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An AHP-Based Priority Selection Method for Capabilities Development: A Case Study of SDN Botok

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ABSTRACT

The critical investment of the future society needed to develop student capabilities for the early stage. Research has contributes considerably to the investigation of necessary student capabilities for improvement. However, previous studies typically focus on proposing a general of capabilities. There is limited knowledge of how a school can identify the necessary of student capabilities and plan the corresponding development program actions. This research aims to determine the capabilities that need to be developed in Botok elementary school use Gap Analysis and Analytical Hierarchy Process (AHP) method. The method supports the analysis of any factors that influence by identify the actual condition, pre-test and post-test assessment of student capabilities in Botok elementary school. The gap analysis results are presented that linguistic and spatial-visual capabilities has excellent category. Meanwhile, the mathematics has good category. This result of gap analysis reinforced by AHP method, that are the eigenvector value of linguistic capabilities (0,20), mathematics capabilities (0,71), and spatial-visual capabilities (0,09). Thus, finding this research shows that the mathematics capabilities are the most important to develop.

INTRODUCTION

The life of a country can be influenced by its economic growth and the welfare of its citizens, who depend heavily on the quality of learning to support job prospects for competent workers in the business world (Sandroto et al., 2018). In current economic conditions, entrepreneurs need increased capabilities that support systemic creativity, even for moderate competitiveness, such as the application of interpersonal and intrapersonal skills (Olson & Whitefoot, 2012). In contrast, graduates who are ready for the world of work can apply their skills in a flexible business climate, and their performance is often influenced by gaps in employability (Leitch, 2006). This situation clearly requires changes in various aspects to create a balance between human capabilities and technology (Khonitan & Utami, 2018). To be able to compete, someone needs to have adequate skills. Therefore, the important investment of the future society needed developing student capabilities for early stage.

Given the worldwide acknowledgment of the increasing significance of STEM (Science, Technology, Engineering, and Mathematics) education, there has been a pressing need to support research and scholarship in this field (Li, 2014, 2018a). Therefore, to support STEM education at the elementary school level, there are at least three basic abilities that students must have, namely linguistic abilities, mathematical abilities, and spatial-visual abilities. The prior research has demonstrated a strong connection between spatial skills and success in mathematics learning and achievement (Kok, 2021; Atit et al, 2020; Mix et al, 2016). National Research Council (2005), defines that spatial thinking encompasses a range of cognitive abilities, including understanding spatial concepts, using representational tools, and applying reasoning processes. Mix (2019), argued that disparities in mathematics performance are often linked to differences in students' spatial skills at various educational stages. To improve students' spatial skills, teachers need to bridge the gap between real-world contexts and students' cognitive processes (Sorby, 1999). Therefore, it is very important to establish more precise, explicit and systematic (more comprehensive) qualification requirements related to the mastery of critical skills and knowledge of teachers to revitalize education, increase the professional excellence of teachers in schools, and encourage the quality of teaching and education.

Therefore, this research aims at a systematic method to assess students' needs in improving their lacking abilities so that teachers can adjust teaching competency standards appropriately. This analysis was carried out by applying the Analytic Hierarchy Process (AHP) decision model. Our research methods and findings provide consistent and comprehensive competencies for teachers and teacher training institutions to use to assess, provide instruction, and develop skills and knowledge relevant to students' growing needs. It is suggested that the criteria for students' lack of abilities that need to be developed can also be used as a benchmark for assessing teacher performance so that they focus more on improving students' lacking abilities.

CASE STUDY

The case study involved SDN Botok. SDN Botok was selected according to observation analysis results from thematic real work lecture (KKNT), State University of Surabaya. The location of SDN Botok is at Botok village, Magetan, East Java. It has B accreditation from Kemendikbud. At the present, SDN Botok has 9 teachers, 1 of teaching staff and 120 of students. Based on the observation results, any subfactor for each factor presented in **Table 1**. Moreover, researchers discover a lack of linguistic, mathematics, and spatial capabilities. The following sections present a detailed description of each factor based on actual condition.

