic, and hierarchical models in educational design assume that problem-solving is based on fundamental components, including concepts, rules, and principles that learners utilize when confronted with challenges (Fardanesh, 2013; Jonassen & Tessmer, 1996). On the other hand, the constructivist approach asserts that problem-solving is a complex activity based on the assembly of its constituent parts (Chang & Kuwata, 2020; Hedberg et al., 2002; Jonassen & Tessmer, 1996). Problem-solving necessarily involves various cognitive elements such as provided information, concepts, rules, and principles (domain knowledge). Conceptual networks and mental models, reasoning skills (constructing/applying arguments, comparison, and inference), and metacognitive skills (goal setting, allocation of cognitive resources, assessment of prior knowledge, progress evaluation/error review) are integral components of it. The need for self-knowledge, expressing prior knowledge, expressing socio-cultural knowledge, articulating personal strategies, and acknowledging predispositions/cognitive weaknesses are also fundamental aspects (Jonassen & Tessmer, 1996; Pham et al., 2023).

This perspective has been extensively examined and substantiated over the years, to the extent that (Arık & Yılmaz, 2020) in a meta-analytical study, demonstrated that constructivist learning and active learning can often be employed in problem-based education in the world. On the other hand, (Bada & Olusegun, 2015; Pham et al., 2023) also confirmed this issue. These definitions indicate that the constructivist approach, on the one hand, is effective in real-world-related education but, on the other hand, lacks a simplistic view of issues. Therefore, teaching how to deal with multifaceted issues in the real world is feasible with this method.

The Similarities between the Characteristics of Design Problems and Wicked Problems

As demonstrated in the previous section, the best approach to learning how to address such ill-defined problems in the real world is through a constructivist learning design approach. Because the approach to the problem in constructivist learning design corresponds to the essence of poorly defined problems in the real world. On the other hand, the nature of poorly defined problems in the real world is in line with the definition of the problem in the design process, and this correspondence helps to better understand and define the solution in the way of learning how to deal with these problems in the real world. For this reason, the essence of design problems was investigated in this section to be effective in understanding ill-defined problems in the real world. Finally, to propose an optimal method in learning how to deal with ill-defined problems in the real world.

For this reason, it is essential to investigate the key characteristics of design problems. Consequently, prominent perspectives in this area were examined in the research:

Lawson (2005) believes that a design problem has both common and unique features. In his view, a design problem is inherently indefinable, and can only be gradually understood through various aspects of the problem. Therefore, creating a diagram for the design process is impossible. This unique characteristic of an indefinable design problem and its ambiguity is indicative of its nature. Another characteristic of such problems is the need for mental interpretation. A design problem is interpreted and examined by each designer based on their expertise and design priorities, as the design process does not have a logical, clear, and explicit method. It is an irregular task that values and evaluates an important and undeniable feature. Additionally, a definitive and correct answer and the best solution in the design process are impossible. Universal agreement on the effectiveness of a solution is unattainable. From Goldschmidt's perspective, design problems are indefinable and ambiguous, lacking a clear and specific solution method (Goldschmidt, 2003; Goldschmidt & Weil, 1998).

On the other hand, in 1989, Goel and Pirolli identified specific and categorized features for a design problem. With these features, the scope of a design question can be somewhat defined.

1. Availability of sufficient information: There is no clear objective in this process. The way and how to transition from the beginning to the goal and the ultimate process is unpredictable.

2. Natural constraints: Inherent constraints exist in the design work in two forms:
a. legal
b. social, political, legal, and economic.

3. Size and complexity of the problem: Design problems are inherently large and complex. Addressing such problems may take days, months, and sometimes years.

4. Constituent parts: Design work has many parts. The larger and more complex it becomes, the more segmented it is considered a definite feature of design work. Segmentation is seen only in a few issues. Designers can develop the ability to segment through practice and exercise.

5. Creating connections between parts: The parts of the design problem are not inherently related. There are ways to relate them.

6. Right and wrong answers: The design problem has no right or wrong answer; rather, it presents better and worse solutions.

