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# Educational Trajectory as Predictor of the Performance of the Students in Calculus 1

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***Abstract*— *The battle cry of the Philippine Education System in carrying out the K–12 Curriculum is "Ready for employment, Ready for entrepreneurship, Ready for college." The extra two years of basic education are meant to help learners get ready for college or the workforce. Additionally, since CHED Memorandum Order No. 105 places a strong emphasis on academic independence, students are still allowed to enroll in any college course they choose, regardless of the senior high school track they have completed. This study aimed to determine the determine the trajectory and performance in Calculus 1 of Bachelor of Secondary Education specializing in Mathematics at Cebu Roosevelt Memorial Colleges, Bogo City, Cebu for the S.Y. 2022 – 2023. Findings served as basis for proposed action plan. A descriptive – predictive research was adopted for this study. The researcher started to investigate the students' SHS strand if this would predict their performance through multiple linear regression. In a result, majority of the Math major students had a poor performance in Calculus 1. Thus, Senior High School Strand influence their performance in Calculus 1.*

***Keywords*— *Calculus, Educational Trajectory, Predictor.*

## I. Introduction

The K-12 program was implemented in the Philippines in 2013. When RA 10533 became effective in 2013. This legislation is known as the "Enhanced Basic Education Act of 2013, which strengthened the Philippine Basic Education System by enhancing the curriculum and increasing the number of years of basic education, adopting the K to 12 primary education system. The four-year secondary education is replaced by a six-year junior and senior high school curriculum. This was pushed through to help Filipino students develop holistic 21st-century skills. Old high school has three primary tracks: general academic, sports and arts, and technical vocational and livelihood education. The strand of science, technology, engineering, and mathematics (STEM) is integrated into the general academic track. The traditional approach replaces a more innovative one emphasizing critical thinking and scientific abilities (Montebon, 2014).

Furthermore, Estonato (2017) stated that STEM encourages secondary school graduates to enrol in science-related tertiary courses. Again, Orale and Sarmiento (2016) discovered that the Philippines' SHS-STEM track is superior to that of Japan and the United States. Cabansag (2014) states that STEM graduates will be better prepared for jobs abroad. Precalculus and Basic Calculus are the specialized subjects of STEM students.

Students' calculus performance in the Philippines has never been promising. Calculus is currently regarded as one of the most demanding and challenging major courses for college students in the Philippines (Angeles, Fajardo & Tanguilig III, 2015; Salazar, 2016). The Philippines fared the worst among the ten countries in mathematics, with students scoring poorly in the calculus topic, according to the Trends in International Mathematics and Science Study results from 2008. Additionally, it is considered a dull and purely procedural subject (Matthews, Hoessler, Jonker & Stockley, 2013). The conventional method of teaching calculus does not aid students in comprehending the fundamental ideas (Martin, 2013). As a result, problem-solving abilities and conceptual grasp of the subject should be emphasized to improve calculus teaching and learning. As Calculus is now a required subject in the STEM (Science, Technology, Engineering, and Mathematics) strand of the Senior High School (SHS) curriculum, this is done to better prepare students for the problems of 21st-century society. This puts a task on all math educators to use a strategy that allows pupils to research and explore diverse mathematical ideas through various representations.

Researchers find evidence of students' struggles and calculus knowledge gaps. Researchers' findings thus support misconceptions, rote learning, and a lack of conceptual knowledge, even while students' success on teachers' designed tests and examination papers shows some signs of wisdom and understanding (Cabansag, 2014). Researchers have found that students struggle to grasp calculus concepts in general and the little idea in particular in-depth and accuracy (Dunlosky et al., 2013; Kang, 2016). Most mathematics teachers' and students' focus in the traditional two approaches is on rules and processes. Due to this routine, most students follow the rules and procedures without internalizing them and concentrating on the underlying principles (Kinley, 2016; Makgakga & Makwakwa, 2016).

Moreover, the requirements for applicants to a specific program in a school altered the Philippines' implementation of K-12 education. To maintain alignment, the curriculum developers stated that only STEM graduates would be accepted in the program for this institution's Bachelor of Secondary Education with a Specialization in Mathematics (Hopkins et al., 2016; Lyle et al., 2020). According to what they observed in other nations, STEM graduates are thought to be better in mathematics than non-STEM graduates. In light of these, the study concentrated on the performance and trajectory of the BSED-Math students in Calculus 1 at Cebu Roosevelt Memorial Colleges School in Bogo City during 2022–2023.

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## II. Methodology

This study used a descriptive-predictive research design. The data were analyzed and interpreted using statistical tools such as frequency count and percent, weighted mean, chi-square, and multiple regression analysis. The correlation design was used to determine whether there are any significant relationships between respondents' profiles and calculus one performance. Furthermore, the predictive method was used if the students' trajectory significantly predicted their success in Calculus 1.

This research was conducted at Cebu Roosevelt Memorial College. Cebu Roosevelt Memorial College, a private institution in Bogo City, Cebu. The respondents of this study were the college students who took up a Bachelor of Secondary Education major in Mathematics at Cebu Roosevelt Memorial Colleges, Inc., Bogo City, Cebu, for the S. Y. 2022-2023 chosen using a purposive sampling technique. There were 15 students from the second year and 15 students from the third year. A total of 30 respondents of college students in the College of Teacher Education Department participated.

This study used researcher–made questionnaires pilot – tested at Cebu Roosevelt Memorial College on the last week of November 2022. The participants for the pilot testing were five (5) 4th year BSEd – Math students who were not part of the identified respondents of this study. Questionnaires composed of three parts were used in this study part I wanted to gather the profile of the respondents: age, gender, and SHS strand. Part II was the Calculus 1 questions which consisted of 25 items. After acquiring permission from the school president, a letter was sent to the CTE dean. With the college dean's consent, a letter of implied and informed consent was sent to the respondents. The questionnaire was distributed personally to the respondents. The item/s in the instrument were carefully explained to the participants, and they were assured that their responses would be used for the study and treated with the utmost confidentiality. A semi-structured interview was conducted to validate the respondents' perceptions and questionnaire responses.

The profile of the respondents was summarized and analyzed using Frequency Count and Percent; the respondents' performance in calculus 1 was summarized and analyzed using Weighted Mean and Standard Deviation. The Chi-Square test determined the significant relationships between respondents' profiles and calculus one performance. Multiple Regression Analysis was used to determine whether the respondents' SHS trajectory significantly predicted their Calculus 1 performance.

## III. Results And Discussion

The primary goal of this study was to assess how the educational trajectory of students could serve as a predictive factor for their performance in Calculus 1. Specifically, the study focused on students at Cebu Roosevelt Memorial Colleges, Bogo City, Cebu, during the School Year 2021-2022. This aimed to uncover the potential influence of various educational paths on students' outcomes in Calculus 1. The findings were presented systematically in tables, laying the foundation for a recommended course of action based on the study's outcomes.

Table 1 presented the frequency and percent of the respondents' profile to their Senior High School Strand. Of 30 respondents, 23 preferred non – STEM strand and 7 preferred STEM strand. The majority (76.67 %) of the respondents came from the non – STEM strand while only (23.33 %) came from STEM strand. This implied that the majority of the respondents who took Bachelor of Secondary Education major in Mathematics came from non – STEM strand.

Table 1. Respondents' Profile

| Profile | Frequency | Per Cent |
|---|---|---|
| Non-STEM | 23 | 76.67 |
| STEM | 7 | 23.33 |

*Level of Performance of the Students in Calculus 1*

The level of performance of the respondents has various ranges and interpretations. Respondents who have a score from 23 - 25 were Excellent, 21 – 22 were Very Good, 19 – 20 were Good, 17 – 18 were Satisfactory, 15 -16 were Fairly Satisfactory and those below 14 were failed.

Table 2. Respondents' Level of Performance in Calculus 1

| Score Ranges | Interpretation | f | % |
|---|---|---|---|
| 23 - 25 | Excellent | 7 | 23.3 |
| 21 - 22 | Very Good | 1 | 3.3 |
| 19 -20 | Good | 2 | 6.7 |
| 17 -18 | Satisfactory | 4 | 13.3 |
| 15 - 16 | Fairly Satisfactory | 1 | 3.3 |
| 14 and below | Failed | 15 | 50 |
| | **Total** | 30 | 100 |
| | **Mean** | **15.967** | |
| | **Standard Deviation** | **5.67** | |

Table 2 showed the mean of 15.97 and a standard deviation of 5.67. It shows that 23.3 % of the respondents were excellent, 3.3 % were very good, 6.7 % were good, 13.3 % were satisfactory, 3.3 % were fairly satisfactory and 50 % were failed. Moreover, 50 % of the respondents were below the mean and standard deviation. It is implied that majority of the respondents have not a good performance in Calculus 1. Meanwhile, 50% of the respondents were under marginal performance, indicating that the scores were spread. Moreover, 3.3% were one standard deviation above the mean, 13.3 % were two standard deviations above the norm, 6.7 % were three deviations above the mean, 3.3 % were four standard deviations above the mean and 23.3 % were five deviations above the mean. Only 7 out of 30 respondents (23.3 %) have an excellent performance in Calculus 1.

*Problems Encountered by the Students*

During the Calculus 1 class, the following problems presented which were the students encountered. Table 3 showed the respondents' problems encountered in Calculus 1. The top – ranked problems were as follows, the students had difficulty in solving complex problems, in determining the trigonometric derivatives and in doing related problem of determining the limit value of a point. "I have difficulty in solving complex problems" (72.73%) interpreted as ranked 1.



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On the other hand, the bottom three in rank were as follows: the students had difficulty in algebraic manipulation, in simplifying algebra of determining limit values and in visual representations. Based on the data, the respondents largely claimed that they had difficulties in solving complex problems in terms of applying the basic concept of Calculus 1.

Table 3. Problems Encountered by the Respondents

| Problems Encountered | Frequency | Percentage | Rank |
|---|---|---|---|
| 1. I have difficulty in graphing conic sections | 19 | 57.58 | 4 |
| 2. I have difficulty in doing related problem by determining the limit value of a point | 20 | 60.61 | 3 |
| 3. I have difficulty in simplifying algebra in determining limit values | 9 | 27.27 | 9 |
| 4. I have difficulty in determining the trigonometric derivatives | 22 | 66.67 | 2 |
| 5. I have difficulty in completing limits in the form of cube root, fourth roots and others | 17 | 51.52 | 5 |
| 6. I have difficulty in visual representations | 9 | 27.27 | 9 |
| 7. I have difficulty in solving complex problems | 24 | 72.73 | 1 |
| 8. I have difficulty in algebraic manipulation | 10 | 30.30 | 8 |
| 9. I have difficulty in solving the minimum and maximum values | 12 | 36.36 | 7 |
| 10. I am preoccupied | 13 | 39.39 | 6 |

*Students' Profile and their Level of Performance in Calculus 1*

To determine the significant relationship between the students' profile and their level of performance in Calculus 1 is through Chi – square.

Table 4. Relationship between Students' Profile and their Level of Performance in Calculus 1

| Students' Profile in relation to: | df | $x^2$ | P-value | Decision on Ho (ά = 0.05) | Interpretation |
|---|---|---|---|---|---|
| Calculus Performance | 11 | 4.845 | 0.938 | Failed to Reject Ho | Not Significant |

** Correlation is significant at the 0.05 level (2-tailed)

Table 4 revealed that the profile of the respondents has a significant relationship to their performance in Calculus 1. This implied that their Senior High School Strand influence their performance in Calculus 1.

Multiple studies have revealed that students that achieve a high grade in introductory calculus actually have a weak understanding of the course's key concepts (Bressoud, Carlson, Mesa, & Rasmussen, 2013). These results put in question whether or not the traditional calculus curriculum is preparing students to use ideas of calculus in future courses (Bressoud, Carlson, Mesa, & Rasmussen, 2013). Ongoing efforts to reform calculus instruction arise from concerns that students are learning calculus as simply a series of algorithms without conceptual understanding (Dawkins & Epperson, 2014). Furthermore, whether they were from STEM strand but they would not go deeper the lesson then they could not be able understand the concept.

*Educational Trajectory as Predictor of the Students' Performance in Calculus 1*

The tables were presented to determine whether the dependent variable would cause a change to the model. These tested the null hypothesis that the predictors in the model have no effect on the dependent variable.

Table 5. Model Summary[b]

| Model | R | R Square | Adjusted RSquare | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .067[a] | .005 | -.031 | 5.75926 |

a. Predictors: (Constant), Strand
b. Dependent Variable: Performance

The table shows the multiple linear regression model summary and overall fit statistics. R-value represents the correlation between the dependent and independent variables. R-value is 0.067 which indicates a weak positive degree of correlation. The result of Table 5 further showed that the R Square is of 0.005 and adjusted R Square of 0.031 that the linear regression explains 5% of the data variance. The R Square shows that it is not effective enough to determine the relationship. Thus, there is no correlation between the respondents' profile to their performance in Calculus 1.

Table 5.1. ANOVA[a]

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 4.234 | 1 | 4.234 | .128 | .724[b] |
| | Residual | 928.733 | 28 | 33.169 | | |
| | Total | 932.967 | 29 | | | |

a. Dependent Variable: Performance
b. Predictors: (Constant), Strand

Showing the summary of the prediction of their Senior High School Strand to their performance in Calculus 1 was presented in Table 5.1. The term "analysis of variance or ANOVA is a group of statistical models and estimation procedures that go with them that are used to examine the difference between means.

Table 5.2. Coefficients[a]

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | Constant | 14.398 | 4.516 | | 3.188 | .004 |
| | Strand | .888 | 2.486 | .067 | .357 | 724 |

a. Dependent Variable: Performance

The table shows that the significance value is 0.724 which is greater than 0.05. Thus, we reject the second null hypothesis which states that respondents' profile doesn't significantly predicts the students' performance in calculus 1. According to Sadler and Sonnert (2015) that the effect of taking pre-calculus in college on subsequent performance in Calculus I. They compared the performance of students just below the cut-off who were allowed to proceed directly to Calculus I with those who were just above the cut-off. If pre-calculus is of benefit, those just below the cut-off should do better in Calculus I than those who are just above. Because of the size of their study, they were able to do this across the range of student levels of preparation for calculus as measured by high school grades in mathematics.

This study sought to examine the academic journey and performance of Bachelor of Secondary Education majors specializing in Mathematics at Cebu Roosevelt Memorial Colleges, Bogo City, Cebu, during the academic year 2022-2023. In terms of the respondents' backgrounds, the majority (76.67%) came from non-STEM educational tracks, while the remaining 23.33% were from STEM tracks during Senior High School. When evaluating the students' performance in Calculus 1, distinct score ranges determined their performance levels, with only 23.3% achieving excellence and 50% falling short of expected performance. Notably, students reported facing challenges with complex problem-solving. The study revealed a significant correlation between students' Senior High School strands and their Calculus 1 performance, demonstrating that the strand they pursued in Senior High School had a discernible impact on their performance in Calculus 1. Furthermore, the findings indicated that despite deviations from their Senior High School strands, students were enthusiastic about pursuing careers as Mathematics teachers, suggesting the importance of tailored instruction, including collaborative group activities, to enhance their learning experiences. In the broader context of global educational trends, various countries, including the Philippines, have been actively reforming their education systems to equip graduates with the knowledge and skills necessary for a rapidly evolving information age and to foster active participation in economic, socio-cultural, and political matters (Okabe, 2013).

## IV. CONCLUSION

In taking up a Bachelor of Secondary Education major in Mathematics, the students should have a strong foundation in Pre–Calculus and Basic Calculus. The alignment of their SHS strand helps the students perform better in Calculus 1. Consequently, the poor performance in Calculus 1 encouraged the school and administrators to pay attention to choosing the SHS strand of the students since this will affect their possible careers. Furthermore, conducting orientation will help the students to anticipate correctly.

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## REFERENCES

[1] Douglas, M. (1986). How institutions think. Syracuse University Press.
[2] Piaget, J. (1983). Piaget's theory. P. Mussen (ed). Handbook of Child Psychology. 4th edition. Vol. 1. New York: Wiley.
[3] Alcock, L., & Simpson, A. (2011). Classification and concept consistency. Canadian Journal of Science, Mathematics and Technology Education, 11(2), 91 – 106.
[4] Akkus, R., Hand, B., & Seymour, J. (2008). Understanding students' understanding of functions. Mathematics Teaching Incorporating Micromath, 207, 10-13.
[5] Angeles, M. R., Fajardo, A. C., & Tanguilig, B. T. (2015). E-math version 2.0, a learning management system as a math reviewer tool for engineering students in the Philippines. International Journal of Engineering and Technical Research, 3(2), 18-21.
[6] Anuada, A. (2017) Factors that influence Senior High School Students of SCC in their choice of strand Retrieved on September 15, 2018 from https://robertbalinton143.wordpress.com/2017/03/11/factors-that-influence-seniorhigh-school-students-of-scc-in-their-choice-of-strand-2/
[7] Axtell, M. (2006). A two-semester precalculus/calculus sequence: A case study, Mathematics and Computer Education, 40(2), 130-137.
[8] Ayebo, A. B. R. A. H. A. M. (2016). Teachers' perceptions on identifying and catering to the needs of mathematically gifted and talented students. Journal Education of Malaysia, 41(1), 19-24.
[9] Bandura, A. (1997). Self-efficacy: The exercise of control. Macmillan.
[10] Bergé, A. (2010). Students' perceptions of the completeness property of the set of real numbers. International Journal of Mathematical Education in Science and Technology, 41(2), 217–227.
[11] Bermudez, M. (2018) Retrieved on September 8, 2018 from https;//news.infoinquier.net/980733/what-went-before-the-K-12-program
[12] Berry, J. S., & Nyman, M. A. (2003). Promoting students' graphical understanding of the alculus. The Journal of Mathematical Behavior, 22(4), 479-495.
[13] Bezuidenhout, J. (2001). Limits and continuity: Some conceptions of first-year students. International journal of mathematical education in science and technology, 32(4), 487-500.
[14] Bezuidenhout, J. (2010). Limits and continuity: Some conceptions of first-year students. International Journal of Mathematical Education in Science and Technology., 32(4), 487–500.
[15] Blair, R., Kirkman, E. E., & Maxwell, J. W. (2013). Statistical abstract of undergraduate programs in the mathematical sciences in the United States (Conference board of the mathematical sciences). Providence, RI: American Mathematical Society
[16] Boyer, N. R., Langevin, S., & Gaspar, A. (2008, October). Self - direction & c constructivism in programming education. In Proceedings of the 9th ACM SIGITE conference on Information technology education (pp. 89-94).
[17] Breidenbach, D., Dubinsky, E., Hawks, J., & Nichols, D. (1992). Development of the process conception of function. Educational Studies in Mathematics, 23, 247-285.
[18] Bressoud, D. M., Carlson, M. P., Mesa, V., & Rasmussen, C. (2013). The calculus student: insights from the Mathematical Association of America national study. International Journal of Mathematical Education in Science and T Technology, 44(5), 685-698.
[19] Cabansag, M. G. S. (2014). Impact statements on the K-12 science program in the enhanced basic education curriculum in provincial schools. Researchers World, 5(2), 29.
[20] Carlson, M. (1997). Obstacles for college algebra students in understanding functions: what do high-performing students really know? The AMATYC Review.19.48-59.
[21] Carlson, M., & Oehrtman, M. (2005). Key aspects of knowing and learning the concept of function. Mathematical Association of America Research Sampler, (9). Retrieved from https://www.maa.or
[22] Carlson, M., Oehrtman, M., & Engelke, N. (2010). The precalculus concept assessment: a tool for assessing students' reasoning abilities and understandings. Cognition and Instruction, 28, 113-145. doi: 10.1080/07370001003676587.
[23] Carpenter, S. K. (2021). Distributed practice or spacing effect. In L.-F. Zhang (Ed.), Oxford research encyclopedia of education. Oxford University Press. Return to ref 2021 in article
[24] Carpenter, S. K., Cepeda, N. J., Rohrer, D., Kang, S. H., & Pashler, H. (2012). Using spacing to enhance diverse forms of learning: Review of recent research and implications for instruction. Educational Psychology Review, 24(3), 369-378.
[25] Cepeda, N. J., Pashler, H., Vul, E., Wixted, J. T., & Rohrer, D. (2006). Distributed practice in verbal recall tasks: A review and quantitative synthesis. Psychological bulletin, 132(3), 354.
[26] Chellougui, F. (2009). L'utilisation des quantificateurs universel et existentiel en première année d'université: entre l'explicite et

l'implicite. Recherches en Didactique des Mathématiques, 29(2), 123–154.
[27] Choi, E., Lindquist, R., & Song, Y. (2014). Effects of problem-based learning vs. traditional lecture on Korean nursing students' critical thinking, problem-solving, and self-directed learning. Nurse Education Today, 34, 52-56.
[28] Confrey, J., Maloney, A.P. & Corley, A.K. Learning trajectories: a framework for connecting standards with curriculum. ZDM Mathematics Education 46, 719–733 (2014). https://doi.org/10.1007/s11858-014-0598-7
[29] Code, W., Piccolo, C., Kohler, D., & MacLean, M. (2014). Teaching methods comparison in a large calculus class. ZDM Mathematics Education, 46, 589–601.
[30] Cornu, B. (1991). Limits. In D. Tall (Ed.), Advanced mathematical thinking (pp. 153 – 166). Dordrecht, The Netherlands: Kluwer
[31] Cottrill, J., Dubinsky, E., Nichols, D., Schwingendorf, K., Thomas, K., & Vidakovic, D. ((1996). Understanding the limit concept: Beginning with a coordinated process scheme. Journal of Mathematical Behavior, 15(2), 167–192.
[32] Davis, J. D. (2007). Real world contexts, multiple representations, student-invented terminology, and y-intercept. Mathematical Thinking and Learning 9, 387-418. doi: 10.1080/10986060701533839.
[33] Davis, R. B., & Vinner, S. (1986). The notion of limit: Some seemingly unavoidable misconception stages. Journal of Mathematical Behavior, 5(3), 281–303
[34] Davis, J. D. (2007). Real world contexts, multiple representations, student-invented terminology, and y-intercept. Mathematical Thinking and Learning 9,387-418.doi: 10.1080/10986060701533839.
[35] Dmitriev, G. D. (2010). Anatomy of an American University. Moscow: Shkol'nyye tehnologii
[36] Donovan, J. J., & Radosevich, D. J. (1999). A meta-analytic review of the distribution of practice effect: Now you see it, now you don't. Journal of Applied Psychology, 84(5), 795.
[37] Dooley, T. (2009). The development of algebraic reasoning in a whole-class setting. In M. Tzekaki, M. Kaldrimidou, & H. Sakonidis (Eds.), Proceedings of the 33rd Conference of the International Group for the Psychology of Mathematics Education, Thessaloniki (Vol. 1).
[38] Dubinsky, E., & McDonald, M. (2001). APOS: A constructivist theory of learning. In D. Holton (Ed.), The teaching and learning of mathematics at university level: An ICMI study (pp. 275–282).
[39] Ellis, J., Fosdick, B.K., & Rasmussen, C. (2016) Women 1.5 times more likely to leave STEM pipeline after Calculus compared to men/; lack of mathematical confidence a potential culprit. PLoS ONE, 11(7), e0157447
[40] Estonanto, A. J. J. (2017). Acceptability and difficulty of the STEM track implementation in senior high school. Asia Pacific Journal of Multidisciplinary Research, 5(2), 43-50.Gayazov, A. S. (2010). Individual trajectories of person's education. Free Internet library. Retrieved March 02, 2020, from http://www.raop.ru/index.php?id=878
[41] Hillel, J. (2001). Trends in curriculum: A working group report. In D. Holton (ed.), The teaching and learning of mathematics at university level, (pp. 59–69). Dordrecht: Kluwer.
[42] Holmlund, T.D., Lesseig, K. & Slavit, D. Making sense of "STEM education" in K-12 contexts. IJ STEM Ed 5, 32 (2018). https://doi.org/10.1186/s40594-018-0127-2
[43] Hopkins, R. F., Lyle, K. B., Hieb, J. L., & Ralston, P. A. (2016). Spaced retrieval practice increases college students' short-and long-term retention of mathematics knowledge. Educational Psychology Review, 28(4), 853-873.
[44] Houston, K. (2001). Assessing undergraduate mathematics students. A working group report. In D. Holton (ed.), The teaching and learning of mathematics at university level, (pp. 407–422). Dordrecht: Kluwer.
[45] Hurtado, S., Eagan, M. K., & Chang, M. (2010). Degrees of success: bachelor's degree completion rates among initial STEM majors. Retrieved from. https://www.heri.ucla.edu/nih/downloads/2010%20-%20Hurtado,%20Eagan,%20Chang%20-%20Degrees%20of%20Success.pdf. Accessed 1 Sept 2015
[46] Idris, N. (2009). Enhancing students' understanding in calculus trough writing. International Electronic Journal of Mathematics Education, 4(1), 36-55.
[47] Janiszewski, C., Noel, H., & Sawyer, A. G. (2003). A meta-analysis of the spacing effect in verbal learning: Implications for research on advertising repetition and consumer memory. Journal of consumer research, 30(1), 138-149.
[48] Johnson, E. (2016). What is in calculus I? MAA Focus, 36(2), 17–20
[49] Jordaan, T. (2009). Misconceptions of the limit concept in a mathematics course for engineering students. Master‟s thesis, University of South Africa. Retrieved from http://uir.unisa.ac.za
[50] Juter, K. (2005a). Limits of functions-How do students handle them? Pythagoras, 2005 (61), 11-20. Retrieved from https://www.researchgate.net
[51] Kang, S. H. (2016). Spaced repetition promotes efficient and effective learning: Policy implications for instruction. Policy Insights from the Behavioral and Brain Sciences, 3(1), 12-19.
[52] Kendra Cherry. 2014, Piaget's Stages of Cognitive Development. [Accessed: 23 September 2014] available at.http://psychology.about.com/od/piagets theory/a/keyconcepts.htm
[53] Kim, D.-J., Ferrini-Mundy, J., & Sfard, A. (2012). How does language impact the learning of mathematics? Comparison of English and Korean speaking university students' discourses on infinity. International Journal of Educational Research, 51–52, 86–108.
[54] Kinzel, T. A. (2006). Exploring process/object duality within students' interpretations and use of algebraic expressions (Unpublished Master's Thesis). Boise State University, Boise, ID.
[55] Kinley, M. (2016). Grade Twelve Students Establishing the Relationship Between Differentiation and Integration in Calculus Using graphs. IEJME-Mathematics Education, 11(9), 3371-3385.
[56] Langen, A.V., & Dekkers, H(2005), Cross – national differences in participating in tertiary science, technology, engineering and mathematics education. Cooperative Education , 1(3) – 329 – 350.
[57] Langshaw, S. J. (2017). Relationship between the self-efficacy and self-directed learning of adults in undergraduate programs (Doctoral dissertation, Capella University).
[58] Latimier, A., Peyre, H., & Ramus, F. (2021). A meta-analytic review of the benefit offspacing out retrieval practice episodes on retention. Educational Psychology Review, 33, 959–987.
[59] Lattuca, L. R. & Stark, J. S. (2009). Shaping the college curriculum: Academic plans in context (2nd ed.). San Francisco: Jossey-Bass.
[60] Lomakina, T. Yu. (2013) Conceptual approaches to the formation of the educational path of the personality in the system of continuing education. Otechestvennaya i zarubezhnaya pedagogika - Domestic and foreign pedagogy, 6(15), 69-77.
[61] Loyens, S. M., Rikers, R. M., & Schmidt, H. G. (2006). Students' conceptions of constructivist learning: A comparison between traditional and a problem-based learning curriculum. Advances in Health Sciences Education, 11, 365-379.
[62] Lyle, K. B., Bego, C. R., Hopkins, R. F., Hieb, J. L., & Ralston, P. A. (2020). How the amount and spacing of retrieval practice affect the short-and long-term retention of mathematics knowledge. Educational Psychology Review, 32(1), 277-295.
[63] Maddox, G. B. (2016). Understanding the underlying mechanism of the spacing effect in verbal learning: A case for encoding variability and study-phase retrieval. Journal of Cognitive Psychology, 28, 684–706.
[64] Makgakga, S., & Makwakwa, E. G. (2016). Exploring Learners'difficulties In Solving Grade 12 Differential Calculus: A Case Study Of One Secondary School In Polokwane District.
[65] Mamona-Downs, J. (2001). Letting the intuitive bear on the formal; a didactical approach for the understanding of the limit of a sequence. Educational Studies in Mathematics, 48, 259–288.
[66] Mamona-Downs, J. (2010). On introducing a set perspective in the learning of limits of real sequences. International Journal of Mathematical Education in Science and Technology, 41(2), 277–291.
[67] Martin, J. (2013). Differences between experts' and students' conceptual images of the mathematical structure of Taylor series convergence. Educational Studies in Mathematics, 82, 267–283
[68] Matthews, A. R., Hoessler, C., Jonker, L., & Stockley, D. (2013). Academic motivation in calculus. Canadian Journal of Science, Mathematics and Technology Education, 13(1), 1-17.
[69] Mkhatshwa, T. P. (2021). A study of calculus students' difficulties, approaches and ability to solve multivariable optimization problems. International Journal of Mathematical Education in Science and Technology, 1–28. doi:10.1080/0020739x.2021.192722
[70] Montebon, D. T. (2014). K12 science program in the Philippines: Student perception on its implementation. International Journal of Education and Research, 2(12), 153-164.

[71] Moore, K. C., & Carlson, M. P. (2012). Students' images of problem contexts when solving applied problems. Journal of Mathematical Behavior, 31, 48–59.
[72] Moru, E. K. (2006). Epistemological obstacles in coming to understand the limit concept at undergraduate level: a case of the National University of Lesotho (Doctoral dissertation, University of the Western Cape).
[73] Muzangwa, J., & Chifamba, P. (2012). Analysis of Errors and Misconceptions in the Learning of Calculus by Undergraduate Students. Acta Didactica Napocensia, 5(2), 1-10.
[74] Niemi, H. (2002). Active learning—a cultural change needed in teacher education and schools. Teaching and teacher education, 18(7), 763-780.
[75] Oehrtman, M. (2003). Strong and weak metaphors for limits. In N. Pateman, B. Dougherty, & J. Zilliox (Eds.), Proceedings of the 27th Conference of the International Group for the Psychology of Mathematics, Honolulu, HI (Vol. 3, pp. 397–404).
[76] Oehrtman, M. (2009). Collapsing Dimensions, physical limitation, and other student metaphors for limit concepts. Journal For Research In Mathematics Education, 40(4), 396–426.
[77] Oehrtman, M., Swinyard, C., & Martin, J. (2014). Problems and solutions in students' reinvention of a definition for sequence convergence. Journal of Mathematical Behavior, 33, 131–148
[78] Ogena, E. B., Lana, R. D., & Sasota, R. S. (2010). Performance of Philippine high schools with special curriculum in the 2008 trends in international mathematics and science study (TIMSS-Advanced). Retrieved from.
[79] Orton, A. (1980). A cross-sectional study of the understanding of elementary Calculus in adolescents and young adults. Unpublished Ph.D. thesis, University of Leeds.
[80] Orale, R., & Sarmiento, D. (2016). Senior high school curriculum in the Philippines, USA, and Japan. Journal of Academic Research, 1(3), 12-23.
[81] Pantalone, G. (2015), "Why I Chose accounting". Published on 2015 and Retrieved from https://sites.sju.edu/blogs/2015/06/02/why-i-chose-accounting/
[82] Pashler, H., Rohrer, D., Cepeda, N. J., & Carpenter, S. K. (2007). Enhancing learning and retarding forgetting: Choices and consequences. Psychonomic bulletin & review, 14(2), 187-193.
[83] Pettersson, K., & Scheja, M. (2008). Algorithmic contexts and learning potentiality: A case study of students' understanding of calculus. International Journal of Mathematical Education in Science and Technology, 39(6), 767–784.
[84] Phillips, B. N., Turnbull, B. J., & He, F. X. (2015). Assessing readiness for self-directed learning within a non-traditional nursing cohort. Nurse education today, 35(3), e1-e7.
[85] Przenioslo, M. (2004). Images of the limit of function formed in the course of mathematical studies at the university. Educational Studies in Mathematics, 55(1/3), 103–132.
[86] Rasmussen, C., & Ellis, J. (2013). Who is switching out of calculus and why? In A. M. Lindmeier & A. Heinze (Eds.), Proceedings of the 37th Conference of the International Group for the Psychology of Mathematics Education (Vol. 4, pp. 73–80). Kiel, Germany: PME
[87] Rasmussen, C., Apkarian, N., Hagman, J. E., Johnson, E., Larsen, S., & Bressoud, D. (2019). Brief report: characteristics of precalculus through calculus 2 programs: insights from a national census survey. Journal for Research in Mathematics Education, 50(1), 98-111.
[88] Rawson, K. A., & Dunlosky, J. (2013). Relearning attenuates the benefits and costs of spacing. Journal of Experimental Psychology: General, 142(4), 1113.
[89] Robert, A. (1982). L'acquisition de la notion de convergence des suites numeriques dans l'enseignement superieur. Recherches en Didactiques des Mathematiques, 3, 307–341.
[90] Roediger III, H. L., & Pyc, M. A. (2012). Inexpensive techniques to improve education: Applying cognitive psychology to enhance educational practice. Journal of Applied Research in Memory and Cognition, 1(4), 242-248.
[91] Roh, K. (2010a). An empirical study of students' understanding of a logical structure in the definition of the limit of a sequence via the ε-strip activity. Educational Studies in Mathematics, 73, 263–279.
[92] Roble, D. B. (2017). Communicating and valuing students‟ productive struggle and creativity in calculus. Turkish Online Journal of Design Art and Communication, 7(2), 255-263.
[93] Roh, K. (2008). Students' images and their understanding of definitions of the limit of a sequence. Educational Studies In Mathematics, 69(3), 217–233.
[94] Rudhumbu, N. PhD (2017) Factors that Influence Undergraduate Students' Choice of a University: A Case of Botho University in Botswana Retrieved on September 27, 2018 https://doi.org/10.5430/ijhe.v7n3p1
[95] Sadler, P. M., & Sonnert, G. (2017). Factors influencing success in introductory college calculus. The role of calculus in the transition from high school to college mathematics. Retrieved from https://www.maa.org
[96] Sagimbayeva, G. S. (2015). Formation of an individual educational path of a future specialist in the context of a credit training system (on the example of the Republic of Kazakhstan) (PhD dissertation, Barnaul).
[97] Sajka, M. (2003). A secondary student's understanding of the concept of function – a case study. Educational Studies in Mathematics, 53, 229-254.
[98] Santos, J., Blas, L. C., Panganiban, A. J., Reyes, K. C., & Sayo, J. C. (2019). Alignment of senior high school strand in college course. Jewel Christine, Alignment of Senior High School Strand in College Course (February 1, 2019).
[99] Sfard, A. (1991). On the dual nature of mathematical conceptions: Reflections on process and objects as different sides of the same coin. Educational Studies in Mathematics, 22, 1–36.
[100] Sierpinska, A. (1987). Humanities students and epistemological obstacles relating to limits. Educational Studies in Mathematics, 18, 371–397.
[101] Sonnert, G. and Sadler, P. 2015. The impact of instructor and institutional factors on students' attitudes. Pages 17–29 in Insights and Recommendations from the MAA National Study of College Calculus. MAA Notes #84. Bressoud, Mesa, and Rasmussen, eds. Washington, DC: MAA Press.
[102] Spirina, T. A., & Sagoyakova N. F. (2014). Foreign and domestic experience of individualization of education in higher education. Mir nauki, kul'tury, obrazovaniya - World of science, culture, education, 3 (46), 110-113.
[103] Swinyard, C. (2011). Reinventing the formal definition of limit: The case of Amy and Mike. The Journal of Mathematical Behavior, 30(2), 93–114.
[104] Swinyard, C., & Larsen, S. (2012). Coming to understand the formal definition of limit: Insights gained from engaging students in reinvention. Journal For Research In Mathematics Education., 43(4), 465–493
[105] Szydlik, J. E. (2000). Mathematical beliefs and conceptual understanding of the limit of a function. Journal for Research in Mathematics Education, 31(3), 258–276.Tall, D., & Schwarzenberger, R. L. (1978). Conflicts in the learning of real numbers and limits. Mathematics Teaching, 82, 44–49
[106] Tall, D., & Vinner, S. (1981). Concept image and concept definition in mathematics with particular reference to limits and continuity. Educational studies in mathematics, 12(2), 151–169.
[107] Tall, D. (1992). The transition to advanced mathematical thinking: Functions, limits, infinity, and proof. In D. Grouws (Ed.), Handbook of research on mathematics teaching and learning (pp. 495–511). New York: Macmillan.Tall, D. (1993). Students' difficulties in calculus. In proceedings of working group (Vol. 3, pp. 13-28).
[108] Teocson, K., Cruz, J. (2017). Published on 2017 and Retrieved from https://bluehost975.wordpress.com/2017/10/07/why-did-i-chose-humss/
[109] Thorndike, E. L. (1932). The fundamentals of learning.
[110] Trigueros, M., & Martínez-Planell, R. (2015). Two-variable functions: Analysis from the point of view of a dialogue between APOS theory and ATD. Ensenanza de las Ciencias, 33, 157–171.
[111] Tupas, F. P., & Matsuura, T. (2019). Moving forward in stem education, challenges and innovations in senior high school in the Philippines: The case of Northern Iloilo polytechnic state college. Journal Pendidikan IPA Indonesia, 8(3), 407-416.
[112] Vandebrouck, F. (2011). Perspectives et domaines de travail pour l'étude des fonctions. Annales de Didactique et de Sciences Cognitives., 16, 149–185.
[113] Veretennikova, V. B. (2015). Structural and functional model of the quality of the competence-oriented educational process in the system of preschool education. Kazanskiy Pedagogicheskiy Zhurnal - Kazan Pedagogical Journal, 5(2), 76-81.

[114] Vinner, S. (1991). The role of definitions in teaching and learning mathematics. In D. O. Tall (Ed.), Advanced mathematical thinking (pp. 65–81). Dordrecht: Kluwer.

[115] Warren, E. (2005). