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Character Education Values in the Process of Mathematical Problem-Solving, Understanding, Connection and Communication: Students' Perspectives

Suci Nurhayati
Department of Mathematics Education, Universitas Terbuka, suci.nurhayati@ecampus.ut.ac.id

Vingky Zulfa Asria
Department of Mathematics Education, Institute Az Zuhra Pekanbaru,
vingkyzulfa@institutazzuhra.ac.id

Ika Tri Yunianika
School of Language, Literature, Music and Visual Culture, University of Aberdeen,
i.yunianika.22@abdn.ac.uk

ABSTRACT

The purpose of this study is to describe students' perceptions of character values that are integrated into each activity of Mathematical Power, which consists of problem-solving, understanding, connecting, and communication. This qualitative research collected data with a survey of students about their perceptions and interviews with mathematics teachers. The sample of schools were selected based on the types of schools: faith-based school and non-faith-based school located in Yogyakarta city. From the four selected schools, 61 samples of grade XI students and 4 mathematics teachers in each school were involved in this study. After the data was collected, the survey data was analyzed descriptively, and the interview data was analyzed using data reduction, data collection, and conclusions. Based on the results of students' perceptions, character values have been widely felt by most students, with the largest percentage in mathematical communication activities. Non-faith-based schools scored higher than faith-based schools in students' perceptions of character values in all four mathematical activities.

keyword: Positive characters, Mathematical Power, Character Education

ABSTRAK

Tujuan penelitian ini adalah untuk mendeskripsikan persepsi siswa tentang nilai-nilai karakter yang diintegrasikan dalam setiap kegiatan pemecahan masalah, pemahaman, penghubung, dan komunikasi (Daya Matematika). Penelitian ini merupakan penelitian kualitatif dengan pengumpulan data berupa survei persepsi siswa dan wawancara terhadap guru matematika. Pemilihan sekolah sampel dipisahkan berdasarkan jenis sekolah yang berbasis agama dan sekolah non-basis agama di Kota Yogyakarta. Dari empat sampel sekolah yang terpilih, kami melibatkan 61 sampel siswa kelas XI dan 4 guru matematika di masing-masing sekolah. Setelah data terkumpul kemudian data survey dianalisis secara deskriptif dan data hasil wawancara dianalisis menggunakan reduksi data, pengumpulan data, dan penarikan kesimpulan. Berdasarkan hasil persepsi siswa terlihat bahwa nilai-nilai karakter telah banyak dirasakan oleh sebagian besar siswa dengan persentase terbesar pada kegiatan komunikasi matematis. Sementara sekolah non-basis agama memiliki nilai persentase yang lebih tinggi dari sekolah bebasis agama dalam persepsi siswa terhadap nilai-nilai karakter dalam keempat kegiatan matematis tersebut.

Kata Kunci: Karakter Positif, Daya Matematis, Pendidikan Karakter

INTRODUCTION

NCTM (1989) defines mathematical power as a series of problem-solving, understanding, connecting, and communicating activities. A series of skills obtained in these activities are believed

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to represent competencies that should be obtained by students in learning mathematics. Problem-solving skills are a complex set of cognitive, behavioural, and attitudinal components that are situational and rely on comprehensive knowledge and experiences (Josep & Lopez, 2007; Rittle-Johnson et.al., 2009). Problem-solving skills are acquired over time and are the most widely applied cognitive tools (Moln´ar, 2013). Problem-solving skills are essential in mathematics education (Moln´ar, 2013; Greiff et.al., 2013). Fostering the development of mathematical problem-solving skills is a key goal of the education system as it provides the tools to achieve success (Moln´ar, 2013; OECD, 2012).

When a person understands the mathematical concepts, rules, and principles well, they can apply them effectively to solve problems. Deep understanding helps to see the core of a problem, identify patterns or mathematical relationships that may exist, and choose the right strategy to solve the problem. Hiebert & Carpenter (1992) specifically define mathematical understanding as involving the construction of conceptual 'context' or 'structure'. NCTM (Bartell et.al., 2013) states that understanding concepts is the basic goal of learning mathematics. In general, Santrock (2011) states that understanding concepts is important in learning activities.

