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Application of the Weighted Product Method in a Decision Support System to Determine Children's Multiple Intelligence

Yuliana Astiti Fonga Wea Tae*[1], Rambu Yetti Kalaway[2], Pingky A. R. Leo Lede[3]
[1,2,3]Faculty of Science and Technology,Wira Wacana Christian University, Waingapu, Indonesia
e-mail: ***[1]astitytae@gmail.com**, [2]kalaway@unkriswina.ac.id,
[3]pingky.leo.lede@unkriswina.ac.id

Abstrak

Kecerdasan tidak bisa semata-mata diukur dari sisi kecerdasan intelektual. Terdapat bermacam-macam tipe kecerdasan pada anak sehingga guru dan orang tua memerlukan waktu untuk menentukan tipe kecerdasan anak. Pengambilan keputusan yang cepat dan mudah dapat dilakukan menggunakan sistem pendukung keputusan. Salah satu metode pengambilan keputusan dalam sistem pendukung keputusan adalah metode weighted product. Penelitian ini bertujuan mengukur tingkat akurasi metode weighted product dalam menentukan tipe multiple intelligence anak. Sistem pendukung keputusan yang dirancang untuk menentukan tipe kecerdasan anak usia dini (usia 4-6 tahun) dengan menggunakan delapan tipe multiple intelligence milik Garner [1] sebagai kriteria dalam pengambilan keputusan. Pengumpulan data dilakukan menggunakan wawancara dan kuesioner pada guru TK Negeri Mutiara. Hasil penelitian disimpulkan bahwa sistem pendukung keputusan menggunakan metode weighted product dapat menentukan tipe multiple intelligence anak dengan tingkat keakurasian sebesar 96%. Dari hasil analisis dan perhitungan metode weighted product menggunakan 55 data kuesioner tes tipe multiple intelligence anak yang dibandingkan dengan hasil identifikasi tipe multiple intelligence oleh guru ditemukan kesesuaian sebanyak 53 anak.

Kata kunci— *Multiple Intelligence, Sistem Pendukung Keputusan, Weighted Product, TK Negeri Mutiara, Tipe Kecerdasan Majemuk Gardner*

Abstract

Intelligence cannot solely be measured in terms of intellectual intelligence. There are various types of intelligence in children, which cause teachers and parents require time to determine the type of intelligence of children. Quick and easy decision-making can be achieved using a decision support system. One method that can be adopted in the decision-making process of a decision support system is the weighted product method. This study aims to measure the level of accuracy of the weighted product method in determining the type of multiple intelligence of children. The decision support system determines the type of intelligence of children in early childhood (ages 4-6 years) using Garner's [1] *eight types of multiple intelligences as decision-making criteria. The data was collected using interviews and questionnaires to the teachers of Mutiara State Kindergarten. The study found that a decision support system using the weighted product method can determine the type of children's multiple intelligences with an accuracy rate of 96%. Based on the result of analysis and calculation using the weighted product method from test questionnaire data of 55 children, compared to the results of identification by the teacher, it was found that the compatibility of 53 children.*

Keywords— *Multiple Intelligence, Decision Support System, Weighted Product, Mutiara State Kindergarten, Gardner's types of multiple intelligence*

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1. INTRODUCTION

Intelligence can be defined as the human ability to understand the world well, think logically, and utilize resources efficiently when facing a challenging activity. Gardner [1] states that intelligence is not a single concept and is not general, but is a set of specific abilities resulting from over one million years of human evolution, all of which are separate parts of the brain[1]. Gardner [1] also explains that intelligence cannot be measured solely in terms of intellectual intelligence (IQ), which is only based on logical-mathematical, linguistic, and spatial intelligence. This underlies the development of the theory of multiple intelligences, where intelligence comprises nine types, including verbal-linguistic intelligence (word smart), logical-mathematical intelligence (number smart), visual-spatial intelligence (picture smart), musical intelligence (music smart), kinesthetic intelligence (body smart), interpersonal intelligence (people smart), intrapersonal intelligence (self smart), naturalist intelligence (nature smart) and existential intelligence. Humans possess these abilities but in different capacities. The combination of these nine multiple intelligence abilities helps humans perform different activities.

All intelligence can be identified, grown, and developed to achieve optimal results. The development of children's intelligence can be done from an early age. Early childhood is the golden age where in this age range children experience very rapid growth and development in various aspects, one of which is the development of the child's brain [2]. The growth of a child's brain is determined by how the environment can provide educational stimulation [3]. Lucy [4] stated that at school, approximately 40% of gifted children were found, but could not achieve the same as their actual capacity. This is very unfortunate because children cannot reach their potential optimally.

