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The relation of complex problem solving with reflective abstraction: a systematic literature review

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ABSTRACT

Complex problem solving (CPS) is a new paradigm in solving problems and is one of the soft skills needed to face the industrial revolution 4.0. Reflective abstraction is associating and modifying pre-existing conceptions into new situations. This article reviews research on CPS and reflective abstraction. This research is needed to know the relationship between reflective abstraction and CPS. The systematic writing of this review was assisted by the Publish or Perish 7 application, Mendeley, and VOSviewer. A literature search was performed through the ScienceDirect and ERIC databases. Based on the search results with the term "complex problem solving" and several exclusion criteria, 58 articles were found, whereas with the word "reflective abstraction" there were 23 articles, totaling 81 papers. Based on the literature review, it was found that there is a relationship between CPS and reflective abstraction by obtaining common ground in the form of prior knowledge. CPS requires prior knowledge from reflective abstraction to integrate the most relevant information. To improve CPS, efforts and special attention can be made to build initial knowledge through reflective abstraction. This article contributes to further research and becomes a study for the themes of CPS and reflective abstraction in learning and education.

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1. INTRODUCTION

The increasingly rapid development of technology, an increasingly complex world, and society make people increasingly face challenges and unknown situations with increasing complexity [1]. The occurrence of the COVID-19 pandemic can be categorized as a complex problem because the COVID virus has a reasonably high complexity, is difficult to manage, and can even evolve in unexpected ways [2]. Globalization and ongoing digitalization are facing increasingly complex societies and environments that demand problems to be solved [3]. A problem becomes complex because of the many interrelated variables that affect the state of the problem. This means that if there is a change in one variable, it will affect other variables and it is difficult to anticipate the possible consequences of an action [4]. So the ability to deal with such situations is needed, namely complex problem solving (CPS) [5]. CPS as a new paradigm in solving problems is one of the ten soft skills that need to be possessed in facing the industrial revolution 4.0 and even becomes very important in the list of job requirements in the 21st century [4], [5]. CPS is fundamental needed as the ability to formulate the issues and make the right decisions in urgent, challenging, and difficult situations [3]. In the 21st century to achieve success requires many competencies, including the ability to solve complex problems [6]. CPS is a new paradigm in solving problems. CPS is a multidimensional set of competencies at a high level of abstraction, such as intelligence, but beyond a person's IQ [6]. CPS is a cognitive process and an emotional process [7] and is highly dependent on one's motivation. CPS is a problem-solving process that is formulated as interrelated elements of a complex system. CPS is the process of identifying complex problems as well as developing, evaluating, implementing potential solutions [8].

Complex problem solving has become an ability that is measured in the Program for International Student Assessment (PISA) assessment, an assessment organized by the Organization for Economic Cooperation and Development (OECD). OECD/PISA chose to describe cognitive activities that are included in competencies based on three competency groups, namely reproductive clusters, connection clusters, and reflection clusters [9]. CPS is contained in the reflection cluster. CPS is in a reflection cluster where this group includes an element of reflectivity to students about The process needed to solve problems, namely the ability to plan situation solving strategies and implement them that contain more elements and are more original, different from other clusters [9].

CPS requires a variety of diverse abilities: cognitive (ability to experiment, gather information from many sources, process it in a short time, and make several decisions simultaneously), personal and emotional (ability to act in new and undefined conditions, inner readiness for a wide range of action outcomes, including unexpected results—both positive and negative), social skills related to understanding and considering the intentions and actions of many people – partners, allies and foes. Thus, problem-solving and complex decision-making are two distinct fields dealing with different and complementary aspects of reality.

In mathematics, there is an essential process called abstraction to organize previously built concepts into new concepts [10]. Abstraction is needed in building mathematical concepts. According to Piaget, abstraction consists of empirical abstraction, pseudo-empirical abstraction, and reflective abstraction [11]. Empirical abstraction focuses on constructing meaning and characteristics of an object (concentrating on objects and their properties). Pseudo-empirical abstraction focuses on establishing definitions and characteristics involving an object (focusing on actions on objects and properties). Reflective abstraction focuses on ideas, activities, and operations (focus on mental objects) [12].

