

Analysis of Student Computational Thinking Ability in PTIK UNS on Database Course

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ABSTRACT

This qualitative descriptive study aims to determine the computational thinking (CT) abilities of PTIK students in a database course and to identify differences in CT abilities among students with low, medium, and high academic grades. This research describes a condition based on existing research results and compares it with supporting theories to provide a systematic overview of the computational thinking abilities of PTIK FKIP UNS students. The research instruments included documents (database scores of PTIK students for the 2021 academic year) and essay test results from third-semester students who had completed the database course. The sampling technique used was purposive sampling. Data was collected through document analysis, test instruments, and in-depth interviews, with data validity tested using method and data source triangulation. The data was analyzed using narrative analysis techniques. The study assessed six aspects of CT ability in the database context: decomposition and reduction, abstraction, conversion and simplification, classification and division of ideas, reverse thinking, and assumptions. The results showed that, overall, PTIK students possess good CT skills. However, the abilities in reduction, simplification, and assumption could be improved. The research also found a clear difference between students with low midterm test scores and those with high midterm test scores. The data confirms that better grades in the database course correspond to better CT abilities among students.

Keywords: Computational thinking, database, non-probability sampling

1. INTRODUCTION

Computational Thinking (CT) is an essential skill, particularly in software development and informatics. A 2009 report from the Royal Academy of Engineering, "ICT for the UK's Future," stated, "It is critical that a large proportion of the 14-19 year age group understand computing concepts such as programming, design, problem solving, communications, and hardware." In 2014, the UK government began requiring programming to be taught in its elementary to secondary school curriculum. The goal was not to mass-produce programmers, but to teach CT from an early age (Susanti, 2019). According to a report by Manila (2014), various other countries have also started implementing CT and early computer science into their curricula.

In Indonesia, CT has been developing through the Bebras challenge since 2016. Bebras is an international initiative that aims to introduce computer science and CT to school students of all ages. Indonesia has now started implementing CT through the "Merdeka Curriculum," which was launched by the Minister of Education, Culture, Research, and Technology, Nadiem Anwar Makarim, in February 2022. The Merdeka Curriculum was first used in the 2021/2022 academic year at the elementary, middle, and high school levels within the Mobilizing School Program (PSP) and the Center of Excellence Vocational High School (SMKPK).

There are fundamental differences between the Merdeka Curriculum and the 2013 curriculum. One key difference at the elementary level is the integration of CT into subjects like Indonesian, mathematics, and Natural and Social Sciences (IPAS). Through this integration, it is expected that students will learn to understand and apply CT to solve problems in their subjects and daily lives.

Many experts have offered different interpretations when defining CT. It has been described as a mental activity for abstracting problems and formulating automatable solutions (Yadav et al., 2014) and as a process of recognizing computational aspects in the world and applying computer science tools to reason about systems (The British Royal Society, 2012). Denning (2017) defines it as the process of formulating a problem so its solution can be represented as computational steps that a processing agent can effectively execute. Simply put, CT is a thinking process that uses computer science concepts to formulate problems and find solutions.

According to Maharani (2020), there is a clear relationship between problem-solving and CT. When students define a problem, they are engaging in decomposition and abstraction. When planning a solution, they look for regularities to find patterns, which is useful for generalization. When executing the plan, they apply structured, algorithmic steps. Finally, after finding a solution, they review and evaluate it by tracing the steps, which is a form of debugging.

A database is a computerized system for maintaining processed data, serving as an information storage medium that can be accessed quickly and easily (Rosa and Shalahuddin, 2015). It contains a collection of data or information arranged so that specific information can be managed and retrieved. The development of databases has been rapid since the mid-1960s, after Charles W. Bachman developed the first integrated database system (DBMS).

Since then, databases have gained significant attention due to their structured storage, minimal data redundancy, data independence, and ease of expansion and programming. The database is a foundational discipline that every programmer must master, as it involves the data needed to support an application. The database course at PTIK UNS is a required course in the first semester, covering database concepts, ER models, relational models, and database design.

A programmer or software designer should have strong CT skills. Good CT skills assist a programmer in solving problems, expanding their thinking, and innovating new methods (Huang & Leng, 2019). These skills are particularly useful when converting databases from abstract forms to real-world applications. Different conversion methods result in varying levels of efficiency and data accuracy, making CT ability crucial for ensuring the quality of the final database design.

The CT abilities trained in programming and database courses will be used throughout a professional's career, both in software design and in debugging processes that require advanced problem-solving skills. This ability develops with a deeper understanding of database material. Given the importance of this connection, research into the level of students' CT skills in the database context is necessary.