To develop children's talents and interests, teachers and parents need to understand the type of intelligence possessed by children. By knowing the type of intelligence of children, teachers and parents will better understand the potential of intelligence possessed by children. Thus, it will make it easier for teachers to direct and develop the potential talents and interests of children from an early age. However, determining the intelligence of children is a little difficult because every child has unique characteristics, qualities, and tempo of development. The level of intelligence and indicators that children have been also different. This causes teachers and parents to spend quite a long time identifying, analyzing, and determining the type of intelligence possessed by children. Teachers must observe children's behavior to see their passion, interests, and talents and then decide the type of intelligence that suits the child. This process took a lot of time and effort, therefore we need a tool to make it easier for teachers and parents to decide faster and easier.

The development of information technology today allows the application of information technology for faster and easier decision-making processes, one of which is a decision support system. A decision support system (DSS) is a computer-based information system that aims to provide solutions to problems in decision-making using data and decision models. DSS is made to support the determination of a decision starting from problem identification, data filtering, determining decision-making strategies, to evaluating alternative determinations [5]. Turban et al. [6] stated that DSS has several characteristics, among others, serves to assist the decision-making process in solving a problem where this system works by entering data and performing a combination of models and techniques of data analysis and information seekers and includes feelings and personal judgments from decision-makers as a basis in decision-making. The decision-making process in a decision support system is carried out after passing through 4 main phases, namely intelligence, design, selection, and implementation [7]. With the use of a decision support system, kindergarten teachers will more easily identify the type of child's intelligence and can develop learning to accord to the child's talents and interests.

Decision support systems have many methods that can be used in making a decision. each of these methods has advantages and disadvantages. This study aims to measure the level of accuracy of the weighted product method in determining the type of multiple intelligence of

children. The results of the application of the weighted product method in a decision support system to determine the type of intelligence of children are expected to be used as a reference for teachers and parents in identifying the type of intelligence of children and also as a reference for teachers and parents in developing learning according to the type of intelligence to optimize children's intelligence.

Several studies have applied various methods in decision support systems to determine the type of intelligence of children, including research conducted by Ahsan [8] where this study used a simple additive weighting method with age, last education, experience, health, hobbies, type, and age status as decision-making criteria and 8 types of multiple intelligences which are grouped into three, namely science, social studies, and language as an alternative. The results showed that the decision support system by applying simple additive weighting was successfully implemented with an accuracy rate of 75%.

In addition, there is a study conducted by Ahsan et al. [9] where this study uses the weighted product method with 64 Multiple Intelligence Test questions with the value of the choice as a criterion and 8 types of multiple intelligences as an alternative to the study. The results showed that the decision support system by applying the weighted product method can determine children's multiple intelligences, with the results in the form of a ranking graph.

Efendi and Chotidjah [10] conducted research using the Simple Additive Weighting method with 9 alternative types of multiple intelligences. The results showed that the application of decision support for children's multiple intelligence type tests can help teachers by simplifying and speeding up the processing time of intelligence tests for children.

Research conducted by Harimurti and Herawati [11] used the Simple Additive Weighting method. This study uses 5 criteria that have been weighted according to the Likert scale and alternative 8 types of multiple intelligences. The results showed that after the parents filled in the answers to all the questions on the multiple intelligences type test application, the decision support system would display the 3 highest intelligence.

Research conducted by Sembiring [12] uses the Simple Additive Weighting method, where this study uses numeracy skills, reading skills, language skills, spiritual formation, and behavior formation as criteria with small zero students at Sanggar Bambini Kindergarten as an alternative to research. The results of the study concluded that it can implement the simple additive weighting method in a decision support system for assessing the intelligence of kindergarten children.