Of the three abstractions, reflective abstraction is the most important because it is the basis of all the development of mathematical thinking and is the highest form of human thought [13]. Reflective abstraction is an abstraction to explain the construction of new, higher-level knowledge. According to Piaget [14], building reflective abstractions is very important to explain the structure of mathematical concepts. Reflective abstraction explains how to build mathematical concepts based on previous mathematical concepts. The ideas generated from reflective abstraction become materials for building higher concepts [15]. Reflective abstraction is a new construction because it shows a different type of abstraction from the classical view of abstraction, such as empirical abstraction or simple abstraction. Knowledge built through reflective abstraction is qualitatively different from the knowledge it builds [14]. It can be said that mathematical concepts can be created through reflective abstraction.

Literature studies on CPS and reflective abstraction have been carried out separately in recent years. Previous research on literature review was a meta-analysis of the correlation between CPS and intelligence as a form of abstraction [16] and research related to reflective abstraction and problem-solving. The research on reflective abstraction that has been carried out includes reflective abstraction in computational thinking [11] and analysis of reflective abstraction in solving mathematical problems. Therefore, this research will review the literature on the correlation of CPS with reflective abstraction by presenting the literature on CPS and Reflective Abstraction regarding their influence, relationship, and contribution by finding common ground between CPS and reflective abstraction.

Complex problem solving and reflective abstraction are important cognitive abilities that play a role in mathematics. However, can the two be connected? Therefore, the research question posed in this study is how is related CPS to reflective abstraction. The research in the form of a literature review is intended to examine the relationship between CPS and reflective abstraction. This research is helpful for readers to find out how CPS is related to reflective abstraction. This literature review can also be used as a basis for further research related to CPS and reflective abstraction. In addition, this research benefits teachers by providing information about good learning to improve CPS and reflective abstraction so that teachers can prepare effective learning models, media, and tools to improve CPS and reflective abstraction.

2. RESEARCH METHOD

The research method used is a literature review with a systematic approach designed to analyze the relationship between CPS and reflective abstraction. Systematic literature review is a scientific process for systematically reviewing something written to answer a particular research question [17]. The systematic review process is characterized by the presence of several criteria used to limit the scope of the review [18].

Systematic literature search to identify all studies reporting complex problem-solving and reflective abstraction. Systematic search through the electronic databases ScienceDirect and ERIC where Scopus indexed articles using the keywords "complex problem solving" and "reflective abstraction". In addition, we also used an ancestry method based on reference lists and citation records from all included studies and screened to identify additional papers that might not meet the requirements when searching for criteria.

Based on a search on ScienceDirect with the term "complex problem solving" from 2010 to 2022, 1,015 papers were obtained, and if limited to only journal articles, 774 papers were accepted. If it is focused on the title with the term "complex problem solving", only 28 reports are obtained. Meanwhile, in the ERIC database with the phrase "complex problem solving" and limited to the last 10 years, 147 papers were received. After searching the ScienceDirect database and ERIC, then downloading it in Bitext form, entering it in Mendeley, and checking for duplicates; finally, 58 papers were obtained. While the search results with the term "reflective abstraction" listed in the keywords, abstract, and title obtained as many as 63 in the ScienceDirect database and 53 in ERIC, so that the total is 116 papers. The data is stored in Bitext and uploaded to Mendeley. After checking for duplicates, 93 documents were obtained with nine replications. One by one, the articles were reviewed and re-sorted by limiting them to only reflective abstractions because they still only contained abstractions or were reflective, so that 23 reports were obtained. In selecting the final article to be reviewed, the researcher examines the title, abstract, and full text. It aims to provide a comprehensive and relevant systematic review of the topic to simplify the selection process because unsuitable articles are eliminated. A total of 81 papers, from 58 CPS themes and 23 reflective abstraction themes, meet the included criteria, which will be reviewed in more detail. The researcher analyzed to answer the research questions and identified the year of publication, the nationality of the first author, the type of research from the 81 papers. For more details, it can be seen in Figure 1.