Factor 1. Linguistic Capabilities

The actual condition of linguistic capabilities in SDN Botok based on observation involved class 5 and 6. Through Pre-test and post-test conducted to determine capabilities rate. Meanwhile, the assessment tests are created to increase student interest in learning.

Factor 2. Mathematics Capabilities

The actual condition of linguistic capabilities in SDN Botok based on observation involved class 3 and 4. Pre-test and post-test conducted to determine capabilities rate. In this sense, the assessment tests are created to increase students understanding by mathematical materials.

Factor 3. Spatial Capabilities

The actual condition of spatial capabilities in SDN Botok based on observation involved class 1 and 2. The observation conducted using Linkert Scale to determine capabilities rate.

Tabel 1. The required subfactor support for successful identification capabilities factor.

Code	Factor 1 (Linguistic)	Factor 2 (Mathematics)	Factor 3 (Spatial)
S1	Understanding Rate	Understanding Rate	-
S2	Problems Understanding	Problems Understanding	-
S3	Using Problems Method	Using Problems Method	-

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S4	Motivation Improvement	Motivation Improvement	Motivation Improvement
S5	Program Effectiveness	Program Effectiveness	Program Effectiveness
S6	Program Usefulness	Program Usefulness	Program Usefulness
S7	Test Assestment	Test Assestment	-

METHOD

This section consist of two subsections, that are Gap Analysis and AHP.

GAP Analysis

Gap analysis in this research includes a quantitative approach in order to provide clearer information in determining the gaps among the factors. A quantitative research conducted by Linkert scale. The range of scoring between 1 until 5, that are 1 (Very Not Good), 2 (Bad), 3 (Enough), 4 (Good), and 5 (Excellent). Due to, the range of scoring between 1 until 5, therefore the index scale is 0.8 to determine index scale factors (Syarief et al, 2014) presented in **Table 2**.

This analysis was carried out using a questionnaire which filled by students and teachers. The scoring of questionnaire according to actual conditions in the fields on subfactors in each factor. Instead as regards of an ideal conditions which are future improvements expectation or expected conditions in the future. The calculations of scoring factor used by average of total subfactor score.

Tabel 2. Indeks Scale Factors (Syarief, et al, 2014).

Range Criteria	**Category**
1 < D ≤ 1,80	Sub-factor Very Not Good
1,80<D≤2,60	Sub-factor Bad
2,60<D≤3,40	Sub-factor Enough
3,40<D≤4,20	Sub-factor Good
4,20<D≤5,00	Sub-factor Excellent

Analytical Hierarchy Process (AHP)

AHP is a multivariate decision making technique used in policy analysis (Pratiwi, 2020). Essentially, AHP is a comprehensive model for decision making with take into account qualitative and quantitative matters. In general, the purpose of AHP method is arrangement of priorities from various existing alternative choices, that are complex or multi-criteria. Through a pairwise comparison approach, the decision making conducted set off from scale of preference among set of alternative (Saaty, 2008). The subjective value interpretation is presented on a 9-point scale based on empirical fundamentals by (Saaty, 1977). The scale value is presented in **Table 3**. One of the functions of AHP is to bring together numerical data or past data from a predetermined group of informants and qualitative data from the decisions of a group of professionals or experts. In this study, an AHP-based evaluation structure is proposed to analytically re-evaluate the current capabilities level of student in Botok elementary school.

Tabel 3. Value Scale of Pairwise Matrix.

Value Scale	**Explanations**
1	Both elements are equally important

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3	One element is slightly more important than the other element.
5	One element is more important than the other elements
7	One element is clearly more absolutely important than the other elements.
9	One element is absolutely more important than the other elements
2, 4, 6, 8	Values between two adjacent consideration values
Reciprocal	If activity i gets one number compared to activity j, then j has the opposite compared to i.

The AHP data processing involves four basic steps:

Step 1: Developing a hierarchy structure

The aim of this study aligns with the hierarchical framework established by various criteria outlined in earlier research. Its goal is to re-identify the capabilities of students. This hierarchy is structured according to the complexity of the elements involved. This study consists of two stages: the first stage includes linguistic, mathematics, spatial criteria, and the second stage 7 sub-criteria of possible identities.