In the research conducted by Harimurti and Herawati [11] and research conducted by Sembiring [12], it was found that the similarity of the research focus, namely determining the type of multiple intelligence in children. To distinguish it from previous research, the authors used a different method by processing the criteria variables and different alternative results. In this study, the author uses the weighted product method, because this method is suitable for solving problems in decision-making with multi-criteria. The weighted product method has the advantage that it can assess alternatives to a set of criteria, where each criterion does not have a dependency on one another [13]. In the research conducted, the author uses the type of intelligence developed by Gardner as a criterion in decision-making, where each type of intelligence and its indicators do not have any dependence on each other. Therefore, the weighted product method is suitable to be applied in this study. In addition, this method has a calculation process that is not so complex, followed by a ranking process to determine the best alternative. This method can determine the type of multiple intelligence in early childhood, where the best alternative results will be ranked from the most dominant type of intelligence to the lowest type of intelligence. With this ranking process, the lowest type of intelligence possessed by the child will be detected so that the teacher can direct learning that can optimize the child's intelligence.

2. METHODS

2.1 Research Description

This research comprises six stages, which begin with problem identification and data collection, data analysis, system analysis, system modeling, user interface design, and report generation as well as a conclusion.

Data collection in this study was carried out using interviews and questionnaires conducted on the parties who are the subjects of the research to get the required information related to the existing problems. The interviews conducted with the teachers of the Mutiara State Kindergarten were semi-structured interviews with in-depth interview techniques, using interview guidelines as a guide. The questionnaire in this study relates to the giving of weights to the indicators of the type of children's intelligence that will be answered by the kindergarten teacher who is the subject of the study. The statement on the questionnaire is taken from the multiple intelligence indicators for early childhood compiled by Musfiroh [14]. The questionnaire can be seen in Figure 1.

No	Statement	Ability Level				
		1	2	3	4	5
C1	VERBAL-LINGUISTIC INTELLIGENCE					
1	Children love to communicate with other people, both peers, and adults.					
2	Children often tell long stories about everyday experiences and things they see and know.					
3	Children easily remember trivial things they hear or know, such as the names of friends and family, locations, or commercial jingles.					
4	Children like to carry books around, pretend to read, love books, and spell faster than other children their age.					
5	Children love to play with words like to do funny things and are easy to talk to.					
6	Children like to pay attention to stories and readings their educators give and are good at repeating them.					
7	Children have more vocabulary than their age, which is shown when they speak.					
8	Children love to imitate the scriptures around them and demonstrate achievements that outperform their peers.					
C2	LOGICAL-MATHEMATICAL INTELLIGENCE					
1	Children who are sensitive to numbers love to see numbers, quickly count what they have, promptly master numerical symbols and numbers, recognize money numbers well, and are good at counting.					

Figure 1. Multiple Intelligence Test Questionnaire For Children

The statements used in the questionnaire have covered all the points of intelligence indicators in early childhood so that children's intelligence can be identified in the existing indicators. This study uses a Likert scale to make it easier for respondents to answer each question based on a measured response scale.

2.2. Weighted Product Method

Data analysis focused on mathematical calculations using the weighted product method manually. The dataset was taken from one of the questionnaires filled out by one of the students of Mutiara State Kindergarten. The questionnaire comprises eight parts comprising 64 statements with a Likert scale as the answer choices. The algorithm of the weighted product method can be seen in Figure 2.

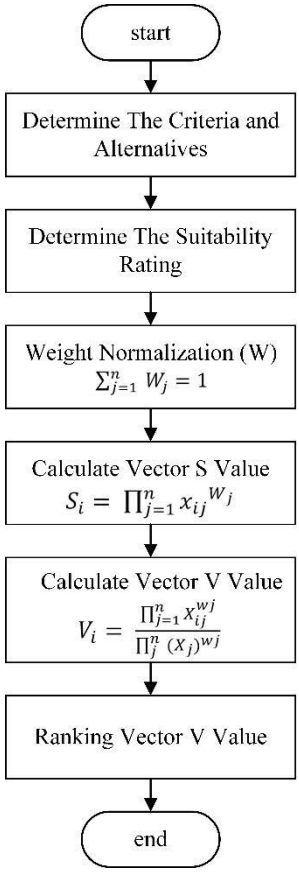

Figure 2. Weighted Product Method Algorithm

The first step of the weighted product method is to determine the criteria and alternatives and the importance of each criterion [15]. The second step is to determine the suitability rating for each alternative on each criterion. The third step is to normalize the weights. Normalized weight is obtained from the results of dividing the weight of each criterion by the total weight value of all criteria. The value of the total normalized weight must meet Equation (1) where the value of W=1.

$$\sum_{j=1}^{n} W_j = 1 \quad (1)$$

The decision-maker gives preference weight to each criterion. After normalizing the weights, the next step is to calculate the value of the vector S. The value of the vector S can be determined using Equation (2) where each criterion of an alternative will be multiplied by the normalized weight as a positive power (+) for the benefit criteria and the normalized weight functions as a negative power (-) for the cost criteria. The eight criteria used have benefit properties, therefore all ranks are positive.