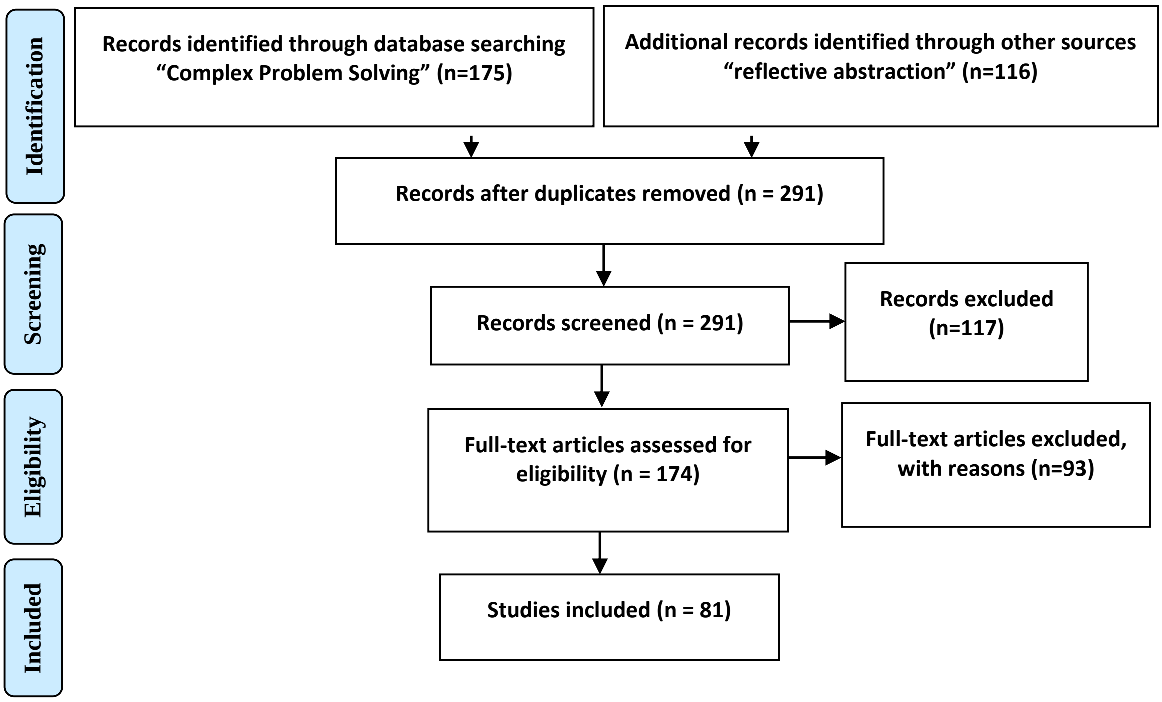

Figure 1. Flowchart of review process [19]

3. RESULTS AND DISCUSSION

The number of articles that meet the included criteria is 81 papers from 58 CPS topics and 23 reflective abstraction topics. Researchers conducted an analysis related to the results of the research paper, as shown in Table 1. Articles about CPS until 2022 tend to increase even though it fluctuates, while articles related to reflective abstraction tend to decrease. In 2020 the year the most reached 29.41% representing many papers related to CPS, and in 2018 reached 42.10% published the most articles related to reflective abstraction. Research associated with CPS can be predicted to increase. As for the topic of reflective abstraction, the trend tends to decrease, but it does not rule out the possibility of being a gap or opportunity to bring up the issue again. The research on the highest CPS came from Germany, reaching 44% of 34 papers, while research on reflective abstraction at 58% came from the US from 19 articles. This identification is based on the country of origin of the first author. The countries that contributed the highest number of documents related to CPS and reflective abstraction came from developed countries, namely the US and Germany. The dominant CPS topics obtain for this type of quantitative research and literature review. In contrast, reflective abstraction was dominated by qualitative research. However, it is still found that these topics are used for other types of study, such as development and design research. From the journal publications, it can be seen that the literature on CPS publishes the most in journals indexed by Scopus Q1.