7. Input and output: Input provides information about users and conditions of product use. Output includes the characteristics and general shape of the final product. Practical information transforms the input into appropriate outputs.

8. Society's reaction and feedback: There is never a real-time reaction when responding to a design problem. The designer must be able to anticipate the real-world reaction. This reaction will be examined after the design is complete, and the product is in actual use.

9. Cost of mistakes: In the real world, every mistake has a cost, and the cost of errors in dealing with such issues is high.

10. Independent product performance: The desired product's performance must be independent of its designer.

11. Distinction between intended features in the product and the result: There is always a difference between the features a designer intends and the produced product's characteristics.

12. Time gap between specified features and the result: There is always a time gap between the specified and produced product features, where the specified product subsequently leads to the produced product (Goel & Pirolli, 1992).

It is important to note that these 12 characteristics have been the foundation of defining design problems for years, and various theorists have endorsed and validated them.

Furthermore, Rittel and Webber (1973) reexamined and analyzed the defined characteristics of wicked problems differently, resulting in the identification of 10 features after their investigation. It should be noted that in the real world, in fields such as planning, policy, sociology, social sciences, etc., ill-defined problems are notorious for being wicked problems.

1. There is no definitive formula for a wicked problem.

2. Ill-defined problems do not have a definite end point: There is no criterion for sufficient understanding, there is no criterion. A planner can always strive to do better.

3. Solutions to wicked problems are not right or wrong, but rather good or bad.

4. There is no immediate and final test for solving an ill-defined problem.

5. Every solution to an ill-defined problem is a *one-shot operation*. Since there is no opportunity for learning through trial and error, every effort is of great importance. In sciences and fields such as mathematics, chess, puzzle solving, or mechanical engineering design, a problem solver can try different approaches without penalty. The result, whatever it may be, in these individual experiments, does not matter much for the subject system or social process. A lost chess game rarely has an impact on other chess games or non-chess players. Large public works are virtually irreversible and have long-lasting consequences. The lives of many people will be irreversibly affected, and a significant amount of money will be spent on another irreversible action. The same is true for other large-scale public works and virtually all public service programs (Rittel & Webber, 1973). There is no final test for the adequacy of a solution, and any attempt to do so is futile. Addressing these issues is a *one-shot* operation that leaves lasting consequences and creates a new set of problems (Almeida, 2021).

6. Wicked problems do not have a finite set of potential solutions that can be counted (or fully described). There is no criterion by which an individual can prove all solutions.

7. Every wicked problem is essentially unique. For both problems, at least one distinctive feature can be found (just as several features can be found that are common to them), and therefore each of them is unique. However, by *essentially unique*, we mean that, despite long lists of similarities between a current problem and a previous one, there may always be an additional distinctive feature of extraordinary importance. Part of the art of dealing with wickedly defined problems is that we don't know very early which solution we should apply.

8. Every wicked problem can be considered a symptom of another problem. It can be seen as a symptom of another, *higher-level* problem. Therefore, efforts should be made to solve the problem at the highest possible level.

9. The existence of a disagreement can be explained in multiple ways, indicating a wicked problem. The choice of explanation determines the nature of problem-solving. *Worldview* is the most powerful determinant in explaining a disagreement and therefore in solving a wicked problem.

10. A planner cannot afford to make a mistake. In the world of planning and wicked problems, such immunity is not tolerable. Here, the goal is not to find the truth but to improve certain features of the world in which people live. Planners are responsible for the consequences of their actions. The impacts can be very significant for those affected by these actions (Rittel & Webber, 1973).

Complex, defiant, and intertwined problems (such as racism or climate change) are ultimately intractable. Rather than being solved, wicked problems can only be creatively and precisely *answered* by networks of committed individuals and institutions. Indeed, a wicked problem requires a *wicked answer*: a sustainable, emergent and fluid strategy that focuses on changing relationships - with people, space and knowledge. Language is unable to define or describe an ill-defined problem.