Step 2: Create a pairwise comparison matrix for the entire survey

Questionnaires were utilized to gather comparative results for each pair of proficiency levels, employing a 9-point rating scale (Saaty, 1994).

Step 3: Discovering the eigenvalues and eigenvectors

The process was conducted in accordance with the guidelines outlined by (Driel & Berry, 2012). It involved comparing each variable in pairs and assigning relative weight values in stages 1 and 2. The pairwise comparison matrix is provided below. W = (W1, W2, ..., Wn) T, as the vector W and n are the numbers of components.

$$\begin{bmatrix} \frac{W1}{W1} & \cdots & \frac{W1}{Wn} \\ \vdots & \ddots & \vdots \\ \frac{Wn}{W1} & \cdots & \frac{Wn}{Wn} \end{bmatrix} \times \begin{bmatrix} W1 \\ \vdots \\ Wn \end{bmatrix} \qquad (1)$$

n and W in (1) In the matrix, the eigenvalue and the corresponding eigenvector of matrix A are specified. The experimental matrix A includes some divergences. The approximation of W, denoted as $\overline{W}$, can be represented similarly to equation **(1)**.

$$\bar{A} \text{ x } \overline{W} = \lambda_{max} \text{ x } \overline{W}$$

$\bar{A}$ is the pairwise judgement observed matrix, λ_{max} is the biggest eigenvalue of, $\bar{A}$ and $\overline{W}$ is its accurate eigenvector.

Step 4: accumulating the relative loads

The various levels obtained in phase three are combined to produce a vector of multiple weights, which serves to represent the varying degrees of student capabilities in achieving the overall objective of the study. To ensure the study's reliability, the Consistency Index (CI) is calculated, which serves as an initial measure of the accuracy of pairwise comparisons. The method for determining this indicator is provided below.

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

Therefore, the consistency ratio (CR) is calculated for further analysis, while the ACI represents the average index of weights generated randomly (Heritage & Heritage, 2013):

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$$CR = \frac{CI}{ACI} X\ 100\%$$

According to (Kleickmann, 2013) the consistency indicator is considered acceptable if the CR value is less than 0.1. Otherwise, the pairwise comparisons need to be repeated.

IMPLEMENTATION

In this research, the observation data used in data processing comes from a program that has been implemented through KKN-T at elementary school of Botok. There are three programs that have been implemented as a basis for knowing the level of ability of elementary school students. These programs are detailed as follows:

SIBEL program (Linguistic Capabilities)

The SIBEL (Tutoring Study) program is carried out with the aim of improving the ability to work on literacy and numeracy questions. This program was implemented from September, 4 to November, 20, 2023. The evaluation results of implementing the SIBEL program was presented in **Table 4**. The data was obtained by observing using Linkert scale of students capabilities who took part in SIBEL activities.

Tabel 4. Observation Results of SIBEL.

Indicator	1	2	3	4	5
Understanding Rate					√
Problems Understanding				√	
Using Problems Method				√	
Motivation Improvement					√
Program Effectiveness					√
Program Usefulness					√
Test Assesment					√

MATHQUEST program (Mathematics Capabilities)

This program is designed to assist students in comprehending mathematics content and to teach them how to effectively and efficiently solve mathematical problems using suitable methods. This program will be implemented from September, 27 to November, 30 2023. The evaluation results of implementing the MATHQUEST program was presented in **Table 5**. The data was obtained by observing using Linkert scale of students capabilities who took part in MATHQUEST activities.

Tabel 5. Observation Results of MATHQUEST.

Indicator	1	2	3	4	5
Understanding Rate				√	
Problems Understanding				√	
Using Problems Method				√	
Motivation Improvement				√	
Program Effectiveness				√	
Program Usefulness				√	
Test Assesment					√

Program Hero Coloring (Spatial-Visual Capabilities)

This program is intended to enhance students' visual-spatial skills by enabling them to observe and analyze objects in detail (Suyadi, 2009). According to Olivia (2009), visual-spatial ability involves the capacity to think visually by conceptualizing shapes from two or three-dimensional images. This skill can be cultivated through diverse activities such as drawing, painting, coloring, and field trips (Musfiroh, 2008). This program will be implemented on November, 10 to 11, 2023. The evaluation results of implementing the Hero Coloring program was presented in **Table 6**. The data was obtained by observing using Linkert scale of students capabilities who took part in Hero Coloring activities.