$$S_i = \prod_{j=1}^{n} x_{ij}^{W_j} \quad (2)$$

Where:
S = state alternative preferences that are analogous to vector S
X = state the score criteria
W = state the weight criteria

I = state alternative
J = state criteria
N = state the number of criteria

After obtaining the value of the vector S, the next step is to determine the value of the vector V or the relative preference of each alternative value that will be used for ranking. The value of the vector V can be calculated by Equation (3) where the value of the vector S of each alternative will be divided by the total value of the vector S.

$$V_i = \frac{\prod_{j=1}^{n} x_{ij}^{wj}}{\prod_{j}^{n} (X_j)^{wj}} \quad (3)$$

Where:
V = state that alternative preference that is analogous to V vector
X = state the score criteria
W = state the weight criteria
i = state alternative
j = state criteria
n = state the number of criteria

After getting the value of the vector V, a ranking process will be carried out to determine the best alternative results.

3. RESULTS AND DISCUSSION

This study uses eight types of intelligence as criteria for decision-making. The eight criteria used have benefit properties. Each criterion has eight sub-criteria used as a reference for each alternative in decision-making. So, the total sub-criteria consists of sixty-four sub-criteria. The sub-criteria in this study uses statements with the Likert scale as the answer choice. The value of the choice is used as a sub-criteria value. Each criterion has a preference weight (level of importance) which is assessed on a scale of 1 to 5. The weighting is carried out by decision-makers based on the results of interviews with kindergarten teachers. The alternatives used in this study consisted of eight types of intelligence. The criteria and alternatives used in this study can be seen in Table 1.

Table 1. Criteria and Alternatives

Criteria (C)	Alternative (A)	Properties	Weight
C1 = Words Smart	A1 = Verbal-Linguistic Intelligence	Benefit	4
C2 = Number Smart	A2 = Logical-Mathematical Intelligence	Benefit	4
C3 = Picture Smart	A3 = Visual-Spatial Intelligence	Benefit	5
C4 = Music Smart	A4 = Musical Intelligence	Benefit	4
C5 = Body Smart	A5 = Kinesthetic Intelligence	Benefit	4
C6 = People Smart	A6 = Interpersonal Intelligence	Benefit	3
C7 = Self Smart	A7 = Intrapersonal Intelligence	Benefit	4
C8 = Nature Smart	A8 = Naturalist Intelligence	Benefit	3

The next step is to determine the suitability rating for each alternative on each criterion. Table 2 shows the alternative suitability rating for each criterion in the calculation of the weighted product method. The dataset was taken from one of the questionnaires filled out by one of the students of the Mutiara State Kindergarten.

Table 2. Alternative Match Rating

Alternative	Criteria							
	C1	C3	C3	C4	C5	C6	C7	C8
A1	4	4	4	3	3	3	4	3
A2	4	5	4	3	4	4	5	5
A3	3	4	4	5	5	4	4	3
A4	5	5	5	5	4	4	4	4
A5	5	4	5	5	5	4	5	4
A6	4	4	4	4	4	4	4	4
A7	4	5	5	5	4	5	5	5
A8	4	4	4	4	4	4	4	5

The decision-maker gives preference weight to each criterion that must be normalized, where the value of the total normalized weight must meet Equation 1. The result of the weight normalization is as follows:

Weighting:

$$W1 = \frac{4}{4+4+5+4+4+3+4+3} = 0{,}129$$

$$W2 = \frac{4}{4+4+5+4+4+3+4+3} = 0{,}129$$

$$W3 = \frac{5}{4+4+5+4+4+3+4+3} = 0{,}161$$

$$W4 = \frac{4}{4+4+5+4+4+3+4+3} = 0{,}129$$

$$W5 = \frac{4}{4+4+5+4+4+3+4+3} = 0{,}129$$

$$W6 = \frac{3}{4+4+5+4+4+3+4+3} = 0{,}96$$

$$W7 = \frac{4}{4+4+5+4+4+3+4+3} = 0{,}129$$

$$W8 = \frac{3}{4+4+5+4+4+3+4+3} = 0{,}96$$

Normalization Based on Weighting:

= W1 + W2 + W3 + W4 + W5 + W6 + W7 + W8

= 0,129 + 0,129 + 0,161 + 0,129 + 0,129 + 0,096 + 0,129 + 0,096

= 1

After normalizing the weights, the next step is to calculate the value of the vector S. The vector S is calculated using Equation 2 with the following results:

$$S1 = (4^{0,129})(4^{0,129})(4^{0,161})(3^{0,129})(3^{0,129})(3^{0,96})(4^{0,129})(3^{0,96}) = 3{,}512$$

$$S2 = (4^{0,129})(5^{0,129})(4^{0,161})(3^{0,129})(4^{0,129})(4^{0,96})(5^{0,129})(5^{0,96}) = 4{,}172$$

$$S3 = (3^{0,129})(4^{0,129})(4^{0,161})(5^{0,129})(5^{0,129})(4^{0,96})(4^{0,129})(3^{0,96}) = 3{,}97$$

$S4 = (5^{0,129})\,(5^{0,129})\,(5^{0,161})\,(5^{0,129})\,(5^{0,129})(4^{0,96})(4^{0,129})(4^{0,96}) = 4{,}52$

$S5 = (5^{0,129})\,(4^{0,129})\,(5^{0,161})\,(5^{0,129})\,(5^{0,129})(4^{0,96})(5^{0,129})(4^{0,96}) = 4{,}652$

$S6 = (4^{0,129})\,(4^{0,129})\,(4^{0,161})\,(4^{0,129})\,(4^{0,129})(4^{0,96})(4^{0,129})(4^{0,96}) = 4$

$S7 = (4^{0,129})\,(5^{0,129})\,(5^{0,161})\,(5^{0,129})\,(4^{0,129})(5^{0,96})(5^{0,129})(5^{0,96}) = 4{,}72$

$S8 = (4^{0,129})\,(4^{0,129})\,(4^{0,161})\,(4^{0,129})\,(4^{0,129})(4^{0,96})(4^{0,129})(5^{0,96}) = 4{,}087$

The next step is to determine the value of the vector V that will be used for ranking. The value of the vector V can be calculated by Equation 3.

$$V1 = \frac{3{,}512}{3{,}512 + 4{,}172 + 3{,}97 + 4{,}52 + 4{,}652 + 4 + 4{,}72 + 4{,}087} = 0{,}1044$$

$$V2 = \frac{4{,}172}{3{,}512 + 4{,}172 + 3{,}97 + 4{,}52 + 4{,}652 + 4 + 4{,}72 + 4{,}087} = 0{,}1240$$

$$V3 = \frac{3{,}97}{3{,}512 + 4{,}172 + 3{,}97 + 4{,}52 + 4{,}652 + 4 + 4{,}72 + 4{,}087} = 0{,}1180$$

$$V4 = \frac{4{,}52}{3{,}512 + 4{,}172 + 3{,}97 + 4{,}52 + 4{,}652 + 4 + 4{,}72 + 4{,}087} = 0{,}1344$$

$$V5 = \frac{4{,}652}{3{,}512 + 4{,}172 + 3{,}97 + 4{,}52 + 4{,}652 + 4 + 4{,}72 + 4{,}087} = 0{,}1383$$

$$V6 = \frac{4}{3{,}512 + 4{,}172 + 3{,}97 + 4{,}52 + 4{,}652 + 4 + 4{,}72 + 4{,}087} = 0{,}1189$$

$$V7 = \frac{4{,}72}{3{,}512 + 4{,}172 + 3{,}97 + 4{,}52 + 4{,}652 + 4 + 4{,}72 + 4{,}087} = 0{,}1403$$

$$V8 = \frac{4{,}087}{3{,}512 + 4{,}172 + 3{,}97 + 4{,}52 + 4{,}652 + 4 + 4{,}72 + 4{,}087} = 0{,}1215$$

After getting the value of the vector V, a ranking process will be carried out to determine the best alternative results. The results of calculations using the weighted product method are described in Table 3.

Table 3. Calculation Results Using the Weighted Product Method

Alternatives (A)	Vector Value V	Rank
A7 = Intrapersonal Intelligence	0,1403	Ranking 1
A5 = Kinesthetic Intelligence	0,1383	Ranking 2
A4 = Musical Intelligence	0,1344	Ranking 3
A2 = Logical-Mathematical Intelligence	0,1240	Ranking 4
A8 = Naturalist Intelligence	0,1215	Ranking 5
A6 = Interpersonal Intelligence	0,1189	Ranking 6
A3 = Visual-Spatial Intelligence	0,1180	Ranking 7
A1 = Verbal-Linguistic Intelligence	0,1044	Ranking 8

Based on the results of manual calculations, the most dominant type of intelligence possessed by the subject is intrapersonal intelligence, followed by kinesthetic intelligence, and musical intelligence. While the lowest intelligence possessed is verbal-linguistic intelligence.