Collaborative engagement can be a component of a sophisticated approach to an ill-defined problem (McCarthy, 2012). Complexity implies the degree of difficulty in defining causal linkages of an event as well as determining the boundaries of their effects to allow for management of them with any meaningful degree of accuracy and confidence. Complexity is determined by the degree of uncertainty and social disagreement on a particular issue. A problem at the far end of an uncertainty and disagreement continuum is considered complex because it challenges existing capacities to predict outcomes and solutions, and therefore heightens disagreement resulting in stakeholder conflicts. Complexity can be judged by source and nature. When a problem is generated by multiple factors from multiple sources, it is difficult to target the linkages of the causal factors and therefore raises questions of complexity to the extent that identification of the problem, and hence its solution, becomes difficult. Complexity can also be of a technical and social nature. The technical side relates to limitations of the quality of information and deficiency in existing knowledge systems that make the diagnosis of a particular situation problematic because of the high degree of uncertainties in the solutions offered. The social aspect focuses on inherent difficulties in the coordination of activities, information, and stakeholders across disciplines, sectors, and scales in a manner that minimizes conflicts and builds consensus around solutions for a situation (Pham et al., 2023). Considering these perspectives leads to a comprehensive definition of an ill-defined problem from the design point of view, which can help to identify ill-defined problems in the real world and lead to a better understanding of the nature of such problems in the real world.

Examining the Views of Several Theorists in Dealing with Ill-Defined Problems

Given that the foundation of the instructional model (Integrated constructivist learning theory) revolves around educating individuals to solve complex, undefined problems, David Jonassen proposed six instructional strategies in 1997 to enhance individuals' insights in dealing with such problems (Jonassen, 1997):

1. Problem Analysis: As ill-defined problems have a broader scope and are dependent on structured issues, teaching the analytical approach to such problems is crucial. Exploring solved problems in the domain contributes to a better understanding of the domain's constraints.

2. Introduction of Problem Constraints: Despite the difficulty of understanding objectives and solutions in problems with inappropriate structures, identifying the constraints considered as problems or the requirements that must be present should be analyzed.

3. Location, Selection, and Development of Resources: Teaching the importance of validation in problem-solving and its applicability, considering that the meaningfulness of the answer lies in the location of responding to these problems.

4. Support from Knowledge Base: The most critical aspect at this stage is teaching the integration of multiple perspectives in the nature of problem-solving, creating a network of interpretations and solutions regarding the ill-defined problem.

5. Promotion of Discussion-Inducing Structure: Considering the use of Divergent conceptualizations of the problem (varied problem spaces), various arguments with conflicting assumptions should be examined, and convincing arguments to support critical thinking should be investigated.

6. Evaluation of Problem Solutions: Evaluating ill-defined problem solutions is more challenging than evaluating solutions to structured problems. Learners should be able to explain the causal relationships between solutions and problems and assess the feasibility of using solutions (Jonassen, 2000). Of course, it should be mentioned that her views are the basis for the constructivist method in such a way that recent studies (Aslami & Ojaghi, 2022; Gu et al., 2020; Hong & Lee, 2022; Zajda, 2021) emphasize the validity of her views. Merrill (2012), another theorist in the field of constructivist education design, also believes that the position of the problem is very important in constructivist education design.

This constructivist theory defines the nature of wicked problems. On the other hand, various theorists have different perspectives on how to understand wicked problems. Here, we refer to these perspectives in order to ultimately reach a conclusion on how to deal with such issues in the real world.

Jeff Conklin writes in his work on *Wicked Problems and Social Complexity* (Conklin, 2001; 2006): There are two common organizational coping mechanisms that are typically applied: Tame Problems: Studying the problem and taming it. While studying a novel and complex issue is natural and important, it is an approach that will be futile If the problem is wicked, pure study is postponement, as only by collecting and analyzing concrete data can quantitative information be learned about a wicked problem. Wicked problems require an opportunity-focused approach. They require decision-making and experimentation.