Tabel 6. Observation Results of Hero Coloring.

Indicator	1	2	3	4	5
Motivation Improvement					√
Program Effectiveness					√
Program Usefulness					√

RESULT AND DISCUSSION

This study uses gap analysis as the initial analysis. Gap analysis is carried out to obtain results regarding the extent of the gap between actual conditions and ideal conditions. The calculation of this gap analysis is by adding up all the values of the subfactors and then dividing them based on the number of subfactors in each factor. In this case, the results of the gap analysis are used as a basis for compiling a hierarchical structure in the AHP method. The hierarchical structure arranged in Figure 4 allows it to be used to accelerate the decision support process. The results of the gap analysis on linguistic ability show that subfactors S2 (Problems Understanding) and S3 (Using Problems Method) have not shown ideal results, this is shown in **Figure 1**. So it is necessary to improve the ability to understand questions and improve the ability in terms of using effective methods to solve the questions being tested.

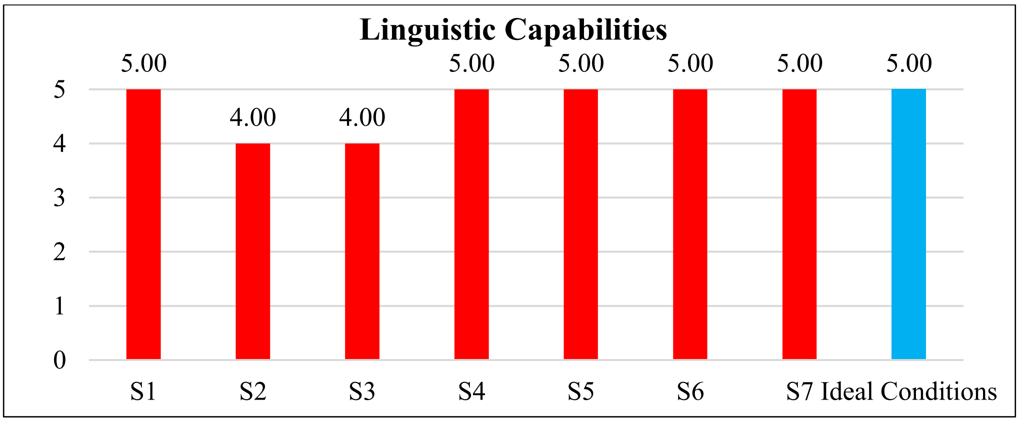

Figure 1. The results of gap analysis linguistic capabilities factor.

Figure 2 describes the results of the gap analysis on mathematical capablities factors. In this case, more subfactors require improvement so that ideal conditions can be achieved, these subfactors include S1 (Understanding Rate), S2 (Problem

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Understanding), S3 (Using Problems Method), S4 (Motivation Improvement), S5 (Program Effectiveness), and S6 (Usefulness Program). Therefore, it is necessary to increase abilities in terms of understanding the material, understanding questions, and understanding the use of methods, as well as increasing motivation to learn mathematics, reviewing the effectiveness of the program being implemented, and the level of program usefulness.