Table 1. Summary of research findings of the included studies

Type of content	References
Relation CPS to knowledge	i) in the CPS process, knowledge is used to understand problems and is applied to achieve goals [20]–[22]; ii) knowledge development is required for complex problem solving [23]; iii) the knowledge possessed, and the environment can stimulate CPS abilities on cognitive and environmental factors [7], [24]; iv) knowledge is built through abstraction to complex problems solving [25]; v) acquiring knowledge of the problem becomes the relationship between intelligence and the application of knowledge in the CPS process [26]–[28]; vi) CPS includes a large number of human higher-order cognitive processes [29]; vii) CPS is related to knowledge and understanding [27], [30], [31]; viii) the importance of knowledge tracking in CPS [32]; ix) there is influence of knowledge and cognitive ability on CPS performance [33], [34]; x) there was no interaction between CPS ability and gender, even though there were differences in math ability [35]; xi) knowledge of the problem will have a positive impact on the success of CPS [1]; xii) through learning can develop skills and experience in dealing with CPS [36]; xiii) metacognition plays a role in increasing motivation in the CPS process [37]; xiv) the roadmap helps the cultivation of knowledge and skills in CPS [38]; xv) problem-solving-based mathematics textbooks can increase knowledge in CPS [39]; xvi) the use of technology in learning can encourage knowledge in CPS [40]; xvii) the contribution of knowledge-based students by making examples based on their own experiences can train students' CPS [3], [41]; xviii) intelligence is highly correlated with CPS performance if the level of knowledge is moderate and has a small correlation if knowledge is very little or very much [16], [42]; xix) CPS as the application of knowledge and skills in the real world [43]; xx) knowledge as a basis for decision-making on CPS [44]; xxi) CPS is a combination of ability and knowledge [45]; xxii) the knowledge, skills, attitudes, and values people need to make sense of and address complex problems [46]; and xxiii) CPS is an essential part of knowledge and a top list of job requirements in the 21st century [47].
Relation CPS to prior knowledge	i) the ability to apply prior knowledge when solving complex problems is of the utmost importance [6], [33], [47]–[49]; ii) students with high CPS use prior knowledge when learning new problems [50]; iii) prior knowledge affects one's CPS ability [22], [50], [51]; iv) applying previous knowledge when solving complex problems was most important [48]; v) the CPS process tends to develop existing ideas rather than create new ones [52]; vi) prior knowledge as a moderation between intelligence and CPS [53]; vii) prior knowledge interacts with reasoning abilities to be utilized effectively for CPS [54]–[56]; viii) in CPS, existing information is integrated with prior knowledge [57]; ix) the level of proficiency in CPS interacts with a dynamically changing problem environment, and prior knowledge is not predominant [58]; x) in CPS, real-world experience complements prior knowledge [59]; xi) in addition to prior knowledge, CPS is influenced by additional cognitive aspects such as searching for relevant information, mindfulness, and the ability to organize mental operations [60]; xii) differences in prior knowledge and experience have an impact on CPS [61]; xiii) prior knowledge or the context of the problem can influence CPS [62]; xiv) in CPS, there is a step in forming a hypothesis based on prior knowledge [63]; and xv) in CPS, prior knowledge is used to define the problem [64].
Relation of prior knowledge to reflective abstraction	i) reflective abstraction is a process of building new concepts based on previous ideas or new knowledge based on prior knowledge [15]; ii) reflective abstraction as a tool to support and contribute to building knowledge based on previous knowledge [65], [66]; iii) there is an influence between reflective abstraction and prior knowledge, and reflective abstraction must be supported by prior knowledge [67]; iv) reflective abstraction constructs new concepts through prior knowledge; [68], [69]; v) prior mathematical knowledge supports constructing knowledge through a process of reflective abstraction [70]; vi) through assimilation generalization based on prior knowledge gives rise to reflective abstraction [71]; vii) construction of new knowledge as the dissemination of prior knowledge through reflective abstraction [72]; viii) the need for connection to prior knowledge in the process of reflective abstraction [73]; ix) the learning objectives largely determine the prior knowledge involved in the reflective abstraction process [74]; x) task and learning design can build on prior knowledge concepts and encourage reflective abstraction [75]; xi) the lack of concepts from prior knowledge that cannot be overcome will limit reflective abstraction [76]; xii) reflective abstraction describes the construction of new high-level knowledge starting from prior knowledge [14]; xiii) student's reflective abstractions can more readily appear using apperception or exploring prior knowledge in the learning process [77]; xiv) reflective abstraction reflects prior knowledge into new mathematical concepts [70]; xv) at the level of reflective abstraction representation, prior knowledge is used to plan problem-solving [10]; xvi) reflective abstraction as a reflection to expand on previous structures or prior knowledge [78]; and xvii) reflective abstraction as a constructive process of prior knowledge [79].
Reflective abstraction in problem-solving	i) problem-solving ability can be described based on reflective abstraction [67]; ii) reflective abstraction ability of students in problem solving is required [80]; iii) reflective abstraction can be used for problem-solving and solving thinking [11]; iv) the importance of reflective abstraction is the ability to understand problems, find solutions, and solve problems [81]; v) reflective abstraction can develop the concept of solving mathematical problems [70]; vi) reflective abstraction is mathematical knowledge that reflects and reconstructs mental structures, and then the schema is used for problem solving [82]; vii) in the first step of problem-solving, which is understanding the problem, a level of reflective abstraction, recognition, and representation appears [10]; and viii) reflective abstraction as an effective tool to improve problem-solving so it needs to be promoted [83].