A good understanding of mathematics can facilitate better mathematical connections and vice versa. A solid understanding of mathematical concepts provides a solid foundation for establishing relationships between those concepts. Conversely, the ability to make mathematical connections can help deepen understanding of mathematics by looking at the overall picture and summarizing relationships between concepts. Mathematical connection is the ability to associate a student's mathematical knowledge with other mathematical and real-life skills (Bahr &; DeGarcia, 2008). Mathematical connections are part of a network of knowledge that is interconnected with other knowledge composed of concepts essential to understanding and developing relationships between mathematical ideas, concepts, and procedures. The ability of students to connect mathematically is one of the important things that students must achieve in the learning process because if students know the relationship between concepts, they will quickly understand mathematics itself and open opportunities for students to develop their mathematical abilities.

In order to optimize mathematical understanding, it is important to understand mathematical connections and then be able to communicate them clearly to others. Effective mathematical communication helps clarify and deepen the understanding of mathematical concepts and provides opportunities to build mutual understanding within the mathematical community. Mathematical communication skills are useful tools to encourage students' creativity and motivation in their mathematics learning (Smieskova, 2017). Mathematical communication is divided into four categories by teachers: verbal communication (including speaking and listening), listening (including verbal communication through reading), and written communication (including writing assignments) (Utomo & Syarifah, 2021; Wilson, 2009; Utari et.al., 2020). Presentation, explanation, and arguments are basic mathematical methods of communication that encourage students to share, exchange, and reflect (Wood, 2012).

Thus, the power of mathematics that reflects the four activities of solving, understanding, connecting, and communicating is important in shaping the purpose of mathematical skills in the

learning process. So that, the cultivation of other aspects needed by students can be integrated when the process of the four activities takes place in an integrated manner. Soejadi (1999) suggested that mathematics education as a vehicle can be used not only to educate students but also to shape students' personalities (characters). Therefore, teachers can use mathematics to educate students about moral education (Yin & Ge, 2020) by building and forming students' positive characters in the process of solving problems, understanding, connecting and communicating mathematically. In addition, the larger purpose of mathematics education is based on the moral goals of schools, primarily to help students develop as morally minded human beings in specific socio-cultural and political contexts (Falkenberg & Noyes, 2010). In Indonesia, character-building is one of the goals of national education. Article 1 of the 2003 National Education System Law states that one of the objectives of national education is to develop the potential of students to have intelligence, personality, and noble morals. Thus, the cultivating good morals needs to be instilled and familiarized in various types of schools, both those with a greater percentage of religious integration content (faith-based schools) and non-faith-based schools. Therefore, mathematics education is one aspect of life that plays a very important role in efforts to foster and form high-quality humans (Lestari & Madio, 2013; Pardimin, 2022). In the context of learning mathematics, positive characters that can be developed are often referred to as mathematical values. According to Bishop et al., (1999), values in mathematics education are deep affective qualities fostered by education through mathematics subjects in schools.

Research on mathematics education that connect mathematics teaching in schools with moral or character education has been widely conducted (Falkenberg & Noyes, 2010; Mahmudi, 2011; Irfan, 2016). In some studies, cultivating character in solving, understanding, liaison, and communication activities has had a good impact (Hasan & Rohmatul, 2018; Apino & Hetnawati, 2019; Lusyana & Wangge, 2016) but still limited in sample classes for each activity. Therefore, the purpose of this study is to describe students' perceptions of character values that are integrated into every problem-solving, understanding, connecting, and communication (Mathematical Power) activity in both faith-based and non-faith-based school types.

METHOD

This research is a qualitative approach with data collection using surveys and interviews. Data collections were carried out in October-November 2022 at four high schools in Yogyakarta City, consisting of two faith-based schools and two non-faith-based schools. Selection of faith-based school samples to see a picture of character education values that are inseparable from the cultivation of moral and religious values for students. In addition, the selected schools have a category as the best high school in Yogyakarta based on the ranking of UTBK scores (computer-based selection test for university entrance in Indonesia) in 2021.