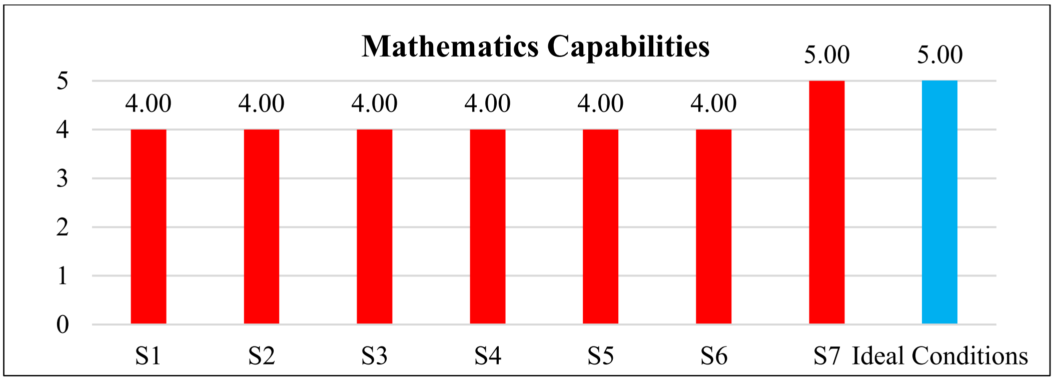

Figure 2. The results of gap analysis mathematics capabilities factor.

The gap analysis related to spatial-visual capabilities in this study is shown in **Figure 3**. The results of this analysis indicate that the subfactors have met the ideal conditions, so there is no need for improvement in this spatial-visual ability. However, in order to maintain this condition, a consistent attitude and commitment are needed between teachers and students.

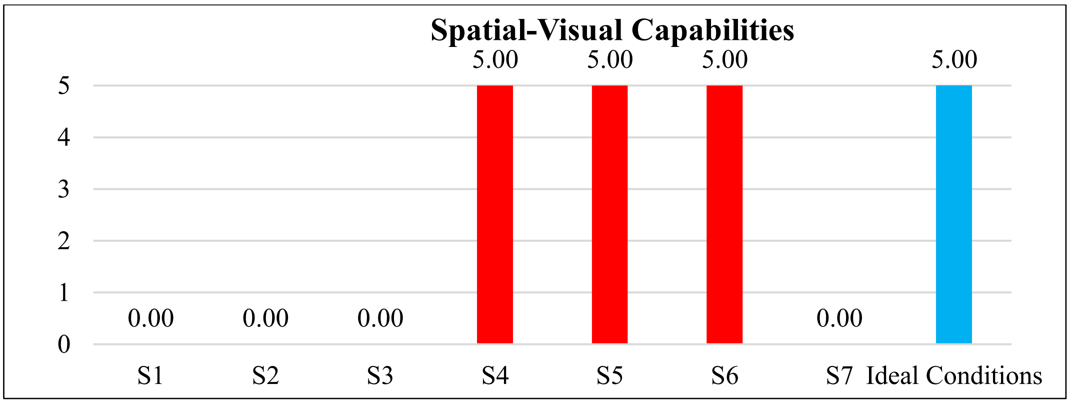

Figure 3. The results of gap analysis spatial-visual capabilities factor.

The results of the gap analysis in this study are shown in **Table 7**. In this case. Linguistic ability and spatial-visual capabilities show excellent category results, while mathematical ability shows good category results. Therefore, evaluation and improvement of the mathematical capabilities factor are needed. So, that the objectives in terms of developing student abilities at Botok elementary school can be maximized. This is in accordance with previous studies which state that students fear of mathematics lessons is also a significant issue (Goenawan & Wijayanti, 2018), this condition indicates Indonesia's low ranking in multialphabetism ability (Abidin et al., 2017).

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Table 7. Gap Analysis Results.

Factor	S1	S2	S3	S4	S5	S6	S7	Ideal Conditions	Average	Category
Linguistic	5.00	4.00	4.00	5.00	5.00	5.00	5.00	5.00	4.71	Excellent
Mathematics	4.00	4.00	4.00	4.00	4.00	4.00	5.00	5.00	4.14	Good
Spatial	-	-	-	5.00	5.00	5.00	-	5.00	5.00	Excellent

The initial of hierarchical structure in this study was built based on the consideration of the results of the gap analysis shown in **Figure 4**. The construction of the hierarchical structure in this study is a preliminary analysis of the AHP method to obtain data on objects (factors) and subfactors in selecting the capabilities that need to be developed at Botok elementary school.