Discussion

Table 1: *Related to examining the coverage of proposed solutions from the processing theories of Jonassen in the constructivist learning theory in teaching how to deal with (ill-defined problems in the real world) based on the 12 characteristics of the design problem.*

Number	12 Design Problem Characteristics	Instruction Features Coverage in Addressing Ill-Defined Problems Based on (Jonassen's Perspective in the constructivist learning theory)
1	Lack of sufficient information	Analyze the problem statement
2	Existence of natural constraints	Introduce problem constraints
3	Size and complexity of the problem	Locate, select, and develop resources
4	The number of constituting parts	Support from a knowledge base
5	Creating relationships between components	Support from a knowledge base
6	Lack of a right or wrong answer	Promotion of Discussion-Inducing Structure
7	Presence of input and output	Evaluate problem solutions
8	Community response and feedback	Lack of adaptability in solution-finding
9	High cost of error	Lack of adaptability in solution-finding
10	Independent performance of the product	Lack of adaptability in solution-finding
11	Distinction between desired characteristics in the product and the result	Lack of adaptability in solution-finding
12	Time gap between specified features and the result	Lack of adaptability in solution-finding

As shown in the table above, the 12 features of the design problem can be attributed to ill-defined problems in the real world, and on the other hand, the degree of coverage of the solutions provided by Jonassen in how to deal with such ill-defined problems in the real world was investigated. If we increase the amount of coverage in learning solutions, the learner will be more successful in dealing with such ill-defined problems. For this reason, a learning model is proposed based on the characteristics of the structuralism learning model and considering the characteristics of the design problems and ill-defined problems in the real world.

As it is clear from the diagram above, in order to achieve a learning model in formulating ill-defined problems in the real world, learning the seven parameters mentioned in the diagram is very important. On the other hand, in order to target this learning, the approach of cooperative interaction is recommended to achieve a better result, which is reviewed in (Figure 2).

Conclusion

Since constructivist learning theory is designed to learn the ability to solve real-world, often ill-defined, problems in fields such as political, social, economic, humanities, etc. (Ally, 2004; Savery, 1994), the constructivist learning model is useful by considering 12 characteristics of the design problem. Therefore, the coverage of this educational model was examined in this regard. On the other hand, by adapting to the 10 features of ill-defined problems in the real world, seven solutions were extracted (Figure 1).

If these solutions are implemented and considered from the perspective of participatory interaction (Figure 2) in problem-solving, dealing with ill-defined problems in the real world is possible.