With the purposive sampling technique, 61 samples of grade XI students from the four schools were involved in filling out survey questionnaires. These instruments were developed based on indicators in each problem-solving, understanding, connecting, and communication activity. In problem-solving activities, activity indicators include the process: (1) solidifying knowledge in solving

mathematical cases, (2) exploring solving mathematical problems in various contexts, (3) deciding on the right strategy to solve mathematical problems, (4) checking and monitoring the process of solving mathematical problems that have been carried out. While indicators of mathematical comprehension activities include the process of: (1) understanding that every mathematical statement must always have a reason, (2) formulating and exploring conjectures for solving mathematical problems, (3) developing and evaluating mathematical thinking accompanied by evidence, (4) choosing and using proof methods that match the mathematical problem at hand. Then, indicators of mathematical connection activities include the process: (1) using known abilities to solve new mathematical problems, (2) understanding that mathematical concepts are interconnected and are whole, (3) applying mathematics in everyday life and to other learning. And the last is an indicator of mathematical communication activities that cover the process: (1) writing down thoughts/ ideas in solving mathematical problems, (2) explaining/conveying mathematical ideas in class, (3) commenting on strategies used by friends in solving mathematical problems, (4) using mathematical language in sharing ideas appropriately. Furthermore, each of these points is integrated with several character education values according to the Indonesian Ministry of National Education (religious, honest, tolerance, discipline, hard work, creative, independent, democratic, curiosity, national spirit, love of the fatherland, appreciating achievements, communicative, love of peace, love of reading, care for the environment, social care, responsibility) which are considered appropriate by researchers with activity indicators. For example, the indicator "explaining/conveying mathematical ideas in class" in mathematical communication activities is integrated with the value "Democratic", then the statement "I am polite and open to suggestions given when conveying my mathematical ideas in class". Likewise with other indicators, it produces 19 points of statements in the student questionnaire (scale 4) to get an idea of student perspectives. Likewise, the second instrument is an interview instrument with a sample of mathematics teachers in each school, which is used to match or clarify student questionnaire answers with the same indicators.

Data obtained from student surveys and teacher interviews were then analyzed qualitatively. According to Leech and Onwuegbuzie (2007, 2008), qualitative analysis techniques can be used to analyze focus group data. The survey data will be presented descriptively to illustrate the percentage of student perspectives based on the school's sample of perceived character education values in each problem-solving, understanding, connecting, and mathematical communication activity. To facilitate the process of calculating percentages, researchers grouped student responses with references in Table 1.

Table 1. Reference Grouping Student Responses

Student response	The values have been perceived by students	The values have not been perceived by the students
Totally agree	√	
Agree	√	
Disagree		√
Strongly disagree		√

While the data obtained from interviews were carried out in two stages. In the first stage, researchers identified keywords used by respondents related to indicators. In the second stage, the

researcher juxtaposes the results identified in the first step for each activity indicator and the type of school; so that, the results of the analysis can be concluded.

RESULTS AND DISCUSSIONS

Results

Mathematical Problem Solving

Based on students' responses to character education values embedded in indicators of mathematical problem-solving activities, most character values have been felt by students. It can be seen from the percentages shown in Table 2. A sense of enthusiasm when establishing knowledge in solving mathematical problems (activity indicator 1), curiosity when exploring solving mathematical problems in various contexts (activity indicator 2) and a sense of earnestness when deciding on the right strategy to solve mathematical problems (activity indicator 3). However, the fourth indicator, "checking and monitoring the process of solving mathematical problems that have been done", has a smaller percentage among other indicators. While looking at the average comparison between the two types of schools, it appears that the values of character education were more widely felt by students in non-faith-based school types.

Table 2. Percentage of Students' Perceptions of Character Education Values in The Process of Mathematical Problem Solving

Activity	Faith-Based Schools			Non-Faith Based Schools		
Indicators	A	B	Average	C	D	Average
1	100%	80%	90%	81.2%	100%	91%
2	100%	80%	90%	87.5%	100%	94%
3	100%	73%	87%	75%	100%	88%
4	67%	67%	67%	81.25%	86.7%	81%
	Total		81%			89%

The small percentage in the table above was because the activity indicator "checking and monitoring the process of solving mathematical problems that have been done" was not carried out independently by students but with the help of teachers and friends. As an overall part of math problem-solving activities, this indicator was still passed in faith-based schools, it's just that the activity process involves other subjects as students check and monitor the mathematical problem-solving process to ensure problem solving. Table 3 is an excerpt of an individual interview of a sample of teachers on the activity indicators.