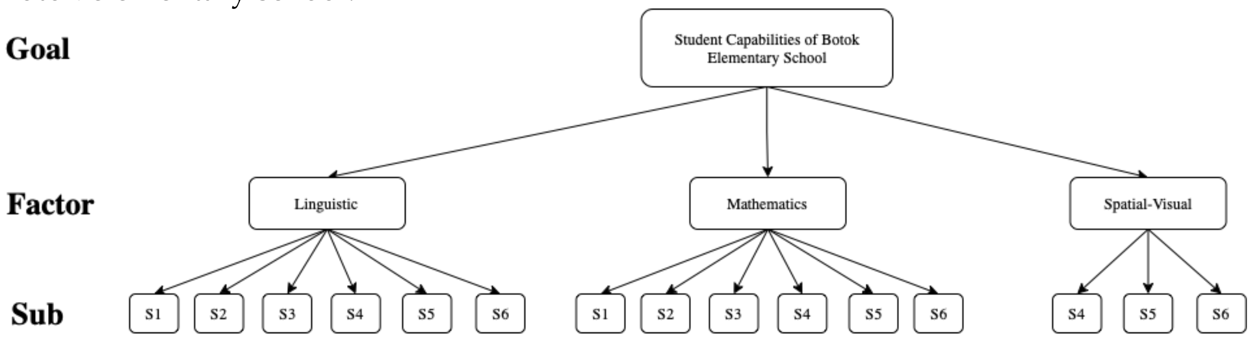

Figure 4. Initial of Hierarchy Structure.

The next stage in the AHP method is the assessment between factors using paired comparisons. This assessment is carried out by the program implementers in KKN-T as shown in **Table 8**. The comparison is carried out by assessing the level of importance between one factor and another. This paired comparison process is carried out using a direct method, namely by entering quantitative data shown in **Table 9** based on the results of the assessment of the level of importance of the factors that have been carried out previously. The comparison value with the same factor is given a value of 1. The comparison of the linguistic factor to the mathematical factor obtained a result of 1/5, this proves that the mathematical factor is more important than the linguistic factor. Conversely, when viewed from the mathematical factor to the linguistic factor, the result obtained is 5. At the level of comparison of the linguistic factor to the spatial-visual factor, the result obtained is 3, which means that the linguistic factor is relatively somewhat more important than the spatial-visual factor. Conversely, when viewed from the spatial factor to the linguistic factor, the result obtained is 1/3. Then, the result of the comparison of the mathematical factor to the spatial-visual factor is 6, this shows that the mathematical factor is in the middle value between the more important value and the very more important value compared to the spatial-visual factor. On the other hand, if we look at the spatial-visual factor against the mathematical factor, the result is 1/6.

Table 8. Gap Analysis Results.

Factor	Assessment																	Factor
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Linguistic													√					Mathematics

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Linguistic		√	Spatial-Visual
Mathematics	√		Spatial-Visual

Table 9. Pairwise Comparisons.

Factor	Linguistic	Mathematics	Spatial-Visual
Linguistic	1	1/5	3
Mathematics	5	1	6
Spatial-Visual	1/3	1/6	1
Total	**6.33**	**1.37**	**10.00**

The eigenvector calculation is shown in **Table 10**. The results of the calculation between linguistic factors and linguistic factors are 0.16, namely from the number 1 divided by the total number of linguistic columns, namely 6.33 in **Table 9**. If all the factors have been calculated then the next step is to add up all the factors. every line. Then the eigenvector calculation is done by dividing the total sum of each factor row by the number of factor columns. For example, the result of the linguistic factor eigenvector is 0.20. This number is obtained from the total row in the linguistic factor, namely 0.60, divided by the number of factor columns, namely 3 (linguistic, mathematics, spatial-visual). The results of all eigenvectors for each factor per row are then added up as a basis for further calculations.

Table 10. Eigenvector Calculations.