In contrast, reflective abstraction based on the literature obtained is mainly published in the Journal of Mathematical Behavior Scopus Q1. Both CPS topics and reflective abstraction are widely published in reputable international journals such as Scopus Q1. This is a sign that CPS and reflective abstraction are still issues whose studies are still accepted internationally.

Next, the researcher tried to analyze CPS research and reflective abstraction using Vosviewer software. This application can present an overview of a published research topic related to any topic or field so that updates can be found. The literature related to CPS and reflective abstraction obtained from the ScienceDirect and ERIC databases was uploaded with the help of Delay and ensured that the literature displayed the appropriate abstract and keywords then inputted into the VOS viewer application for the CPS topic and the reflective abstraction separately obtained Figure 2.

Figure 2 shows that in research on CPS, there are many topics related to intelligence, motivation, psychology, and PISA. Still, none of them are related to reflective abstraction. Meanwhile, research on reflective abstraction appears to be related to learning, cognition, cognitive development, mathematical concepts, and so on. Still, it has not been seen to be associated with the topic of CPS. Thus, research that links CPS with reflective abstraction becomes an opportunity and a challenge because it will become a novelty topic that can provide an overview and contribution of scientific thought.

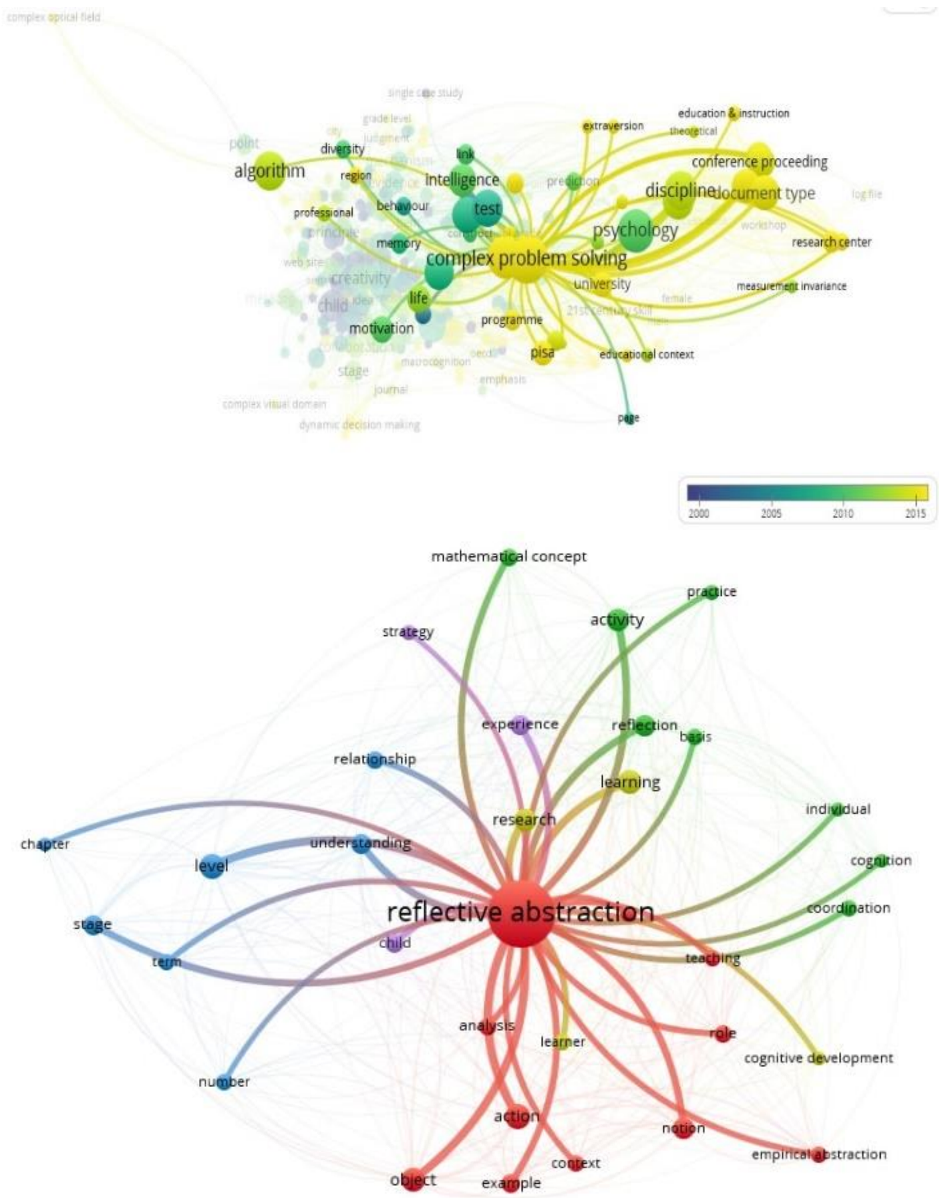

Figure 2. Vosviewer output related to CPS and reflective abstraction

The literature on CPS and reflective abstraction that has been presented is analyzed in more depth to provide insight to answer research questions about i) how does reflective abstraction affect CPS; and ii) how does reflective abstraction contribute to CPS. First, it is necessary to know about the meaning of CPS from some of the literature that has been studied. A research [64] argued that CPS is a group of tasks that require cognitive mastery to link causality between variables in a system. CPS is a complex problem solving that involves dynamic interaction with unknown systems to acquire knowledge and use this knowledge for its purposes [63]. CPS is a collection of multidimensional competencies at a high level of abstraction, similar to intelligence, but beyond a person's intelligence questions (IQ) [6], [84]. CPS is a problem-solving process formalized as a set of interrelated elements such as a complex system. CPS is a cognitive and emotional process [7] and is highly dependent on one's motivation. It can say that CPS is the ability a person has to solve complex problems related to more than one variable, involving cognitive, affective, psychomotor, and even psychological.

Reflective abstraction is the ability to reconstruct or build new knowledge that is unknown to students through the mechanism of connecting, combining, and even changing specific mathematical structures [12], [68], [80]. Reflective abstraction is the mapping of mathematical logic frameworks in developing one's dynamics to construct new concepts through the interrelationships between images, which can sometimes lead to different construction generalizations [12], [85]. Reflective abstraction is the ability to associate, combine, and change pre-existing conceptions into new situations.

Based on the literature review, there is no article entitled ‘impact of reflective abstraction on CPS’. So, to find out the effect of reflective abstraction on CPS, the researcher tries to present it based on an analysis of a collection of articles discussing reflective abstraction and CPS. Students' reflective abstraction ability in solving problems is needed because the result of a person's reflective abstraction is a scheme that can be used to understand something, find a solution, or solve a problem [81]. In CPS, knowledge acquisition and knowledge application [64]. Knowledge addition is related to prior learning. So how do previous skills and knowledge affect the ability to solve complex problems, and reflective abstraction can reflect their prior knowledge into higher-order thinking and reorganization of new mathematical concepts [70] included in solving problems. Reflective abstraction leads the subject to constructive generalizations and generates new synthesis to acquire new knowledge [81]. This new knowledge can be used as knowledge in solving problems. Previous experience can influence the context of the situation in CPS. However, these aspects are not a significant concern, and some issues are designed to be solved without prior knowledge. However, prior knowledge through reflective abstraction is essential because students will know, form, and produce mathematical concepts. The importance of reflective abstraction is evidenced by the cognitive abilities that students can develop because of reflective abstraction [70].

Piaget’s opinion about how new knowledge arises outside the sensorimotor, the answer is the existence of reflective abstraction which is an important aspect in forming new knowledge. The basic principle of reflective abstraction is that a new higher form of knowledge involves some process of reflection at a lower level. otherwise humans will be limited to sensorimotor or interactive learning [79], [86]. In addition, concepts built from reflective abstractions will be used to create other concepts related to the concept. Mathematical concepts are the main points in learning mathematics. Students who understand mathematical concepts well will not have difficulty dealing with any mathematical situation; even when students are given the most complex or challenging math problems, they can solve them based on their understanding of mathematical concepts. As research [73] has shown that students whose fractional concepts are limited to some extent have difficulty with advanced fractions concepts seen when teaching experiments are carried out to learn how students can develop concepts of fractional measurement and how a sequence of tasks can be developed to demonstrate necessary abstraction. By involving reflective abstraction, students can understand so that mathematical concept are formed. This is evidence that reflective abstraction plays an important role in supporting students' understanding of mathematics learning [77] and solving CPS. Thus, one's reflective abstraction affects the ability of CPS.