Table 3. Excerpts of Interviews on Indicator 4 Mathematical Problem Solving

Question	What is the picture of students' attitudes when monitoring and reflecting on the process of solving mathematical problems? Do they do it independently?
Answer of faith-based school's teacher (A)	For reflection activities, the teacher will provide some kind of assistance and direction. Given that not all children have the same orientation to learning mathematics. That difference in interests and talents is also valued in learning or reflecting on mathematics learning. Results are not solely learning objectives but how each child processes well during learning activities with the teacher. Reflection activities are always accompanied by teachers in order to provide direction and guidance to the learning that has been done. Not done solely by the child independently
Answer of non-	The attitude of students when monitoring and reflecting on the process of

faith-based-school's teacher (D)	solving mathematical problems is carried out independently. This is shown by students by recording important points in their respective books and independence in solving problems in quizzes, individual exercises and tests

Mathematical Reasoning and Proof

After observing student responses in mathematical problem-solving activities, another connected activity is their mathematical understanding. When a person understands the mathematical concepts, rules, and principles well; they can apply them effectively to solve problems. Based on the results of student responses, the percentage of mathematical comprehension activities was not greater compared to responses of mathematical problem-solving activities. However most of them were still felt by students. The sense of honesty in understanding that every mathematical statement must have a reason (activity indicator 1) and curiosity that arises when it comes to choosing and using proof methods that match the mathematical problem at hand (activity indicator 4) had mostly been felt by students. Meanwhile, the other two statements, namely creativity when formulating and exploring conjectures for solving mathematical problems (indicator 2) and a sense of responsibility to develop and evaluate mathematical thinking accompanied by evidence (indicator 3) had lower percentages.

Table 4. Percentage of Students' Perceptions of Character Education Values in the Process of Mathematical Reasoning and Proof

Activity	Faith-Based Schools			Non-Faith Based Schools		
Indicators	A	B	Average	C	D	Average
1	86.7%	66.7%	76.7%	81.2%	93%	87.1%
2	93.3%	56.25%	74.78%	81.2%	80%	80.6%
3	73.3%	73.3%	73.3%	75%	93%	84%
4	93.3%	80%	80%	93.75%	93%	93.38%
	total		76%			86%

Based on Table 4, activity indicator 2 has the lowest percentage value in students of class B in faith-based schools, while activity indicator 3 has the same percentage value in both classes in faith-based schools. The activity of formulating and exploring conjectures is indeed not in the low category in Bloom's taxonomy so that the value of student creativity is not easy to do. As with developing and evaluating thoughts, if they are not used to it, a sense of responsibility in students to do it is difficult to build. Excerpts of individual interviews of teacher samples in these activity indicators show that teachers have tried to build these habits (Table 5).

Table 5. Excerpts of interviews on indicators 2 and 3 of Mathematical Reasoning and Proof

Question (indicator 2)	What is the description of students' attitudes when formulating and exploring conjectures for solving mathematical problems? Do they try to be as creative as possible?
Answer of faith-based school's teacher (B)	Our students also have an interest in exploring both through asking questions between friends, teachers to find solutions to math problems through the internet, and this proves that there is creativity that students have in finding media and strategies for solving problems
Question (indicator 3)	What is the picture of students' attitudes when it comes to developing and evaluating their mathematical thinking with evidence? Do they feel responsible for doing so?
Answer of faith-	Basically, at every step in solving math problems, there must be

based school's teacher (A)	accountability. Students are educated to be responsible for actions in developing and evaluating mathematical thinking that must be accompanied by evidence. This is encouraged because mathematics must always be done based on the legal basis of mathematical rules. Students behave this way because the teacher gives an understanding that mathematical solutions that are always based on axioms must be with correct mathematical rules. Strictly speaking, children are able to account for answers to their math problems with clear concepts, theories, or mathematical rules
Answer of faith-based school' teacher's (B)	Students have an active role in developing and evaluating thoughts with evidence, and this is evidenced through the presentation presented, where in carrying out the evidence, students must choose what method is suitable for solving the problem

Mathematical Connection

Another part of mathematical power besides mathematical reasoning and proof activities is mathematical connections. When someone has understood the concepts, rules and principles of mathematics and solved mathematical problems, they need the ability to connect between mathematical topics, other disciplines, and problems in everyday life, therefore it expands their mathematical knowledge. Based on the results of students' responses to this indicator of mathematical connection, although not greater in percentage compared to problem-solving and mathematical reasoning and proof, most students have felt a spirit of creativity in using their abilities to solve new mathematical problems (indicator 1) and a sense of honesty in understanding that mathematical concepts were interconnected and were a unity (indicator 2). At the same time, statements about enthusiasm for applying mathematics in everyday life and other learning (Indicator 3) had the lowest percentage.