Factor	Linguistic	Mathematics	Spatial-Visual	Total	Eigenvector
Linguistic	0.16	0.15	0.30	0.60	0.20
Mathematics	0.79	0.73	0.60	2.12	0.71
Spatial	0.05	0.12	0.10	0.27	0.09
		Total			**1.00**

The calculation of the inconsistency ratio shown in **Table 11** is as follows in the linguistic and linguistic factors obtained a result of 0.20. The result of this calculation is obtained by dividing the result of **Table 9** in the linguistic factor and the linguistic factor, which is 1, with the eigenvector result in the linguistic row of **Table 10**, which is 0.20. In this case, the eigenvector value used in the calculation is based on the suitability of the factor name between the row in **Table 10** and the factor name in the column of **Table 9**. The next step is to add up the results of all factors in each row of factors entered in the Total column.

The calculation in the eigenvalue column is obtained from dividing the total in each row of **Table 11** with the Eigenvector value in **Table 10**. For instance, for the linguistic factor, the eigenvalue is 3.07. This value is obtained from the results of dividing 0.62 (Total Linguistic factor in **Table 11**) / 0.20 (Eigenvector Linguistic factor in **Table 10**). Furthermore, sum of all the eigenvalues and find the average value of the total eigenvalues.

Table 11. Inconsistency Ratio.

Factor	Linguistic	Mathematics	Spatial-Visual	Total	Eigenvalue
Linguistic	0.20	0.14	0.27	0.62	3.07
Mathematics	1.01	0.71	0.55	2.26	3.20
Spatial	0.07	0.12	0.09	0.28	3.02
		Total			**9.29**
		Average			**3.10**

Next is to calculate the value of ƛ max by dividing the result between Total in **Table 11** by the number of criteria, which is 9.29/3, so that the result is 3.097. Then calculate the CI value, which is (3.097-3)/(3-1) so that the result is 0.049. So that the CR value is 0.049/0.58 and the result is 0.08. Therefore, because the CR value <= 0.1, the comparison matrix can be accepted.

Table 12. Synthesis of Priority.

Factor	Eigenvector	Priority
Linguistic	0.20	2
Mathematics	0.71	1
Spatial-Visual	0.09	3

In this case it can be concluded that based on the synthesis priority shown in **Table 12**, the mathematics factor has a larger eigenvector of 0.71 compared to other factors. This explains that the mathematics factor is the first priority factor that needs to be developed or in other words at SDN Botok students' mathematical abilities need to be evaluated and improved in the future. Therefore, consistent with research on motivation and learning in mathematics (Hembree, 1990; Pajares & Graham, 1999) it is indeed very much needed. The linguistic factor is a factor that has an eigenvector value of 0.20 and is ranked second in need of development. On the other hand, the factor that has the smallest eigenvector value is spatial-visual, which is 0.09, which means this factor is the best factor compared to other factors. These results align with recent research showing that younger students demonstrate enhancements in these spatial skills (Lowrie, et al., 2017, 2019). However, a significant amount of research indicates that cognitive skills and motivation are fundamentally interconnected (Ashcraft & Kirk, 2001; Ferguson et al., 2015; Ganley & Vasilyeva, 2011).

CONCLUSION

This research suggested that student capabilities can be categorized into three primary criteria: linguistic, mathematical, and spatial, using gap analysis and AHP analysis to measure the systematic structure of student development levels. These criteria were further broken down into seven sub-criteria, which were represented in assessment questionnaires. The relative importance of these sub-criteria was evaluated using AHP, based on teachers' preferences and expectations. The resulting rankings and weights were used as metrics to aid decision-making. These assessments can serve as tools for benchmarking teacher performance, evaluating teaching effectiveness, and conducting needs analysis to enhance student capabilities. The gap analysis results are presented that linguistic and spatial-visual capabilities has excellent category. Meanwhile, the mathematics has good category. This result of gap analysis reinforced by AHP method, that are the eigenvector value of linguistic capabilities (0,20), mathematics capabilities (0,71), and spatial-visual capabilities (0,09). Thus, finding this research shows that the mathematics capabilities are the most important to develop.

However, there are limitations in this analysis that indicate directions for future research. First, the student capabilities were assessed using a small sample from Botok Elementary School in just one region of Indonesia. Future research should include samples from different provinces or countries. Second, the expert sample have similar backgrounds, so future studies should involve experts from diverse fields of expertise.

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