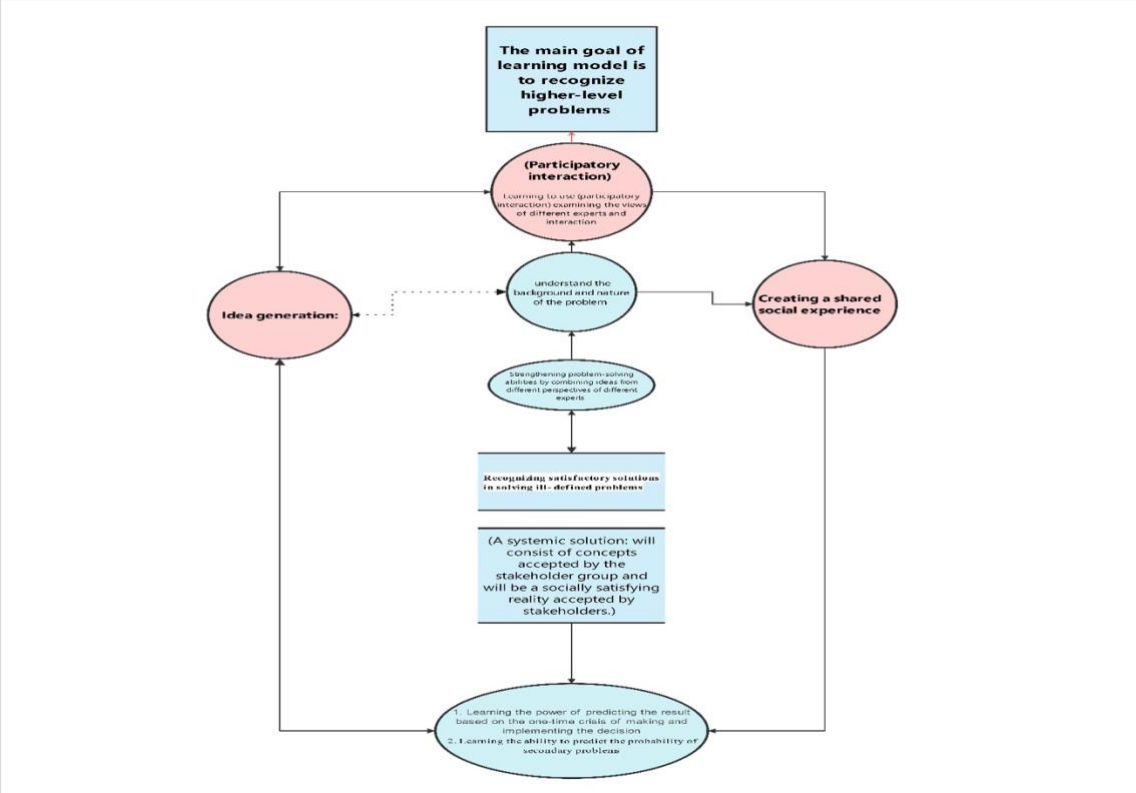

Figure 1: *Strategies for learning how to deal with ill-defined problems in the real world.*

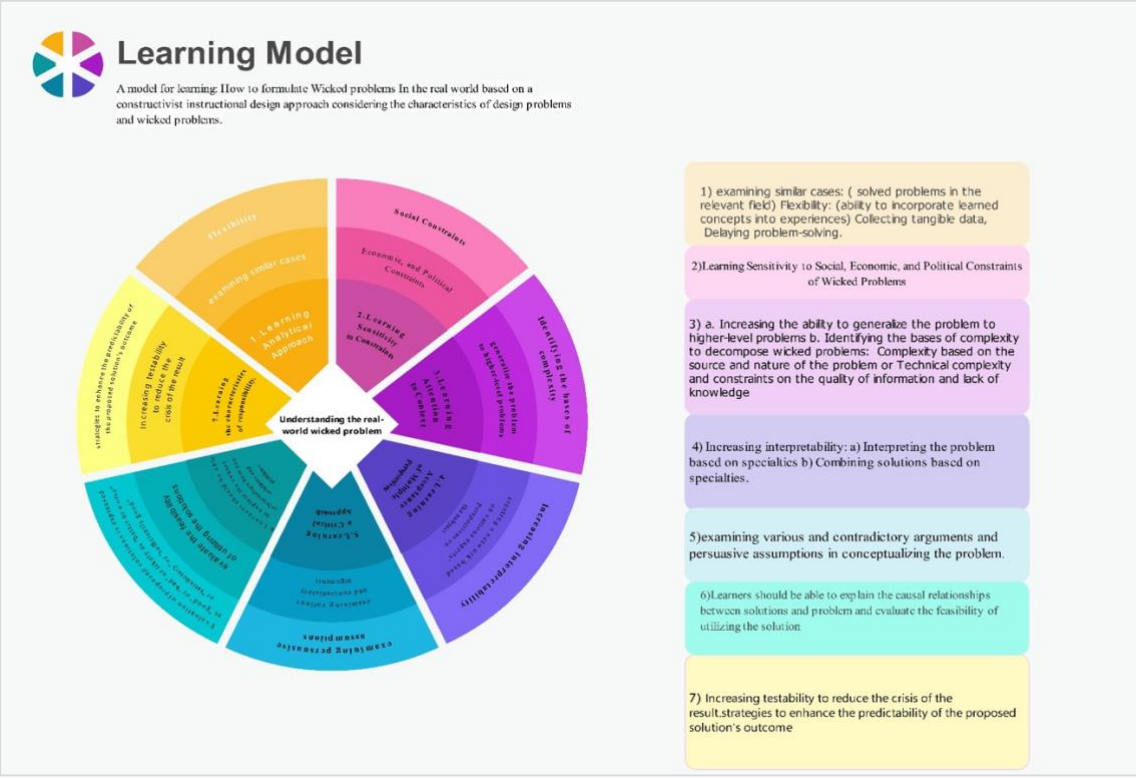

Figure 2: *Learning how to deal with ill-defined problems in the real world based on participatory interaction.*

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