Table 6. The Percentage of Students' Perception of Character Education Values in The Mathematical Connection Process

Activity	Faith-Based Schools			Non-Faith Based Schools		
Indicators	A	B	Average	C	D	Average
1	86.7%	66.7%	76.7%	87.5%	100%	93.75%
2	93.3%	73.3%	83.3%	87.5%	100%	93.75%
3	73.3%	40%	56.65%	62.5%	73.3%	62.5%
	Total		72.22%			83.33%

Based on Table 6, activity indicator 3 had the lowest percentage of students in class B faith-based schools. This showed that students did not fully have the desire to apply mathematics in everyday life or other learning because of the difficulties experienced by students themselves. At the same time, teachers always tried to connect topics in mathematics with problems that exist in everyday life. This was by individual interview footage of a sample of teachers on the activity indicators.

Table 7. Excerpts of interviews on indicator 3 Mathematical Connection

Question (indicator 3)	What is the picture of students' attitudes when applying mathematics in everyday life and other learning? Do they feel excited?
Answer of faith-based school's teacher (B)	The attitude of students when applying mathematics in everyday life and in other learning always feels excited. This can be seen from the readiness of students at the beginning of learning. In addition, the emergence of this spirit can be seen in the activeness of students in participating in the learning process and actively solving problems

	faced both independently and in groups.
Answer of non-faith-based school's teacher (C)	There must always be one or two children who are interested in contextualizing maths learning in everyday life (there are not many children like this yet). Many children still have difficulty relating maths lessons (formulas) to everyday life. And things like that became homework for me. When it comes to hooking mathematical formulas for use in everyday life, children still struggle.

Mathematical Communication

The last observation of the response is in mathematical communication activities. When a person can already relate between mathematical topics, other disciplines, and problems in everyday life, it is also necessary to organize his mathematical thinking both orally and written. Based on these responses, most students used good, polite, and responsible language in explaining or conveying mathematical ideas in class (indicator 2), giving honest comment, and asking open questions about the strategies used by friends in solving math problems (indicator 3). Meanwhile, in faith-based schools, activity indicator 4 had the smallest average percentage value; thus, students did not feel enthusiastic about using mathematical language to share their ideas appropriately (indicator 4). Further, not all students felt that they had tried hard to double-check the results of their thoughts or ideas in solving math problems (indicator 1b) in non-faith-based schools. This can be seen from the average percentage, which was smaller than the average percentage of other activities in non-faith-based schools.

Table 8. The Percentage of Students' Perception of Character Education Values in The Process of Mathematical Communication

Activity	Faith-Based Schools			Non-Faith Based Schools		
Indicators	A	B	Average	C	D	Average
1a	100%	73.3%	86.65%	100%	100%	100%
1b	93.3%	73.3%	83.3%	75%	93.3%	84.15%
2a	86.7%	80%	83.35%	93.75%	93.3%	93.53%
2b	100%	93.3%	96.65%	100%	93.3%	96.65%
2c	80%	86.7%	83.35%	81.25%	100%	90.63%
3a	100%	80%	90%	100%	93.3%	96.65%
3b	93.3%	86.7%	90%	100%	100%	100%
4	86.7%	66.7%	76.7%	81.25%	93.3%	87.28%
	Total		86.25%			93.61%

Based on Table 8, the smallest average percentage in faith-based schools lied in the indicator of activity 4 in school B. The percentage value in activity 4 was the smallest among others, even though the teacher had accustomed students to use mathematical language in channeling their ideas appropriately. Thus, it can be said that the enthusiasm of students was not maximally boosted. The difficulty and ignorance of students in using mathematical notation and symbols as part of mathematical communication activities was considered an obstacle to students' curiosity to search. While, the smallest percentage of non-faith-based schools was in activity indicator 1b where students did not put enough effort into double-checking the results of their thoughts or ideas in solving math problems. Although not all students feel that way, the teacher confirms that most students have tried to re-examine the results of their thoughts or ideas in some context of activities related to problem-solving. The following were excerpts of individual interviews with teachers on the activity indicators.