2. RELATED WORK

A relevant study was conducted by Huang and Leng (2019), which discusses appropriate learning models for databases. Their study also provides an analysis of CT in the database that can be used as a guide for this research. The aspects that will be used as guidelines are decomposition and reduction, abstraction, conversion and simplification, classification and division of ideas, reverse thinking, and assumptions.

3. RESEARCH METHOD

The type of research used is descriptive qualitative. According to Bogdan and Taylor (1975), descriptive qualitative research is a procedure that produces descriptive data in the form of written or spoken words from people and their observed behavior. The descriptive analysis research method, according to Silalahi (2006), is a method that analyzes, describes, and summarizes various conditions from data collected through interviews or observations of problems in the field. This research was conducted by analyzing the results of tests given to participants regarding their CT skills. The sampling technique used was a non-probability technique, specifically purposive sampling.

Data was taken from a test instrument assessing CT ability in the database context. Data collection began with document analysis to identify appropriate data sources and participants. The purpose of this analysis was to determine the extent of students' existing database skills. Participants were selected based on their grades in the database course, with three levels used for selection: low scores (<75), moderate scores (75-85), and high scores (85-100). These score levels were based on the conversion from a 100-point scale to a 4-point scale as outlined in Permendikbud No. 81A of 2013. Participants from each grade level were selected based on their midterm exam scores in the database course.

The tests given to participants were in the form of essay questions based on the CT aspects identified by Huang & Leng (2019). These included six CT aspects applied to databases: decomposition and reduction, abstraction, conversion and simplification, classification and division of ideas, reverse thinking, and assumptions. These aspects were aligned with the stages of database design, starting from problem

identification, determining entities and fields, creating ERDs and tables, improving and normalizing data, and finally, finalizing the design. The test results were then analyzed to determine each subject's CT ability. The indicators for the essay questions can be seen in Table 1.

Table 1. CT Indicators

CT Skill	CT Level			Question number
	High	Middle	Low	
Decomposition and reduction	Able to mention the entity that needs to be added	Able to mention but too much or less	Unable to name the table that needs to be added	1
	Able to mention entities and fields that need to be added	Able to mention but too much or less simple	Unable to name the attribute that needs to be added	2
	Able to mention the attributes that need to be added	Able to mention but too much or too little	Unable to name the attribute that needs to be added	3
Abstraction	Able to make ERD completely and consistently from decomposed problems	Able to make ERD but less complete and consistent than the problems that have been decomposed	Not able to make ERD completely and consistently from decomposed problems	4
	Able to create a table structure and its table relationships	Able to make a table structure and its table relations but incomplete	Unable to create a table structure and its table relationships	5
Conversion and simplification	Able to answer completely and precisely	Able to answer in full but there is something less precise	Unable to answer completely and precisely	6
	Able to simplify table relation	Able to do simplification but the not complete yet	Incapable of simplification	7
Classification and division ideas	Able to give the right answer	Can answer but less detailed	Unable to give a precise answer	8
	Able to normalize to form 3	Able to normalize to the 1st or 2nd form	Unable to normalize	8
Reverse thinking	Able to find the source of the problem and solve problems from the causes of problems	Can't understand the cause of the problem and less able to solve the problem	Not being able to find the source of the problem and solve the problem from the cause of the problem	9
Assumption	Able to find similar problems that match the criteria	Less Able to find similar problems that match the criteria	Unable to find similar problem	10
	Be able to find similar problems that match the criteria and be able to create models that are almost the same	Less Able to find similar problems that match the criteria and are able to make models that are almost the same	Unable to find similar problems and able to make models that are almost the same	10
	Able to find the best solution to a problem	Inability to find the best solution to a problem	Unable to find the best solution to a problem	10

Interviews in this study were conducted to deepen the understanding of the test results by exploring the respondents' perspectives. A structured interview technique was used because the researcher had already determined what information was needed and had prepared alternative questions in case the initial answers were not sufficient. The interviews were based on the results of the test instrument to strengthen the findings and gain a more in-depth understanding of the participants' CT skills.

4. RESULT AND ANALYSIS

4.1. RESULT

Document analysis was conducted in this study to find participants who matched the required score criteria: students with low, medium, and high levels of database knowledge. The analysis was based on grades from the database course. The document used was the midterm exam (UTS) results for the 2021 academic year, even semester.

