

Cognitive and Affective Variables of Learning and its Influence on General Mathematics Competencies of Grade 11 Students:

Basis for Intervention Plan

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Abstract

Affective and cognitive variables may influence the performance of students in mathematics. This study was conducted to find out the relationship between the extent of cognitive (knowledge, application and reasoning) and affective variables of learning (attitude, motivation, confidence, interest, and value of Mathematics) and the competency in General Mathematics. Data were gathered by using a self-made questionnaire which consisted of eight items per indicator while data about the competencies in General Mathematics were obtained through a 20-item test. The findings of the study revealed that both cognitive and affective variables are of moderate extent while the respondents' performance were in the beginning level. A significant relationship is found in both cognitive and affective variables and the competencies in General Mathematics in terms of evaluating functions. An intervention plan was proposed to improve the competencies in Mathematics of the Grade 11 students. Mathematics teachers are encouraged to continuously enhance the cognitive and affective variables of learnings of students. They may ask support from teachers handling other subjects to enhance and sustain both the cognitive and affective variables of learnings not only in Mathematics, but also in other disciplines. Other factors not included in the study should be undertaken in future studies to be conducted.

Keywords: cognitive, affective, competency, General Mathematics

Introduction

Students' cognitive factors, such as their knowledge, application, and reasoning, might influence their mathematical proficiency. There is a close correlation between math proficiency and cognitive capacities. As revealed by the study conducted by Bull and Lee (2014), there is a strong link between cognitive skills and Math proficiency. In addition, Ritchie and bates (2013) also revealed a significant correlation between math ability and intelligence, suggesting a close link between the two.

To succeed academically, students must be able to grasp the cognitive levels. Additionally, students must be ready to apply what they have learned in class to their own learning. Cognitive levels have an impact on how well a person understands mathematics and chooses the best approach to solving math issues. Students with low mathematical aptitude had trouble defining equations, solving inequalities, identifying similarities and differences, correctly differentiating between linear and non-linear, and writing or looking for hidden information in the question.

Similarly, affective learning such as attitude, confidence, motivation, interest and value

are all factors that play a crucial role in an individual's math performance. A positive attitude towards mathematics involves believing in one's ability to excel in math and perceiving it as a valuable and interesting subject. Positive attitudes help foster resilience, problem solving abilities, and a willingness to tackle challenging math problems. On the other hand, a negative attitude can lead to feelings of frustration, and avoidance of mathematical tasks, hindering math performance.

According to Rysdon (2010), the primary reason for students' poor math performance is their inability to see the relevance of mathematics in their everyday lives. While students understand how basic mathematical concepts can be applied in practical situations, they struggle with more complex topics and tend to question the purpose of the subject.

To address this issue, an investigation was carried out to enable students to reflect on their math education and gain a better understanding of the factors that either support or hinder their academic progress. If attitudes are indeed found to play a significant role in students' achievement, teachers could adjust their teaching methods to incorporate more motivational elements, particularly for below-average performers. This study aimed to identify the variables that influence student success by establishing a relationship between these variables and their performance in mathematics.

Methodology

The research utilized descriptive-correlational method of research. The strata were the selected private schools in Roxas District. 102 Grade 11 students were chosen using proportional stratified random sampling utilizing the G*power analysis with Power(1- β) of 0.95 and alpha values of 0.05 with the effect size of 0.2.

This research study used a three-part self-made questionnaire. (1) Extent of Cognitive Variables of Learning, (2) Extent of Affective Variables of Learning and (3) General Mathematics Competencies. It was validated by three (3) master teachers who are at least five (5) years in their current position in Roxas District. Upon validation, the reliability was tested using Pearson Product Moment Correlation Coefficient from the responses of the 10 non-respondents. The computed reliability were: 0.883, knowledge: 0.852, application: 0.855, reasoning: 0.823, attitude: 0.848, confidence: 0.830, motivation: 0.887, interest: and 0.843, value of mathematics.

In data gathering, approval from the District Supervisor of Roxas was sought through a letter. Upon approval, coordination with the principals of the strata were made.

The statistical tools used were weighted mean, frequency and percentage, and Multiple Regression Analysis.

Data on the extent of cognitive and affective variables of learning were measured using a four-point scale with its numerical value, statistical limits and verbal description: 3.75-4.00, high extent: 2.50-3.74, moderate extent: 1.25-2.49, slightly extent: 1.00-1.24, low extent.

Results and Discussion

Knowledge

The respondents' cognitive variables of learning is of moderate extent as indicated by

the overall mean of 2.81. These results indicated that the respondents demonstrate a strong grasp on mathematical concepts and can apply them in new situations. This also means that they know mathematical formulas and can comprehend or solve complex mathematical problems.

This result is similar to the idea of Al-Kurdi, et al. (2020) which stated that when an individual has enough cognitive knowledge, they are able to use this knowledge in solving mathematical problems.

Application

The overall mean of 2.85, described as moderate extent, showed that the respondents are proficient in applying various mathematical tools and methods to solve problems. They are skilled at identifying appropriate operations needed to address a particular issue, and can effectively display data in tables and graphs for easy interpretation. Additionally, they possess the ability to create equations that accurately model real world situations and can implement these operations to arrive at an effective solution.

The results showed that the students appear to have a solid foundation in mathematical knowledge and skills, but may benefit from improving their creativity and flexibility in representing mathematical ideas. This is in consonance with the idea of Warwick and Essay (2011) that application involves seeing the agreements, arguments and the explanation in the context.

Reasoning

The overall mean of 2.73 described as moderate extent shows proficiency in identifying relationships among numbers and expressing them through various mathematical expressions. These indicators suggested they have a deeper understanding of the subject matter and can effectively apply their knowledge to solve complex mathematical problems.

These results are consistent with the findings of Jusman (2018) which revealed that formal reasoning ability directly impacts mathematics learning achievement, particularly when combined with metacognitive awareness. Moreover, this result supported the idea of Mullis and Martin (2017) that reasoning goes beyond the solution of routine problems to encompass unfamiliar situations, complex contexts and multistep problems. It is when fact is distinguished between facts and beliefs and assertions are identified that the difference of opinion is built.

Attitude

The respondents have a high affinity towards mathematics as showed in the overall mean of 2.99, described as moderate extent. All these indicators suggested that the individual has a positive attitude towards mathematics and they find it interesting. This could also imply that they may have a natural inclination towards mathematics and may excel in mathematical tasks.

This result is strengthened by the thoughts of Ingram (2015) that attitude as an affective component is the source of driving the engagement of students towards mathematics. Attitude creates a mindset that becomes constant over time and influences the feelings of the students towards learning mathematics. Moreover, Casey & Fernandez-Rio (2019) mentioned that when examining students' interest in and responses to mathematics, attitudes are crucial factors to take into account. Positive feelings toward mathematics offer a better learning environment than negative feelings. Students who

have favorable feelings, attitudes, and ideas about mathematics are more likely to use it in real-world situations.

Confidence

Based on the overall mean of 2.58, described as moderate extent, it appears that the respondents have high level of confidence and comfort in regards to learning and working with mathematics. They stated that they could learn advanced math, indicating a willingness and capability to challenge themselves in the subject. They also feel confident in their math abilities, suggesting that they have a good grasp of various math concepts. They further express comfort with answering math problems, indicating a lack of anxiety or stress surrounding math tasks.

These results are in consonance with the idea of Khayati and Payan (2014) that by using cooperative learning, game-based learning, and other tactical techniques, it is feasible to boost students' confidence in their ability to master mathematics.

Motivation

Based on the results, the overall mean of 2.60, described as moderate extent, indicated that the respondents have high level of positive attitude towards mathematics. Additionally, they have high expectations for success in math class, suggesting a belief in their own ability to perform well. They also express feeling a sense of security when attempting math, which may indicate a level of confidence in their own problem-solving skills.

These results find consonance with the idea of Michaelides et al. (2019) that it encourages students to put in more effort in pursuit of their academic objectives and that motivation plays a crucial role in mathematics learning. A person's drive and perseverance to participate in or complete a task are determined by their motivation, which is classified as extrinsic if it is influenced by an outside factor like material gains or intrinsic if a task is pursued or completed for one's own personal satisfaction (Fischer et al., 2019).

Interest

The overall mean of 2.63, described as moderate extent, suggested that the respondents have high extent of positivity towards mathematics and their ability to use the subject in college and beyond. They expressed that they like to continue using math in college, indicated that they find value in the subject and intend to pursue it in their academic career.

These results are of relevance to the thoughts of Hashim et al. (2021) who claimed that students' attitudes toward learning mathematics were influenced by their enthusiasm in the subject.

Value of Mathematics

These results highlighted the importance of connecting math education to real-life contexts and career aspirations with the overall mean of 3.04 considered as moderate extent. Teachers can help students see the relevance of math by incorporating real-world examples and problem-solving tasks into their lessons. Additionally, promoting math-related extracurricular activities can help students see the practical applications of math outside of the classroom.

These findings are parallel to the idea of Adelson and McCoach, (2011) that students'

perceptions of the relevance and advantages of learning mathematics for their own life increased their desire to study mathematics.

Function

The results indicated that the respondents had difficulty in answering items about functions. This means that they lacked the prerequisite skills in solving functions such as basic algebra skills (algebraic operations), understanding of function notation, knowledge of domain and range, and familiarity with different types of functions. They may also need to improve their critical thinking and analytical skills, as well as problem solving strategies. Such difficulties could lead to math anxiety which can therefore affects math performance.

The results can be supported by the idea of James et al. (2013) that mathematical anxiety is a long-standing issue in mathematics education that prevents students from developing their mathematical proficiency. Moreover, Gunderson et al. (2018) mentioned that when students have less mathematics anxiety, there can be high mathematical achievement.

Evaluating functions

Results indicated that a lesser percentage of the respondents obtained grades that can be described as advanced. This means they are able to master the necessary competencies and skills in order to evaluate functions. On the contrary, most of the respondents are in the beginning level only which implies that they lack the important skills that are prerequisites in evaluating functions which can cause anxiety. As mentioned by James et al. (2013), anxiety may impede students' development of mathematical skills.

Operations on functions

The results showed that the respondents do not perform well in operation on functions which can be attributed to failure to master the different operations, including the rules. This result is supported by the findings of Soleymani and Rekabdar (2016) that prior success influences one's attitude and performance in mathematics.

Solving problems involving functions

These results indicated that the respondents are not performing well in problem solving. This can be attributed to lack of understanding, limited mathematical proficiency, poor problem solving skills, and lack of engagement. This is in lined with finding of Suan's (2014) study that student characteristics, such as time management, study habits, attitudes toward mathematics, and enthusiasm in mathematics, all play a significant role in academic achievement.

Table 1. Regression Results on the Influence of Cognitive Variables of Learning in General Mathematics Competencies of Grade 11 Students in terms of Functions

Cognitive Variables			Functions		
			R	R ²	Interpretation
Knowledge	0.1797	0.0323	0.0226	0.0707	Not significant
Application	0.1741	0.0303	0.0206	0.0801	Not significant

Reasoning	0.1211	0.0147	0.0048	0.2252	Not significant
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As revealed, there is no significant relationship between cognitive variables in terms of knowledge, application and reasoning and the competencies in General Mathematics in terms of function as indicated by the obtained p values of 0.0707, 0.0801, and 0.2252, respectively, which are higher than the significance level of 0.05. The result means that only a small portion of the variable in the function variable can be explained by the variation in the knowledge, application and reasoning variables. This further means that the cognitive variables cannot predict math achievement which is contrary to the findings of Brainware (2017) and Una's (2013) study which revealed that cognitive skills is an important factor in math execution, and that there is a positive correlation between students' cognitive abilities and their learning outcomes in mathematics.

Table 2. Regression Results on the Influence of Cognitive Variables of Learning in General Mathematics Competencies of Grade 11 Students in terms of Evaluating Functions

Cognitive Variables			Evaluating Functions		
			R	R ²	Interpretation
Knowledge	0.3659	0.1339	0.1252	0.0002	Significant
Application	0.4151	0.1723	0.1640	0.0000	Significant
Reasoning	0.2673	0.0714	0.0622	0.0066	Significant

The result showed that there is a significant relationship between cognitive variables in terms of knowledge, application and reasoning and the competencies in General Mathematics in terms of function as indicated by the obtained p values of 0.0002, 0.0000, and 0.0066, respectively, which are lower than the significance level of 0.05. The result showed that knowledge, application and reasoning can predict the General Mathematics Competencies of Grade 11 Students in terms of evaluating function. This means that high extent of knowledge, application and reasoning can affect the performance in evaluating functions. This result is supported by the findings of Schanzenbach (2016) that cognitive skills, which encompass the capacity to think, process, learn and reason, are important knowledge which are predictors of academic and mathematics achievement.

Table 3. Regression Results on the Influence of Cognitive Variables of Learning in General Mathematics Competencies of Grade 11 Students in terms of Operation on Functions

Cognitive Variables			Operation on Functions		
			R	R ²	Interpretation
Knowledge	0.0340	0.0012	-0.0088	0.7347	Not significant
Application	0.1456	0.0212	0.0114	0.1443	Not significant
Reasoning	0.1719	0.0295	0.0198	0.0841	Not significant

As revealed, there is no significant relationship between cognitive variables in terms of knowledge, application and reasoning and the competencies in General Mathematics in terms of operation of function as indicated by the obtained p values of -0.7347, 0.1443, 0.0841, respectively, which are greater than the significance level of 0.05. The result showed that knowledge, application and reasoning does not influence competencies in operation of functions. This means that neither high nor low extent in the cognitive variables has no influence on the performance in operation on function. This findings can be attributed to metacognition. This finding is contrary to the findings of Cirino et al. (2015) that cognitive abilities such as knowledge, application and reasoning is a predictor of math achievement.

Table 4. Regression Results on the Influence of Cognitive Variables of Learning in General Mathematics Competencies of Grade 11 Students in terms of Solving Problems Involving Functions

Cognitive Variables			Solving Problems Involving Functions		
			R	R ²	Interpretation
Knowledge	0.1225	0.0150	0.0051	0.2201	Not significant
Application	0.0039	0.0000	-0.0100	0.9686	Not significant
Reasoning	0.0421	0.0018	-0.0082	0.6744	Not significant

No significant relationship exists between cognitive variables in terms of knowledge, application and reasoning and the competencies in General Mathematics in terms of solving problems involving functions as indicated by the p values of 0.2201, 0.9686, and 0.6744 which are higher than the significance level of 0.05. This result indicated that knowledge, application and reasoning does not predict competencies in solving problems involving functions. The result of the study is contrary to the findings of España (2023) which revealed that there is a strong relationship between the cognitive skills and general mathematics performance. When cognitive skills increase or decrease, the other one also moves at the same direction.

Table 5. Regression Results on the Influence of Affective Variables of Learning in General Mathematics Competencies of Grade 11 Students in terms of Functions

Affective Variables			Functions		
			R	R ²	Interpretation
Attitude	0.0712	0.0051	-0.0049	0.4771	Not significant
Confidence	0.1033	0.0107	0.0008	0.3017	Not significant
Motivation	0.0704	0.0050	-0.0050	0.4820	Not significant
Interest	0.0155	0.0002	-0.0098	0.8769	Not significant
Value of Mathematics	0.1434	0.0206	0.0108	0.1505	Not significant

As revealed, there is no significant relationship between affective variables in terms of attitude, confidence, motivation, interest and value of Mathematics and the competencies in General Mathematics in terms of function as the obtained p values of 0.4770, 0.3017, 0.4820, 0.8769 and 0.1505, respectively, which are higher than the significance level of 0.05. The results showed that all the indicators of affective variables do not influence the competencies of Grade 11 students in General Mathematics in terms of function. This means that the affective variables do not predict the competencies in terms of functions. This result is contrary to the findings of Garcia (2014) that affective skills or variables, also known as non-cognitive variables play a vital role in in the education process.

Table 6. Regression Results on the Influence of Affective Variables of Learning in General Mathematics Competencies of Grade 11 Students in terms of Evaluating Functions

Affective Variables			Evaluating Functions		
			R	R ²	Interpretation
Attitude	0.3707	0.1374	0.1288	0.0001	Significant
Confidence	0.2397	0.0575	0.0480	0.0152	Significant

Motivation	0.3452	0.1192	0.1104	0.0004	Significant
Interest	0.2322	0.0539	0.0444	0.0189	Significant
Value of Mathematics	0.4281	0.1833	0.1751	0.0000	Significant

As shown, there is a significant relationship between affective variables in terms of attitude, confidence, motivation, interest and value of Mathematics and the competencies in General Mathematics in terms of evaluating function since the obtained p values of 0.0001, 0.0152, 0.0004, 0.0189 and 0.0000, respectively, are lower than the significance level of 0.05. Based from these result, all the indicators of affective variables can predict the General Mathematics Competencies of Grade 11 Students in terms of evaluating function. This means that the higher the extent of attitude, confidence, motivation, interest and value of Mathematics, the higher is the performance in evaluating functions. Likewise, having low extent of these indicators could also result to low competencies. The result is similar to that of Gabrieli et al. (2015) which found out that students who possess stronger affective skills are able to achieve high academic achievement in mathematics. These students performed better than those who only exhibit high cognitive levels.

Table 7. Regression Results on the Influence of Affective Variables of Learning in General Mathematics Competencies of Grade 11 Students in terms of Operation on Functions

Affective Variables			Operation on Functions		
			R	R ²	Interpretation
Attitude	0.1103	0.0122	0.0023	0.2699	Not significant
Confidence	0.1558	0.0243	0.0145	0.1180	Not significant
Motivation	0.1557	0.0242	0.0145	0.1181	Not significant
Interest	0.1064	0.0113	0.0014	0.2872	Not significant
Value of Mathematics	0.1102	0.0121	0.0023	0.2702	Not significant

As shown, there is no significant relationship between affective variables in terms of attitude, confidence, motivation, interest and value of Mathematics and the competencies in General Mathematics in terms of operation on function as indicated by the obtained p values of 0.2699, 0.1180, 0.1181, 0.2872, 0.2702, respectively, which are higher than the significance level of 0.05. The results showed that all the indicators of affective variables do not predict the competencies of Grade 11 students in General Mathematics in terms of operation on function. This result is contrary to that of Farrington (2012) who revealed that aside from academic skills, non-cognitive or affective variables play a vital role to academic performance, including that of Mathematics.

Table 8. Regression Results on the Influence of Affective Variables of Learning in General Mathematics Competencies of Grade 11 Students in terms of Solving Problems Involving Functions

Affective Variables			Solving Problems Involving Functions		
			R	R ²	Interpretation
Attitude	0.0317	0.0010	-0.0090	0.7517	Not significant
Confidence	0.0309	0.0010	-0.0090	0.7582	Not significant
Motivation	0.1142	0.0130	0.0032	0.2533	Not significant
Interest	0.0501	0.0025	-0.0075	0.6171	Not significant
Value of Mathematics	0.1107	0.0122	0.0024	0.2681	Not significant

There is no significant relationship that exists between affective variables in terms of attitude, confidence, motivation, interest and value of Mathematics and the competencies in General Mathematics in terms of solving problems involving functions as indicated by the p values of 0.7517, 0.7582, 0.2533, 0.6171 and 0.2681, respectively, which exceeded the significance level of 0.05. This can mean that beliefs can impact problem-solving competence. This result is opposite to the conclusion drawn by Barrett (2014) that non-cognitive or affective skills was more critical in value than cognitive values in association to academic achievement.

Conclusions

Based on the findings of the study, it is concluded that the Grade 11 student respondents possessed moderate level of knowledge, application and reasoning. The respondents have moderate level of attitude, confidence, motivation, and interest in Mathematics and they recognize the importance of Mathematics. The respondents performed below average in the General Mathematics competencies. They may lack the prerequisite skills necessary in learning higher math. Knowledge, application and reasoning are not predictors of General Mathematics performance in terms of function, operation of function, and solving problems involving functions. However, these variables affect the performance in evaluating functions. Attitude, confidence, motivation, interest and value of mathematics do not affect the competencies in General Mathematics in terms of function, operation of function, and solving problems involving functions. Meanwhile, these variables have influence in terms of evaluating function. The proposed intervention plan can be implemented to improve the competencies of the students in Mathematics.

References

- Adamma, O. N., Ekwutosim, O. P., & Unamba, E. C. (2018). Influence of extrinsic and intrinsic motivation on pupils academic performance in mathematics. *Supremum Journal of Mathematics Education*, 2(2), 52-59. <https://doi.org/10.35706/sjme.v2i2.1322>
- Adelson, J. L., and McCoach, D. B. (2011). Development and psychometric properties of the math and me survey: measuring third through sixth graders' attitudes toward mathematics. *Measur. Eval. Counsel. Dev.* 44, 225-247. doi: 10.1177/0748175611418522
- Al-Agili, M. Z., Mamat, M. B., Abdullah, L., & Maad, H. A. (2012). The factors influence students' achievement in mathematics: A case for Libyan's students. *World Applied Sciences Journal*, 17(9), 1224-1230. <https://www.scholar.google.com>
- Alkan, V. 2013. Reducing Mathematics Anxiety: The Ways Implemented by Teachers at Primary Schools. *International Journal of Social Sciences and Education*. P795-807 2013.
- Andaya, O. J. F. (2014). Factors that affect mathematics achievements of students of Philippine Normal University-Isabela Campus. *Researchers World*, 5(4), 83. <https://www.researchersworld.com>.
- Arthur YD, Asiedu-addo S, Assuah, C. Connecting Mathematics to real life problem using instructor quality and availability, Mathematics facility and teacher motivation for prediction. *International Journal of Scientific Research in Education*. 2017a;10(3):311-324.
- Arulmoly, C., & Branavan, A. (2017). The impact of academic motivation on student's academic achievement and learning outcomes in mathematics among secondary school students in Paddiruppu Educational Zone in The Batticaloa District, Sri Lanka. *International Journal of Scientific and Research Publications*, 7(5), 115- 126.
- Attard, C. (2012). Engagement with mathematics: What does it mean and what does it look like? *Australian Primary Mathematics Classroom*, 17(1), 9-12.
- Ayuman-Valdez, E., & Guiab, M. R. (2015). Predictors of mathematics performance of Grade VI pupils in a School District in Northern Philippines. *Asia Pacific Journal of Research*, 1(XXXIV). Retrieved from <https://scholar.archive.org/work/zzcymkhcr2rggif4y3j2tf34/access/wayback/http://www.apjor.com/downloads/101220154.pdf>
- Barkl, S., Porter, A., and Ginns, P. (2012). Cognitive training for children: effects on inductive reasoning, deductive reasoning, and mathematics achievement in an Australian school setting. *Psychol. Sch.* 49, 828-842. doi: 10.1002/pits.21638
- Capinding, A. T. (2022). Impact of modular distance learning on high school students mathematics motivation, interest/attitude, anxiety and achievement during the COVID-19 pandemic. *European Journal of Educational Research*, 11(2), 917- 934. <https://doi.org/10.12973/eu-jer.11.2.917>
- Capuno, R., Necasario, R., Etcuban, J. O., Espina, R., Padillo, G., & Manguilimotan, R. (2019). Attitudes, study habits, and academic

- performance of junior high school students in mathematics. *International Electronic Journal of Mathematics Education*, 14(3), 547-561. <https://doi.org/10.29333/iejme/5768>
- Casey, A., & Fernandez-Rio, J. (2019). Cooperative learning and the affective domain. *Journal of Physical Education, Recreation & Dance*, 90(3), 12-17. <https://doi.org/10.1080/07303084.2019.1559671>
- Cerezo, R., Fernández, E., Amieiro, N., Valle, A., Rosário, P., and Núñez, J. C. (2019). The mediating role of self-efficacy and perceived usefulness between strategy knowledge and its use. *Rev. Psicodidact.* 24, 1-8. doi: 10.1016/j.psicoe. 2018.09.001
- Chen, L., Bae, S. R., Battista, C., Qin, S., Chen, T., Evans, T. M., & Menon, V. (2018). Positive attitude toward math supports early academic success: Behavioral evidence and neurocognitive mechanisms. *Psychological Science*, 29(3), 390-402. Available at: <https://doi.org/10.1177/0956797617735528>.
- Cho, E. H., & Hwang, S. H. (2019). Exploring changes in multi-ethnic students' mathematics achievement motivation: A longitudinal study using expectancy-value theory. *The Mathematical Education*, 58(1), 101-120. Available at: <https://doi.org/10.7468/mathedu.2019.58.1.101>.
- Culaste, Irene C. (2011). Cognitive Skills of Mathematical Problem Solving of Grade 6 Children. *International Journal of Innovative Interdisciplinary Research*. Issue 1 Dec 2011. ISSN 1839-9053
- Davadas, S. D., & Lay, Y. F. (2017). Factors affecting students' attitude toward mathematics: A structural equation modeling approach. *Eurasia Journal of Mathematics, Science and Technology Education*, 14(1), 517-529. Available at: <https://doi.org/10.12973/ejmste/80356>.
- Di Martino, P., & Zan, R. (2011). Attitude towards mathematics: A bridge between beliefs and emotions. *ZDM*, 43(4), 471-482. Available at: <https://doi.org/10.1007/s11858-011-0309-6>.
- Dowker, A., Cheriton, O., Horton, R., & Mark, W. (2019). Relationships between attitudes and performance in young children's mathematics. *Educational Studies in Mathematics*, 100(3), 211-230. Available at: <https://doi.org/10.1007/s10649-019-9880-5>.
- Emefa, A.J., Miima, F.A. and Bwire, A.M. (2020), "Education impact of motivation on junior high school students' interest in reading comprehension in Hohoe Municipality: a literature based review", *African Journal of Emerging Issues (AJOEI)*, Vol. 2 No. 8, pp. 1-16.
- Fischer, C., Malycha, C. P., & Schafmann, E. (2019). The influence of intrinsic motivation and synergistic extrinsic motivators on creativity and innovation. *Frontiers in Psychology*, 10, 137. <https://doi.org/10.3389/fpsyg.2019.00137>
- García, T., Rodríguez, C., Betts, L., Areces, D., and González-Castro, P. (2016b). How affective-motivational variables and approaches to learning predict mathematics achievement in upper elementary levels. *Learn. Individ. Differ.* 49, 25-31. doi: 10.1016/j.lindif.2016.05.021
- Gunderson, E. A., Park, D., Maloney, E. A., Beilock, S. L., & Levine, S. C. (2018). Reciprocal relations among motivational frameworks, math anxiety, and math achievement in early elementary school. *Journal of Cognition and Development*, 19(1), 21-46. <https://doi.org/10.1080/15248372.2017.142153>
- Guo, J., Marsh, H. W., Parker, P. D., Morin, A. J., & Yeung, A. S. (2015). Expectancy-value in mathematics, gender and socioeconomic background as predictors of achievement and aspirations: A multi-cohort study. *Learning and Individual Differences*, 37, 161-168. Available at: <https://doi.org/10.1016/j.lindif>
- Hamid, K., et al. 2013. Factors contributing to the students Academic performance: A Case study of Islamia University Sub-Campus. *American Journal of Educational Research*. 1(8),283-289.DOI:10.12691/education-1-8-3
- Hammoudi, M. H. (2019). Predictive factors of students' motivation to succeed in introductory mathematics courses: evidence from higher education in the UAE. *Intern. J. Math. Educ. Sci. Technol.* 50, 647-664. doi: 10.1080/0020739X.2018.1529339
- Harackiewicz, J.M., Smith, J.L. and Priniski, S.J. (2016), "Interest matters: the importance of promoting interest in education", *Policy Insights from the Behavioral and Brain Sciences*, Vol. 3 No. 2, pp. 220-227, doi: 10.1177/2372732216655542.
- Hashim, S., Masek, A., Mahtir, B. N. S. M., Rashid, A. H. A., & Nincarean, D. (2021). Association of interest, attitude and learning habit in mathematics learning towards enhancing students' achievement. *Indonesian Journal of Science and Technology*, 6(1), 113-122. <https://doi.org/10.17509/ijost.v6i1.31526>
- Hulleman, C.S., Kosovich, J.J., Barron, K.E., & Daniel, D.B. 2017. Making Connection: Replicating and extending the utility value intervention in the classroom. *Journal of Educational Psychology*, 109(3), 387-404. <https://doi.org/10.1037/edu0000146>
- Hwang, Sunghwan & Son, Taekwon. 2021. Students' Attitude toward Mathematics and its Relationship with Mathematics Achievement. *Journal of Education and e-Learning Research*, 2021, 8(3): 272-280
- Ingram, N. (2015). Students' relationships with mathematics: Affect and identity. In M. Marshman, V. Geiger, & A. Bennison (Ed.), *Mathematics education in the margins* (Proceedings of the 38th annual conference of the Mathematics Education Research Group of Australasia) (pp. 301-308). Sunshine Coast, Australia: MERGA.
- James, A. O., Tunde, B. F., Ademuyiwa, A. C., & Bolanle, A. O. (2013). Effects of gender, mathematics anxiety and achievement motivation on college students' achievement in mathematics. *International Journal of Education and Literacy Studies*, 1(1), 15-22. <https://doi.org/10.7575/aiac.ijels.v1n1.15>
- Jamieson, J. P., Black, A. E., Pelaia, L. E., & Reis, H. T. (2021). The impact of mathematics anxiety on stress appraisals, neuroendocrine responses, and academic performance in a community college sample. *Journal of Educational Psychology*, 113(6), 1164-1176. <https://doi.org/10.1037/edu0000636>
- Jufrida, J., Kurniawan, W., Astalini, A., Darmaji, D., Kurniawan, D. A., & Maya, W. A. (2019). Students' attitude and motivation in mathematical physics. *International Journal of Evaluation and Research in Education*, 8(3), 401-408. <https://doi.org/10.11591/ijere.v8i3.20253>
- Jusman, M.J. (2018). Pengaruh Kemampuan Penalaran Formal, Motivasi, Berprestasi, dan Kesadaran Metakognitif Terhadap Prestasi Belajar Matematika Siswa Kelas XI Ipa SMA Negeri di Kota Pare-Pare. Thesis. Makassar: Makassar State University 2018.
- Kasimu, Osman & Imoro, , Majeed. 2017. Students' Attitudes Towards Mathematics: The Case of Private and Public Junior High Schools in The East Mamprusi District, Ghana. *IOSR Journal of Research & Method in Education (IOSR-JRME)* e-ISSN: 2320-7388,p-ISSN: 2320-737X Volume 7, Issue 5 Ver. VI (Sep. - Oct. 2017), PP 38-43
- Khayati, S., & Payan, A. (2014). Effective factors increasing the students' interest in mathematics in the opinion of mathematic teachers of Zahedan. *International Journal of Educational and Pedagogical Sciences*, 8(9), 3077-3085.
- Kibrislioglu, N. (2015). An investigation about 6th grade students' attitudes towards mathematics. *Procedia Social and Behavioral Sciences*, 186, 64-69.

- Kiwanuka, H.N. (2020). Temporal relationship between attitude toward mathematics and mathematics achievement. *International Journal of Mathematical Education in Science and Technology*. <https://doi.org/10.1080/0020739X.1832268>
- Lazarides R, Ittel A. Instructional quality and attitudes towards mathematics: Do self-concept and interest differ across students' patterns of perceived instructional quality in mathematics classrooms. *Child Development*; 2012.
- Lee, C., & Chen, M., (2009). A computer game as a context for non-routine mathematical problem solving: The effects of type of question prompt and level of prior knowledge, *Computers & Education*, 52, 530–542.
- Li, Q., Cho, H., Cosso, J., & Maeda, Y. (2021). Relations between students' mathematics anxiety and motivation to learn mathematics: A meta-analysis. *Educational Psychology*, 33, 1017–1049. <https://doi.org/10.1007/s10648-020-09589-z>
- Mensah, J. K., Okyere, M., & Kuranchie, A. (2013). Student attitude towards mathematics and performance: Does the teacher attitude matter? *Journal of Education and Practice*, 4(3), 132–13
- Michaelides, M. P., Brown, G. T., Eklöf, H., & Papanastasiou, E. C. (2019). The relationship of motivation with achievement in mathematics. In motivational profiles in TIMSS mathematics. Springer. https://doi.org/10.1007/978-3-030-26183-2_2
- Mohd, N., Mahmood, T.F.T.P., & Ismail, M.N. 2011. Factors that Influence Students in Mathematics Achievement. *International Journal of Academic Research*. Vol. 3. Retrieved from <https://www.researchgate.net/publication/228757092>
- Mohd, Z.I. 2011. Factors that influence students in mathematics achievement.
- Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). TIMSS 2019 international results in mathematics and science. Paper presented at the TIMSS & PIRLS International Association for the Evaluation of Educational Achievement.
- Murayama, K., Pekrun, R., Lichtenfeld, S., and vom Hofe, R. (2013). Predicting long-term growth in students' mathematics achievement: the unique contributions of motivation and cognitive strategies. *Child Dev.* 84, 1475–1490. doi: 10.1111/cdev.12036
- Naungayan, R. R. (2022). Attitude towards mathematics and mathematics achievement of secondary school learners in Banayoyo-Lidlidda District. *Puissant*, 3, 395-407.
- OECD. (2013a). PISA 2012 assessment and analytical framework: Mathematics, reading, science, problem solving and financial literacy. https://www.oecd.org/pisa/pisaproducts/PISA%202012%20framework%20ebook_final.pdf
- Organisation for Economic Co-Operation and Development. Measuring Student Knowledge and Skills: A New Framework for Assessment. (1999). OECD Publications. Printed in France. (96 1999 05 1 P) ISBN 92-64-17053-7 – No. 50619 199
- Patena, A. D., & Dinglasan, B. L. (2013). Students' performance on mathematics departmental examination: Basis for Math Intervention Program. *Asian Academic Research Journal of Social Science & Humanities*, 1(14), 255-268
- Pretz, J. E., Naples, A. J., & Sternberg, R. J. (2003). Recognizing, defining, and representing problems. In J.E. Davidson & R.J. Sternberg (Eds.), *The psychology of problem solving*, (pp. 3-30). New York: Cambridge University Press.
- Saha, J., Ahmmed, S., Ali, M., Tamal, M., & Rezaul, K. (2020). ICT based mathematics skill development program: An initiative to overcome mathematics anxiety. *International Journal of Emerging Technologies in Learning*, 15(14), 252-261. <https://doi.org/10.3991/ijet.v15i14.14149>
- Shoaib, A. and Saeed, M. (2016), "Exploring factors promoting students' learning in mathematics at secondary level", *Journal of Educational Sciences and Research*, Vol. 3 No. 2, pp. 10-19
- Suan, J. S. (2014). Factors affecting underachievement in mathematics. *Proceeding of the Global Summit on Education GSE*, 5. Retrieved from <http://conference.kuis.edu.my/icommm/5th/images/eeproceeding2018/IC-009.pdf>
- Suarez-Alvarez, J., Fernandez-Alonso, R., and Muñoz, J. (2014). Self-concept, motivation, expectations, and socioeconomic level as. *Learn. Individ. Differ.* 30, 118–123. doi: 10.1016/j.lindif.2013.10.019
- Thien, L. M., & Ong, M. Y. (2015). Malaysian and Singaporean students' affective characteristics and mathematics performance: Evidence from 2012. *SpringerPlus*, 4, 563–577. <https://doi.org/10.1186/s40064-015-1358-z>
- TIMSS 2019 International Results in Mathematics and Science. Retrieved from <https://timss2019.org/reports/students-value-math-science>
- Toli, G. and Kallery, M. (2021), "Enhancing student interest to promote learning in science: the case of the concept of energy", *Education Sciences*, Vol. 11 No. 5, pp. 1-15, doi: 10.3390/educsci11050220
- Una, M. (2013). Hubungan antara Gaya kognitif siswa dengan Hasil Belajar Matematika (Suatu Penelitian Survei dengan Pendekatan Korelasional pada Siswa VIII di SMP Negeri 1 Tilong Kabila Tahun Pelajaran 2012-2013). Thesis. Gorontalo State University. Gorontalo, 2013.
- Wigfield, A., Eccles, J. S., Fredricks, J. A., Simpkins, S., Roeser, R. W., and Schiefele, U. (2015). "Development of achievement motivation and engagement," in *Handbook of Child Psychology and Developmental Science: Socioemotional Processes*, eds M. E. Lamb and R. M. Lerner (Hoboken, NJ: John Wiley & Sons Inc), 657–700.
- Wigfield, A., Tonks, S. M., & Klauda, S. L. (2016). Expectancy-value theory. In Wentzel, K. R., & Miele, D. B. (Eds.), *Handbook of motivation at school* (pp. 55–74). New York: Routledge.
- Wong, L.H., Chan, T.W., Chen, W., Looi, C.K., Chen, Z.H., Liao, C.C.Y., King, R.B. and Wong, S.L. (2020), "IDC theory: interest and the interest loop", *Research and Practice in Technology Enhanced Learning*, Vol. 15 No. 3, pp. 1-16, doi: 10.1186/s41039-020-0123-2.
- Wong, S.L. and Wong, S.L. (2019), "Relationship between interest and mathematics performance in a technology-enhanced learning context in Malaysia", *Research and Practice in Technology Enhanced Learning*, Vol. 14 No. 21, pp. 1-13, doi: 10.1186/s41039-019-0114-3.
- Yu, R., & Singh, K. (2016). Teacher support, instructional practices, student motivation, and mathematics achievement in high school. *The Journal of Educational Research*, 1–14. <https://doi.org/10.1080/00220671.2016.1204260>
- Zakaria, E., Zain, N. M., Ahmad, N. A., & Erlina, A. (2012). Mathematics anxiety and achievement among secondary school students. *American Journal of Applied Sciences*, 9(11), 1828-1832. <https://doi.org/10.3844/ajassp.2012.1828.1832>
- Zhang, X., Yang, Y., Zou, X., Hu, B. Y., & Ren, L. (2020). Measuring preschool children's affective attitudes toward mathematics. *Early Childhood Research Quarterly*, 53, 413-424. <https://doi.org/10.1016/j.ecresq.2020.05.012>