Table 9. Excerpts of interviews on indicators 4 and 1b of Mathematical Communication

Question (indicator 4)	What is the description of students' attitudes when it comes to using mathematical language in sharing their ideas appropriately? Do you feel excited to find out?
Answer of faith-based school's teacher (B)	In general, familiarizing them with mathematical notations in learning has been done. Mastery of mathematical symbols is an absolute must-have for students in learning mathematics. When they are ignorant mathematical symbols or language in the learning process, they will usually try to find out (there is curiosity). That curiosity is seen when they try to ask the math teacher about it. In addition teachers, when students find out the relationship between their ignorance of language, they also sometimes asks their peers. Then, they also take the initiative in literacy to find materials (videos, books, etc.) that they do not know the meaning and content (related to the language of mathematics). This means that learning resources to find out related to mathematical language is very open and students are welcome to access it.
Question (indicator 1b)	What is the picture of students' attitudes when double-checking the results of their thoughts or ideas in solving math problems? Did they try hard?
Answer of non-faith-based school's teacher (C)	Depending on the characteristics of each student, for example, there are students who, when the exam ends, and the answers are collected by the teacher then go to the teacher (me). They confirm their work with answers from the teacher (discussions given by the teacher). However, besides that, there are also students who surrender (do not conform to the teacher after the exam ends) although there are not many like that.

Discussion

Character is a concept that is interrelated with several things, such as moral concepts, attitudes, and behaviour (Lickona, 2009). By looking at these three components, good character is supported by knowledge of goodness, the desire to do good, and doing good deeds. Building character values in mathematics learning is an important aspect of shaping students not only as individuals who have mathematical skills, but also as good citizens with integrity. The results of students' perception of each indicator of mathematical problem-solving activities, mathematical understanding, mathematical connections, and mathematical communication with the cultivation of character values had been mostly felt by students. This success was seen that non-faith-based schools had a higher percentage of students' perceptions of indicators of mathematics learning activities integrated with character values. This showed that character growth in the social and cultural environment in schools that were not religiously based has also developed well.

Mathematical communication activities were activities that had the highest percentage value. In the process of this activity, many students felt the cultivation of several character values. In addition to its scope consisting of various forms (verbal to symbolic representation), this activity is also relevant in everyday life and careers in various fields. Involving students in a positive mathematical communication process can help them develop character values such as cooperation, empathy, patience, creativity, independence, and integrity. Thus, learning mathematics becomes not only the development of mathematical skills but also the development of positive character. However, the four aspects of mathematical power are interrelated and support each other in the process of learning

mathematics. Success in mathematics learning involves the integration of mathematical communication skills, problem-solving, mathematical understanding, and mathematical connections.

The indicators of activities that were less felt by students based on low percentage values, such as: 1) checking and monitoring the process of solving mathematical problems that have been carried out (problem solving), 2) formulating and exploring conjectures for solving mathematical problems (reasoning and proof), 3) developing and evaluating mathematical thinking accompanied by evidence (reasoning and proof), 4) applying mathematics in everyday life and in other learning (connection), 5) using mathematical language to channel ideas appropriately (communication), and 6) double-checking the results of thoughts or ideas in solving mathematical problems (communication). Thus, it can be said that students were still weak in the process of reflection, exploration, evaluation, and application to mathematical processes related to independent values, creativity, responsibility, enthusiasm, and hard effort. This confirms that teachers, as facilitators, are expected to plan and implement teaching processes that build students' character, such as: 1) Providing tasks or projects that require student independence in solving mathematical problems, 2) Providing tasks that stimulate creativity and critical thinking to develop character values such as courage and innovation, 3) Emphasize responsibility in completing mathematical tasks and provide space for students to manage their own time, 4) Using mathematical examples relevant to everyday life and relating them to social problems can develop students' empathy and understanding of the surrounding context, 5) Teachers can teach values such as patience, perseverance, and resilience in the face of difficulties in solving math problems.

CONCLUSION

Based on the results of the percentage of student perception in both types of schools, character values have been felt by most students through the process of problem-solving, mathematical understanding, mathematical connections, and mathematical communication. Although the percentage of students' perceptions is highest in mathematical communication activities, the four activities interact and support each other. The communication process provides opportunities for students to interact with each other to express mathematical ideas, so that it becomes a good vehicle for integrating positive character with students. While based on the aspect of school type, the success of the non-faith-based school sample in building character values in students has been widely felt by students. It should be noted that observing characters cannot be seen from one side alone because many factors influence them. Each aspect influences each other in the process of its formation. Therefore, a good synergy between the school environment and social (family and community) is needed to create a positive student personality.

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