**The role of students’ non-cognitive factors and school resources in predicting mathematics achievement using PISA 2018 Indonesia data**

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**Abstract.** Many factors affect students’ mathematics achievement. In addition to cognitive factors, many studies also highlight and show that non-cognitive factors of students and school resources become important factors in influencing students’ mathematical achievement. This study analyzed the relationship between students' non-cognitive factors and school resources to mathematics achievement. The data were taken from 9,620 of the 388 schools in Indonesia involved in participating in the 2018 Program for International Student Assessment (PISA). The results of the multilevel analysis found that the students' happy feelings, the students’ cooperation and the students’ belief were a statistically significant relationship to mathematics achievement with all positive relationships. The low quality of educational materials and teaching staff in schools were statistically significant and negatively correlated with mathematics achievement. This study showed that the non-cognitive factors and low quality of teaching staff had an important role for students in achieving mathematics.

1. **Introduction**

Education becomes an important aspect in the process of development and advancing the civilization of a nation. As an evaluation and development process in education, Indonesia participates in the Program for International Student Assessment (PISA) which is carried out by the Organization for Economic Co-operation and Development (OECD). PISA is an international level program to measure the extent to which students have acquired important knowledge and skills to participate in and contribute to socio-economic life, and to assess students in the application of students' knowledge and skills in new or unknown environments, both inside and outside of school [1].

In the PISA 2018 results, in mathematics, Indonesia is at level 1 which is at the lower level with an average score of 379, far below the OECD average of 489 [2]. About 1% of students in Indonesia score at level 5 or higher in mathematics (OECD average: 11%) [3], it appears that student achievement at a high level still has a fairly wide range with the average achieved by the OECD.

The overall achievement of Indonesian students in the field of mathematics is at the lower level in PISA 2018. There are several factors influence this achievement in the field of mathematics, both the influence of factors at the student level or school level. PISA 2018 reported that as many as four out of ten students always feel happy [1]. This condition is a concern about the effect on student achievement in mathematics when learning conditions do not make students feel happy in following the learning process, because students' happy feelings become an important part of the educational construct [4]. In addition, the level of student cooperation and competition is also a variable that influences student achievement, as is Roseth, Johnson & Johnson [5] stated that higher student achievement was supported by student cooperation rather than competition or individualism. Another non-cognitive variable that also has a relationship with student achievement is student confidence, this is shown in research Stankov [6] that student confidence is the most powerful non-cognitive influence on student improvement. In addition to student level variables, school level also influences the achievement of students' mathematics scores. Based on OECD [7] that low-performing students are caused by a lack of availability or quality of educational material. Likewise, schools with a shortage of teachers are associated with low student performance [7][8].

Based on the previous explanation, it becomes important to see and examine the influence of variables at the student level such as student belief (Blif), happiness that often arises in students (Hapy), students' feelings towards the level of cooperation (Cprt) and competition in the learning process (Cmpt). And variables at the school level, namely, the lack of availability or quality of teaching staff (TeSf) and educational materials (textbooks, information technology equipment, library, laboratory material, etc.) (EdMa) on the achievement of students' mathematics scores in Indonesia.

This study used multilevel modeling in analyzing PISA 2018 data and the variables used, enabling fairly comprehensive results to be obtained, as it not only considered at the student level but also considered how the influence of the school level on the achievement of students' mathematical scores. This study more specifically analyzed aspects that need to be built into the learning process related to non-cognitive factors of students who are also influenced by conditions at the school level. Specifically analyzing non-cognitive factors of students regarding students’ happy feelings, students' belief, and students' feelings were important to assess in the learning process. This study looking at how educators should be in managing and building students and learning situations related to students' happy feelings, student's belief, and the level of cooperation and student competence in following the learning process to further develop student achievement in mathematics. Likewise, this study analyzed specifically about school resources were not only looking at the overall socioeconomic status of the school, such as availability or quality of teaching staff and educational important to understand their influence on students’ achievements. So that school can see how the level of influence of school resources on the development of student achievement in mathematics, especially related to the level of availability or quality of educational materials and teaching staff. Therefore, this can be the basis for schools to make more targeted development related to school resources.

1. **Literature Review**
2. *Mathematical Literacy*

In PISA 2018 mathematics literacy is defined as the ability of students to formulate, use, and interpret mathematics in various contexts. This includes mathematical reasoning, the use of concepts, procedures, facts, and mathematical tools to describe, explain, and predict a phenomenon [1]. According to Sumirattna, Makanong & Thipkong [9] mathematical literacy refers to the knowledge and ability of students to apply the knowledge and mathematical skills acquired to understand situations involving mathematics in real life. Based on Sumirattna, Makanong & Thipkong [9] mathematical literacy comprises the following two components: (1) Knowledge refers to conceptual and procedural understanding as to the basis for connecting and solving mathematical problems in real life. (2) Competence refers to the ability of students to apply the knowledge and mathematical skills acquired to real life to solve situations involving mathematics.

This shows that mathematics becomes an important component to be developed in learning, in accordance with Sumirattna, Makanong & Thipkong [9] that teaching mathematics in schools one of which must aim to develop mathematical literacy and improve students' ability to apply mathematical knowledge and solve problems in real life.

1. *Student's Happy Feelings*

According to Lyubomirsky, King & Diener [10] happy people are those who feel positive emotions, such as joyful, pride, and interest, rarely feel negative emotions, such as sadness, anxiety, and anger. This study analyzes the extent of the relationship or the influence of students who have happy feelings towards their achievement in mathematics scores. The 2018 PISA data reported that four out of ten students always feel happy [1]. This condition raises an important concern and question, where students are classified as less who feel happy compared to other feelings. What factors influence students so students do not feel happy? This happiness becomes important to be owned by students because students' happy feelings become an important part of an educational construct [4]. In 65 countries and economies, students who express positive feelings are associated with a stronger sense of student ownership at school and are associated with peers who show a cooperative attitude [1]. Someone who has a sense of happiness makes it possible to carry out what is his duty and purpose well done, as stated Lyubomirsky, King & Diener [10] that someone happy succeed in various domains of his life, including friendship, income, and work performance.

1. *Student Cooperation and Competition*

On research Johnson et al [11] raises some controversies between cooperation and competition. Does cooperation encourage better achievement than the competition? And does cooperation support achievement better than individualist efforts? This is important to study, to see how the influence of cooperation and competition on a student's achievement in learning. Based on Gillies [12] stated that cooperation encourages better achievement and productivity than competition and individualist efforts, and this result applies to subjects in language arts, reading, mathematics, science, social studies, psychology, and physical education. This is in accordance with the theory of social interdependence which states that higher achievement and more positive relationships are supported by cooperation rather than the structure of competition or individualist goals [5]. This result also confirms that cooperation among students is more important than the competition [2]. Thus, cooperation leads to an increase in the achievement of another, and competition leads to conditions where one prevents the achievement of the other. Also in line with the research that stated that students in structured cooperating groups supported more cooperative behavior and help students' understanding than students in unstructured groups [13][14]. This shows students are more focused on assignments and groups.

In addition, better relationships or bonds between generations show higher academic achievement [15][16]. This relationship shows that not only the relationship or cooperation between students, but it is possible to establish a good relationship or cooperation between students and teachers. The teacher certainly here supports students to engage in cooperation well, stimulate students to interact with each other, and express their opinions. Based on Gillies [12] several components must be built-in students to support successful cooperation, namely building interdependence or positive relationships between group members, facilitating dynamic interaction, encouraging a sense of responsibility, building appropriate social skills, encouraging groups to reflect on the task management process and interact with fellow group members.

1. *Student Belief*

According to Stankov [6] that academic achievement can be more successfully predicted with a measure of self-belief. Based on Morony, Kleitman, Lee & Stankov [17] explained some constructs about students' mathematical beliefs, such as self-efficacy, self-concept, and anxiety. Self-efficacy refers to a person's view of their ability to perform certain behaviors. Self-concept is positively correlated with self-efficacy and explains a more general understanding of how well one thinks or acts in school subjects or a series of tasks. While anxiety is self-efficacy and self-concept in its negative form, which in this case is related to anxiety, it shows the student's response when facing or doing an assignment. But in this research is more directed to the construct of belief in self-efficacy and self-concept.

Belief in mathematics became a statistically significant variable that could predict the achievement of mathematical scores [18][19]. In addition, self-belief is the most powerful non-cognitive influence on knowledge development [6]. This statement in line with the statement that self-efficacy being the strongest or best predictor in achieving students' mathematics scores [20][21]. Supported also by the results of research conducted by Morony, Kleitman, Lee & Stankov [17] stated that most of the variance in mathematical performance can be explained by self-efficacy and self-concept. Research result Lee [22] stated self-efficacy showed a positive relationship with the achievement of mathematical scores. Thus, students who have a higher level of belief can have a better achievement score. Students who have low self-efficacy tend to avoid their assignments [23]. These results can be the basis for educators to pay attention to the development of students' self-efficacy, as stated Kitsantas & Ware [19] that it is important for educators to focus on increasing self-efficacy related to the development of students' mathematical performance.

Likewise with self-concept being one of the significant predictors in predicting the achievement of mathematical scores [21][24]. Self-concept has a positive relationship with mathematical performance, students who have a high level of self-concept make student performance in mathematics better [25][26]. In addition, self-concept can affect one's well-being and development [25]. Research Marsh & Craven [26] stated that academic achievement was substantially related to academic self-concept. Based on some previous explanations, confirmation from what it stated Lee [22] that self-construct (self-concept, self-efficacy, and anxiety) has an important contribution in explaining a mathematical performance. Thus this predictor becomes important and interesting to study in realtion to the achievement of Indonesian students' mathematics scores.

1. *Availability or Quality of Teachers and Educational Materials*

Teaching staff and teachers and educational materials (textbooks, information technology equipment, libraries, laboratory materials, etc.) form a part that contributes to implementing an educational process. Effective teachers have at least two things, good experience and development training [27]. A school system that does not have quality teachers, infrastructure, and textbooks will almost certainly appear at a lower level than other systems [7]. In PISA 2015, around half of participating countries showed that students scored lower in schools whose principals informed that their school's capacity to organize learning was hampered by the lack of availability or quality of educational material [28]. And schools that lack teachers tend to be associated with lower student performance [7][8]. And schools that are more likely to report that schools are hampered by educational material and teaching staff are schools that are less fortunate than schools that benefit [29][27]. In this case, disadvantaged schools are schools attended by students who have low socioeconomic levels, and vice versa with schools that benefit.

School facilities are related to the achievement of student performance in mathematics [30]. High-quality material resources in schools, including learning books and infrastructure, are required prerequisites for higher student performance [8][31]. In addition, the availability of educational material in the form of textbooks becomes a separate part that supports the learning process. Because students who are in school with a high student to textbook ratio, in this case, fewer textbooks available at school tend students to have lower mathematics test scores than students who are in school with a low student to book ratio text [32].

In addition to the educational material factors having a relationship with student performance, the quality of teaching also makes it possible to have a close relationship with student performance [28]. Based on Clotfelter [33] concluded that teacher experience, test scores, and regular licenses had a large positive effect on student achievement in mathematics. This result is also in accordance with the result of research which stated that teachers who have more experience were more effective in increased student achievement than those with less experience [33][34][35][32][36]. Teachers' experience in teaching encourages teachers to be more productive [34]. Including teachers who took training substantially increased student test scores in mathematics [37]. Teachers who obtain advanced degrees can improve the ability of teachers to improve student achievement [34]. As well as teachers who have credentials influence student achievement [38] and teachers who have credentials such as good licenses and certifications affect producing better student achievement in mathematics [38][33]. This indicates the teacher's credentials are important and have a major influence on student achievement in mathematics [33]. And teacher knowledge has a significant influence on students' mathematical achievement [39]. Thus improving teacher quality becomes an important part of improving student performance [40][41][42]. And the teacher has a big impact on student learning [43]. This is important to see how the influence of the availability or quality of teaching staff and educational materials on the achievement of Indonesian students' performance in mathematics.

1. **Research Objectives and Questions**

The factors used to predict the results of Indonesian students' achievement in mathematics are feelings of happiness in students (Hapy), feelings of students towards cooperation (Cprt) and competition in the learning process (Cmpt), and student belief in dealing with a problem (Blif) this is a factor at the student level. Whereas the factors at the school level are the lack of availability or quality of teaching staff (TeSf), as well as the lack of availability or quality of educational material (EdMa). These explanatory factors or variables are used to examine in depth the achievement of Indonesian mathematical results at PISA 2018 and specifically to answer the following research questions:

1. How much variance cannot be explained in students' mathematical results is related to differences within and between each school?
2. Which factors can statistically significantly predict the ignition of mathematical results?
3. How much total variance in mathematical achievement can be explained by variables in the last multilevel model?
4. **Method**
5. *PISA Design*

PISA is a three-year survey of 15-year-old students worldwide that assesses how well students have acquired and applied useful knowledge and skills to be able to participate in social and economic life [1]. PISA leads to the process of connecting data about student learning outcomes with data about students' backgrounds and attitudes towards learning, with this being able to identify the characteristics of students, schools, and education systems that are performing well [1]. PISA has the concept of literacy, this refers to the ability of students to apply knowledge and student skills to identify, interpret, and solve problems in a variety of situations [1]. Tests given to students are comprehensive, not only leading to the cognitive domain but also assessing aspects or backgrounds of students and schools. The overall analysis of the ignition of results in the field of mathematics combined with information obtained from the questionnaire provided [44]. PISA assessment leads to basic indicators to identify the knowledge and skills possessed by students, indicators from questionnaires that show how the relationship of knowledge with various backgrounds of students, as well as indicators in trends that show changes in the relationship between student background and systems and the results of performance in achievement mathematical results [44]. Achievements or findings in PISA can be the basis for measuring students' knowledge and skills and for understanding strengths and weaknesses as a process of improving an education system [44].

1. *Data source*

Based on OECD [2] sampling was carried out in two stages. The first stage chooses a representative sample of at least 150 schools, taking into account factors from the school, such as school location and education level. The next stage is about 42 students aged 15 years randomly selected from each school. Around 600,000 students completed the assessment at PISA 2018, representing around 32 million 15-year-old children in schools from 79 participating countries and economies [1][3]. In Indonesia, 12,098 students completed the 2018 PISA assessment in 399 schools, representing 3,768,508 students aged 15 years (85% of the total population of children aged 15 years)[3]. Students who participate in PISA are 15 years 3 months and 16 years 2 months when they complete the assessment, and they have completed at least 6 years of formal schooling [1]. In this study, there was a reduction in data for Indonesia, because there were students who did not have data on the variables analyzed in this study, so the student data did not include in this study, this also resulted in a reduction in the number of schools. So that the number of students in this study was 9,620 students from 388 schools.

1. *Data analysis*

Analysis of PISA data conducted in this study use a multilevel model. This model assumes that schools will impact student performance, which this impact will manifest as a correlation in achievement test scores among students who attend the school [45]. Specifically, in this study applied a two-level multilevel model with a random intercept model, the student as level one is nested in school as level two. At the first level, namely the level of students there are a variable feeling of happiness (Hapy), students' feelings about the importance of cooperation (Cprt) and competition in learning (Cmpt), and student belief in overcoming a problem (Blif). These student level variables are used to examine differences in school. At the school level as the second level, there are variable level of lack of availability or quality of teaching staff (TeSf) and educational material (EdMa). The school level variables are to analyze the differences between schools.

1. **Research Result**

This multilevel model is used to examine the extent to which variables at the student and school level contribute to the achievement of results in the field of mathematics. In this study, first looking at the simplest model, that is a model without a predictor as a step one (null model). Then proceed to the model that includes student level predictors in step two. And in step three review the model by including all predictors (full model). The equation of mathematical scores from the multilevel model in this study, namely:

(1)

(2)

where is the dependent variable with *i* as an individual or student and *j* as a group or school. are independent variables or predictors. is the average overall mathematical score, while the coefficient of each predictor, and is the error or residual at the student or individual level.

In equation (2), it shows an error or residual at the school or group level.

1. *Step 1: Null model*

In table 1 it can be seen that the average achievement of mathematics scores for the whole school is 392.869, and as shown by equation (3) with as a school level error. This shows that the effects of schools are taken into account in the achievement of mathematical performance and provide information on the amount of variance between schools and within schools. The variance that cannot be explained in schools is 2,611 and the variance between schools is 3,546, so the total variance is 6,157.

(3)

To determine the necessity of applying multilevel models in this study, it can be analyzed using ICC and design effects [46]. Based on Peugh [46] ICC equation as follows:

(4)

The greater ICC score indicates the large impact of grouping or schooling, and the need for applying multilevel models in the analysis [45]. The ICC score above also shows that 57.6% of the total variance in the achievement of mathematics scores is related to differences between schools, and 42.4% of the total variance in achieving mathematics scores is related to differences at the student level.

The equation of the design effect [46] as follows:

*Deisgn effect* (5)

based on the value of the ICC and the design effect that shows a large enough value, this indicates that the multilevel model can be applied to analysis in this study.

1. *Step 2: Model by adding predictors at the student level*

Table 1 shows that students who feel happy, have a sense of cooperation, and belief in solving a problem are statistically significant predictors that can predict the achievement of scores in mathematics. While students who have a sense of competing with other students are not statistically significant predictors.

(6)

It can be seen that students who have a sense of happiness, cooperation with other students, and have a belief in solving a problem, have a positive relationship with student performance in achieving mathematics scores. So that students who are often or higher have a sense of happiness, have a better performance in achieving mathematics scores compared to students who have a less sense of happiness. Likewise, students who have a higher sense of cooperation with other students in the learning process, have better performance in mathematics tests than students who lack a sense of cooperation with other students.

In this model by including explanatory variables at the student level, it can be seen that there is a decrease in variance in schools from 2,611 to 2,576 and at the school level from 3,546 to 3,471. This decrease shows that much of the variance in the achievement of the student and school level mathematics scores are caused by student background variables. In this model, about 2% can be explained from the overall variance in the achievement of mathematical scores. Specifically, this student level variable explains 1% of the total variances at the student level and 2% at the school level.

1. *Step 3: Full model*

After entering the school level explanatory variables in this model, students who have a sense of competition or competence are still not statistically significant predictors, while other explanatory variables are significant. The negative coefficient value on the explanatory variable of the EdMa shows that schools that can reduce the level of lack or low quality of educational material have better student performance in achieving mathematics scores. Likewise, the negative relationship on the explanatory variables of TeSf shows that schools that can reduce the level of lack or low quality of the teaching staff have better student performance in achieving mathematics scores. With including school-level explanatory variables in this model, causing an unexplained decrease in variance at the school level by 704, this shows that the explanatory variables in this model explain 20% of the total variance at the school level. Broadly, around 20% of the total variance in the achievement of mathematical scores is explained by this model.

(7)

1. *Interpretation of the Final Model*

In the final multilevel model shows a decrease in total variance from 6,157 to 5,343, this shows that the final multilevel model explains about 13% of the total variance that cannot be explained in achieving mathematical scores. Specifically, this model explains 1% difference at the student level and 22% at the school level. Thus, in general this multilevel model has a good level of suitability because most explanatory variables are statistically significant and some can explain the overall variance that cannot be explained.

Based on the coefficients in the final multilevel model, with other explanatory variables constant, explaining that for every one-point added to students' happy feelings, the importance of cooperation, and students' belief in facing a problem, the achievement of students' mathematical scores will increase respectively by 2.140, 3.624 and 7.927 points. While the achievement of students' math scores will decrease by 21.108 and 12.496 points for each one additional point on the lack or low quality of the teaching staff and educational material with other predictors remains constant.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Null Model | The model with student-level predictors | Full Model |
|  | Estimate (SE) | Estimate (SE) | Estimate (SE) |
| Intercept  Hapy  Cprt  Cmpt  Blif  TeSf  EdMa | 392.869 (3.303) | 349.410 (5.240)\*\*\*  2.148 (0.835) \*  3.632 (0.801) \*\*\*  0.169 (0.689)  7.957 (0.943) \*\*\* | 424.589 (9.734)\*\*\*  2.140 (0.835) \*  3.625 (0.800) \*\*\*  0.202 (0.689)  7.927 (0.943) \*\*\*  -21.108 (2.859) \*\*\*  -12.496 (3.442) \*\*\* |
| Variance cannot be explained  Variance in school  Variance between schools  ICC | 2,611  3,546  0.576 | 2,576  3,471 | 2,576  2,767 |

**Table 1**. The results of the multilevel model analysis for the fixed and random effect

Note: Parameter estimate (standard error in parentheses)

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1. **Discussion and Conclusions**
2. *Discussion*

Regarding the first research question about the many unexplained differences in the achievement of students' mathematical scores related to differences within and between schools, this is explained from the results of the ICC calculation that 57.6% of the total variance in the achievement of mathematics scores is associated by differences between school, and 42.4% of the total variance is associated with differences in student levels. This is consistent with the research conducted by Kartianom & Ndayizeye [47] that the importance of students attending school in shaping students' mathematical performance. This is based on predictors at the school level which explains most of the performance achievement of mathematics scores.

This study can also explain related to the second research questions, namely regarding factors that are statistically significant can predict the achievement of mathematical scores. Each of them can be explained in the final multilevel model which shows that students who have feelings of happiness, a sense of cooperation with other students, and belief in solving a problem become predictors that are statistically significant to predict the achievement of mathematical scores. This finding confirms previous findings that students' feelings of happiness become an important factor in the education construct [4]. Likewise, support statements Johnson et al [11] that better achievement and more positive relationships were supported by cooperation. And according to research Karakolidis, Pitsia & Emvalotis [18] which concluded that self-belief became a statistically significant variable predicted student performance in mathematics.

More specifically, the study found that students who often feel happy achieved better mathematics scores. This finding supports the previous research Lyubomirsky, King & Diener [10] that happy people tend to succeed in various domains. Likewise, students who have a higher sense of cooperation than other students have better achievement scores in mathematics. This supports the previous research conducted [5]. This shows that students who have a sense of cooperation, group work or discussions with other students can encourage and complement each other's understanding between students. Likewise, students who have a higher level of belief in facing a problem in mathematics have a better mathematics score achievement. This finding is in accordance with previous research, that student belief had a positive and significant relationship predicting the achievement of mathematical scores [18]. However, related to students' feelings who consider competition or competition in learning important, it is not a statistically significant predictor of the achievement of mathematical scores. The findings of this study are consistent with the study Roseth, Johnson & Johnson [5] which stated that better achievement and positive relations with the achievement of mathematical scores were supported by cooperation rather than competition or individualism.

This study also finds that the lack of availability or low quality of teaching staff and educational material is a statistically significant predictor. This supports previous research which states that teacher quality was an important part of improving student performance [40][41][42] and had a big impact on student learning [43].

Regarding the final research question about the amount of total variance in achieving mathematics scores explained by explanatory variables in the final multilevel model, in this study the final multilevel model explains 13% of the total variance that cannot be explained, more specifically this model explains 1% and 22% differences within and between schools.

1. *Conclusion*

The results of the analysis in this study indicate that the variables at the student and school level succeeded in explaining some variances in the achievement of mathematics scores. The final multilevel model also shows that the feelings of students who feel happy, feel that cooperation between students becomes an important thing, and the belief that students have in solving a problem statistically significant can predict the achievement of students' mathematical scores. Likewise, at the school level shows that the lack of availability or quality of teaching staff and educational material is statistically significant and negatively related to the achievement of mathematics scores.

Overall, the findings of this study indicate that policymakers, educators, and parents must consider or pay attention to students' feelings about feeling happy, their sense of the importance of cooperation with other students, belief in dealing with a problem, and availability and quality from teaching staff and educational materials in designing education policies and curricula, as a development process that can contribute and support to student performance.

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