After obtaining the results of manual calculations, tests were conducted to compare the accuracy of the results of calculations using the weighted product method with the results of

teacher identification. From the questionnaires distributed to 60 TK Negeri Mutiara students, 5 questionnaires were not filled out completely, so they were not suitable for analysis.

Based on the analysis of data from appropriate questionnaires, the following results were obtained: 8 children have verbal-linguistic intelligence, 3 children have logical-mathematical intelligence, 9 children have visual-spatial intelligence, 25 children have kinesthetic intelligence, 3 children have interpersonal intelligence, 6 children have intrapersonal intelligence, and 1 child has naturalist intelligence.

The results of calculations using the weighted product method are compared with the results of the identification of the type of intelligence carried out by kindergarten teachers. The results obtained from the teacher identification are as follows: 8 children have verbal-linguistic intelligence, 3 children have logical-mathematical intelligence, 9 children have visual-spatial intelligence, 23 children have kinesthetic intelligence, 4 children have interpersonal intelligence, 6 children have intrapersonal intelligence, and 2 children have naturalist intelligence. The sample data used were 55 children, after calculating using the weighted product method and compared with the identification of the teacher. It was found that 53 children or 96% were following the calculation results, while two children did not match the calculation results. The comparison of the percentage of the suitability of the calculation results using the weighted product method with the results of identification by the teacher can be seen in Figures 3, 4, and 5.

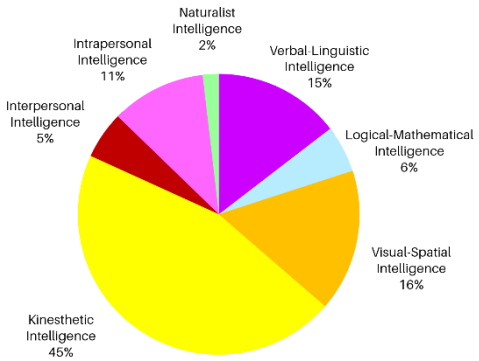

Figure 3. Calculation Results Using The Weighted Product Method

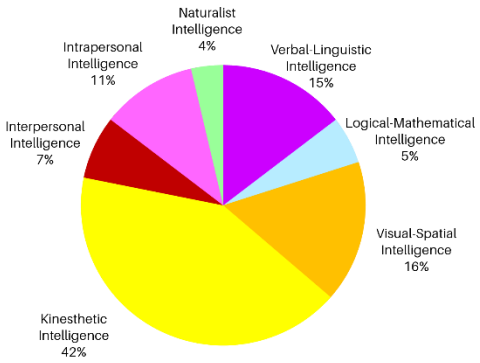

Figure 4. Identification of the Type of Intelligence Carried Out by Kindergarten Teachers

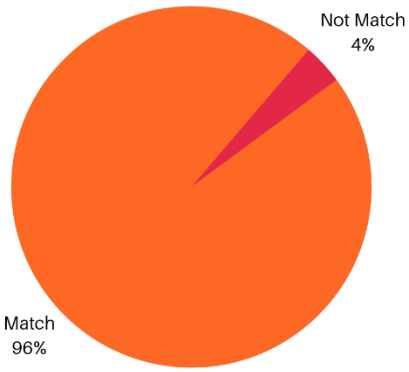

Figure 5. Comparison of The Weighted Product Method Calculation and Identification by teacher

4. CONCLUSIONS

Based on the results of research on the application of the weighted product method in multiple intelligence type decision support systems for children, it is concluded that the weighted product method can help teachers and parents determine the type of multiple intelligence of children with an accuracy rate of 96%. From the results of the analysis and calculations carried out using 55 children's data collected through questionnaires and interviews, the comparison of the results of calculations using the weighted product method with the results of the identification of the type of multiple intelligence by the teacher was found to be fit for 53 children.

Decision support systems can help teachers and parents optimize intelligence by providing learning recommendations to optimize the type of intelligence that is detected to be low in children. The design of a decision support system determines the type of children's multiple intelligence that is designed to provide learning recommendations to optimize children's intelligence.

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