Reflective abstraction is rearranging/reshaping a new mathematical concept by connecting previously owned concepts [70]. The concept of reflective abstraction can be a powerful tool in the study of advanced mathematical thinking because the concept of reflective abstraction can provide a theoretical basis that supports and contributes to the understanding of what is currently being thought and can help students develop the abilities involved in it [12]. There are six steps in solving complex problems [63], namely i) Elaboration of goals, where specific and concrete goals are formulated; ii) Formation of hypotheses based on prior knowledge; iii) Prognosing system dynamics (changes in values related to the variables) exist; iv) Planning and decision making; v) Monitoring the consequences (the system can change due to the decision of the problem solver or regardless of the action of the problem solver) over time, the information processing itself can be the object of monitoring, in the metacognitive action; and vi) Self-reflection. Seen in the hypothesis formation step is carried out based on previous knowledge. Reflective abstraction can help build new concepts or reconstruct new knowledge used in solving complex problems.

Complex problem solving requires high knowledge, even CPS is defined as a person's capacity in cognitive processing to understand and solve problems [30]. An instrument to measure CPS skills, knowledge, and abilities to assess general knowledge and understanding of people about complex problems. And knowledge is related to the abstraction process. The level of abstraction has an important role because it is one of the three aspects of CPS, namely i) different levels of abstraction; ii) changes (potentially unpredictable) over time; and iii) rich knowledge with many potential strategies [6]. The abstraction referred to in this case includes reflective abstraction.

The iterative filtering of knowledge from the problem-solving process can improve and develop the quality of solutions [34]. Improving the ability to integrate knowledge and skills is needed in designing, analyzing, and developing solutions to complex problems [38]. The CPS process requires mental processes such as active interaction with problems to gain knowledge about them, and this is a more complex mental process than intelligence [16]. There is a significant and substantial correlation between CPS and intelligence [16]; and intelligence as a cognitive ability influenced by prior knowledge. Intelligence correlates with CPS if the minimum level of knowledge is moderate, but the correlation will be small if the knowledge possessed is very low [42]. CPS performance is influenced by other cognitive aspects such as the search for relevant information, prudence, relevance to prior knowledge, and the ability to regulate cognitive operations [60]. The knowledge possessed influences the importance of prior planning in solving complex problems [3], [87]. There is a strong influence of context and background knowledge or prior knowledge to an indeterminate extent in solving complex problems [6].

In research on CPS in determining the population, there are things to consider, namely prior knowledge [6]. CPS requires complex cognition that plays a role in cognitive operations such as action planning, strategy development, knowledge acquisition, and evaluation [28]. Intelligently using prior knowledge is usually part of solving complex problems [54]. One of the characteristics of good problem solvers is that they can effectively increase their previous knowledge [54]. In the problem-solving process, there are cognitive processes, including formulating where the existing problem is integrated with previous knowledge and identifying strategies and procedures relevant to solving the problem [57]. Prior knowledge becomes an element that can be applied to find the best approach and reduce the problem space in CPS [64]. The correlation between problem-solving and intelligence depends on prior knowledge [64].

Previous research [63] identified six characteristic phases for CPS, namely i) goal elaboration; ii) hypothesis formation; iii) system dynamics prognosis (changes in value associated with the variables); iv) planning and decision making; v) monitoring consequences; vi) self-reflection. The stage of forming the hypothesis is strongly influenced by the previous knowledge possessed. The CPS process is controlled by cognitive, emotional, personal, and social abilities and knowledge [31]. In CPS, there are dimensions of knowledge acquisition and knowledge application [58]. CPS can take advantage of feedback that produces positive influence, requiring a processing style. At this time, individuals refer to pre-existing knowledge structures [7]. Solving complex problems requires broad strategies, creative knowledge, and memory [52]. Solving complex problems involves integrating knowledge such as scientific knowledge, societal knowledge, organizational knowledge, and personal knowledge [44]. CPS is influenced by previous experience and knowledge [61], [88].

The CPS indicator as the ability to solve complex problems must be able to i) collect information systematically; ii) integrate the most relevant information; iii) build a mental model of the system structure (to represent problems efficiently and appropriately); iv) make forecasts, plans, and decisions; and v) set and balance goals (to find solutions) [88]. As seen in the indicators, integrating the most relevant information requires knowledge and insight, including prior knowledge that can be known through reflective abstraction. The relationship between CPS and reflective abstraction can be seen in Figure 3.

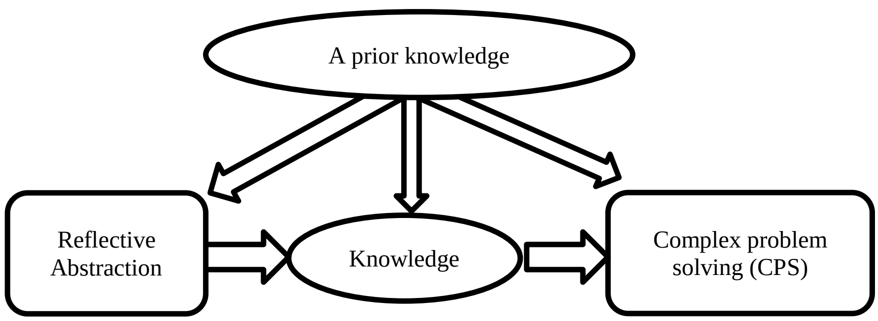

Figure 3. Schema of CPS and reflective abstraction

Based on the Figure 3, it can be said that reflective abstraction is influenced by prior knowledge. Reflective abstraction ability affects knowledge; of course, previous knowledge influences knowledge. CPS is influenced by knowledge, and previous knowledge also influences knowledge and CPS. So, it can be concluded that reflective abstraction affects the ability of CPS. The knowledge possessed by individuals strongly influences CPS. Relevant knowledge is used to solve complex problems. Previous knowledge is very instrumental in solving complex problems.

CPS requires a complex set of cognitive operations such as planning and executing actions, building models, and self-control [88]. In CPS, there is a knowledge repeat. At the same time, in reflective abstraction, students can project knowledge about existing concepts into a higher form of thinking, and this can be seen from the results of students in solving mathematical problems [77]. According to Piaget, reflection in reflective abstraction is based on individual actions, and concepts and relationships are abstracted by bringing these actions together [85]. Reflective abstraction is the arrangement of a logical-mathematical framework in personal cognitive development. It depends on the formation of concepts, as shown in several theories, and serves to express these concepts through mental and systematic analysis with the help of connections and relationships between objects. In mathematics, students will find it easier to understand and build new concepts if there is a connection with previously existing concepts. Of course, the mathematical concept is not wrong and problematic because it will affect other related concepts [70], [78].

To overcome this problem, it is necessary to measure complex cognitive processes in completing CPS [89]. Students who experience a lot of difficulty in solving problems need a new process to form experiences through abstraction. The reflective abstraction used to construct mental structures or mental reconstruction processes varies from person to person. Reflective abstraction used to build mental structures or mental reconstruction processes varies from person to person. If students have good mental reconstruction skills (reflective abstraction), they can form mathematical concepts well to solve problems well [82]. Understanding algorithms results from a series of reflective abstractions while algorithms can be built from activities carried out by students [73]. Students' understanding through mathematical problems by reconstructing the mental structure used to solve problems [82]. Previous experience or the context of the problem may affect CPS even though previous experience is not the primary cause and it is not necessarily the case that the problem for which it is designed can be solved without prior domain-specific knowledge [89]. Students' reflective abstraction in reconstructing previous material can solve problems differently. Prior knowledge has a very important role because errors in routine procedures when solving problems are caused by the strong influence of prior knowledge memory and experience of learning [90]. So an effort is needed to optimize basic abilities through knowledge and experience [91]. This research can be used as a theoretical basis for conducting further research related to reflective abstraction and complex problem-solving.

4. CONCLUSION

Based on the results of the literature review analysis, it can be concluded that there is a relationship between CPS and reflective abstraction by obtaining common ground in the form of prior knowledge. CPS requires prior knowledge to integrate the most relevant information to get solutions, whereas prior knowledge is needed to construct new concepts through reflective abstraction. Reflective abstraction can reflect prior knowledge into higher-order thinking and reorganize new concepts needed for CPS. Reflective abstraction can help build new ideas or reconstruct new knowledge used in CPS. So that CPS requires prior knowledge that can be obtained from reflective abstraction. Thus, it can be suggested that special efforts and attention can be made to improve CPS by building initial knowledge through reflective abstraction. For example, prerequisite learning that focuses on prior knowledge can be implemented to help enhance reflective abstraction and CPS. Not much research has been done on CPS and reflective abstraction, and this is an opportunity for further research related to CPS and reflective abstraction. This literature review will become the basis for studies on CPS themes and reflective abstractions in learning and education.

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