Table 2 lists the students who met the requirements and were willing to answer the given questions. Subjects 1 and 2 are those with low initial midterm scores (below 75). Subjects 3 and 4 have moderate midterm scores (between 75-85), indicating they have a sufficient understanding of the database material. Finally, subjects 5 and 6 have high scores (above 85), indicating they have a good knowledge of the database material.

Table 2. Test Subject

Subject	Database score	Database score (100 scale)
1	C	66,67
2	D	54,17
3	B	75
4	B	75
5	A	83,33
6	A	100

The essay test assessment was based on the indicators in Table 1 and produced a summary of student abilities in Table 3. In the decomposition section, only one subject answered correctly. In the abstraction and assumption sections, subjects 1 and 2 were unable to answer correctly. In the conversion section, only subject 1 was unable to answer correctly. Meanwhile, in the simplification question, only subject 3 was unable to answer correctly.

Table 3. Essay Result

CT Skill	Question No	Result					
		S1	S2	S3	S4	S5	S6
Decomposition and reduction	1	Mid	Mid	High	Mid	Mid	Mid
	2	Mid	Mid	High	Mid	Mid	Mid
	3	Mid	Mid	High	Mid	Mid	Mid
Abstraction	4	Mid	Mid	High	High	High	High
	5	Mid	Mid	High	High	High	High
Conversion and simplification	6	Mid	High	High	High	High	High
	7	High	High	Mid	High	High	High
Classification and division ideas	8	High	Mid	High	High	High	High
	8	High	Mid	High	High	High	High
Reverse thinking	9	High	High	High	High	High	High
	10	Mid	Mid	High	High	High	High
	10	Mid	Mid	High	High	High	High
Assumption	10	Mid	Mid	High	High	High	High
	10	Mid	Mid	High	High	High	High

After the test results were obtained, interviews were conducted to ensure the authenticity of the data. Table 4 shows the results of the CT ability analysis after the interviews. Based on the interview results, the findings were consistent with the essay test, as the subjects answered according to their abilities.

Table 4. Interview Result

CT Skill	Question No	Result					
		S1	S2	S3	S4	S5	S6
Decomposition and reduction	1	Mid	Mid	High	Mid	Mid	Mid
	2	Mid	Mid	High	Mid	Mid	Mid
	3	Mid	Mid	High	Mid	Mid	Mid
Abstraction	4	Mid	Mid	High	High	High	High
	5	Mid	Mid	High	High	High	High
Conversion and simplification	6	Mid	High	High	High	High	High
	7	High	High	Mid	High	High	High
Classification and division ideas	8	High	Mid	High	High	High	High
	8	High	Mid	High	High	High	High
Reverse thinking	9	High	High	High	High	High	High
	10	Mid	Mid	High	High	High	High
	10	Mid	Mid	High	High	High	High
Assumption	10	Mid	Mid	High	High	High	High
	10	Mid	Mid	High	High	High	High

Based on the results of the essay and interview tests, a final conclusion was drawn regarding the subjects' CT abilities. The subjects with low initial scores had an intermediate level of CT ability overall, though both struggled with the aspects of decomposition, abstraction, and assumption. The subjects with medium and high initial scores each had one deficiency. Subject 3 was lacking in the simplification aspect due to a lack of

thoroughness. Subjects 4, 5, and 6 had the same constraint in the decomposition and reduction aspect, as they were unable to perform table reduction. Table 5 shows the summary.

Table 5. CT ability result on database course

Initial Score	Subjek	DR	AB	CS	CD	RT	AS
Low	Subject S1	Mid	Mid	Mid	High	High	Mid
Low	Subject S2	Mid	Mid	High	Mid	High	Mid
Mid	Subject S3	High	High	Mid	High	High	High
Mid	Subject S4	Mid	High	High	High	High	High
High	Subject S5	Mid	High	High	High	High	High
High	Subject S6	Mid	High	High	High	High	High

4.2. ANALYSIS

According to Huang & Leng (2019), there are six aspects of CT that must be considered in a database: decomposition and reduction, abstraction, conversion and simplification, classification and division of ideas, reverse thinking, and assumptions. The six aspects mentioned have their respective roles in helping programmers create simple, non-redundant databases and ensuring the completeness of the database conversions.

The first aspect is decomposition and reduction. In general, decomposition in CT is the process of breaking down a problem into smaller or simpler steps (Wing, 2010). In a database context, decomposition is used to break down a problem or system requirement into smaller components, which later become the tables used in the database system. In determining system requirements, reduction is also carried out to reduce the components to be used so that the database can be simpler and more efficient. The decomposition ability of the participants was quite good, but there were deficiencies in the reduction aspect.

In the decomposition section, the subjects were able to identify the system requirements well enough, and the important components were mentioned precisely. However, most of the participants were still not able to do table reduction properly; the reductions made were not precise and could lead to non-simple relationships between entities. Subject 3, who had an intermediate grade in the database course, was actually able to do the reduction well. The subjects with low scores did not master the material provided, while other subjects reasoned that the extra components could be used in the future. Despite having the same theoretical ability, subject 3 had an advantage in data reduction. This could be caused by gender differences, as research by Izu et al. (2017) suggests that males have a better level of CT.

Abstraction in a database is the ability to see a pattern in a problem (Wing, 2010). In this case, the pattern is expressed in a model, namely an entity-relationship diagram (ERD). According to Huang & Leng (2019), relational databases have a close relationship with abstraction. The ability to think abstractly increases when a person can solve problems in a world that is still abstract. The students' ability to do abstraction was good; the consistency between the decomposition results and the components in the diagram was the same, and students could also correctly identify the degree of relationship or cardinality in the table.

The aspect of conversion and simplification was quite difficult for students; 2 out of 6 subjects had problems and gave incorrect answers. Based on the interviews, it is known that students did not understand some of the rules for using and the differences between commands in MySQL and did not understand the use of relations between entities. At this stage, students are required to change data from an abstract form to a concrete or real form—in this case, from a design to its original form. After a database is created, the next step is to apply the principle of normalization according to Storey (1991) and carry out a special classification on problematic tables. Classification is also carried out to separate data types in tables. At this stage, students had quite difficulty answering questions; 3 out of 6 students could not give the right answer. This is because some participants lacked mastery of database normalization material.

Reverse thinking is the ability to think backward to find the causes of problems or things that can exacerbate a problem, and then find solutions after understanding the causes (Li & Wen, 2020). Reverse thinking is a must-have skill for a programmer to be able to find the cause of an error. In the essay questions given to the subjects, errors were presented in tabular form. The subjects had to be able to find out what caused the error display to occur. In the process, the subject must understand the anomaly that occurred and its causes, then find a solution to the problem by breaking the table or by doing normalization.

The last stage is assumptions. According to Huang & Leng (2019), this is the final stage where various approaches are used to optimize the created system. At this stage, students had a good enough ability to analyze systems with several existing approaches and draw conclusions. Overall, the CT ability of PTIK students from

the 2021 academic year who have taken semester 5 is good. However, the reduction, simplification, and assumption capabilities can still be improved to get better results.

In a database, good CT capabilities will affect data conversion from an abstract form to a virtual form. According to Huang and Leng (2019), different levels of CT ability will result in different conversion accuracy and completeness. Mastery of the database material will certainly affect the ability to solve problems within it. From the research conducted, data on the CT ability of 6 participants was obtained, and from the test results, a conclusion was made regarding the CT ability of each participant. The overall test results can be seen in Table 3.

From the research conducted, there is a difference between students who have low UTS scores and students with high UTS scores. The data obtained also confirms that the better the grades obtained from the database course, the better the CT ability of the students. The constraints only occurred for students with low and medium scores, while students with high scores could answer the questions well and were able to provide complete answers.

To be able to properly apply CT skills to databases, the role of the teacher is required. This can be achieved through interactive learning between instructors and students and by actively combining database theory with direct application or implementation in the real world. In addition, training in database courses must use CT as the core and be combined with database teaching materials through various levels of thinking skills, which include abstraction, automation, recursion, separation, heuristic reasoning, data protection, and decomposition. To form a good CT ability, this combination needs to be applied scientifically.

5. CONCLUSION

From the results of the study, it can be concluded that UNS PTIK students have good CT skills. However, there are still deficiencies in several aspects, such as reduction, simplification, and assumption. Each measurement instrument offered a different point of view in assessing CT ability. The analysis also shows that there are differences in CT abilities that correlate with students' academic scores in the database course.

The implications of this study are that it can provide a more in-depth description and knowledge of students' computational thinking skills in databases for educators, students, and educational institutions, as well as serve as a reference for further research. The results are also expected to be taken into consideration when choosing an instrument to measure and analyze CT capability profiles, both in terms of implementation and the specific aspects to be measured. The development of these thinking skills needs to be accompanied by theoretical understanding. This can be achieved through the teacher's role in increasing comprehension and through interactive learning between teachers and students, which will play an important role in developing CT skills.

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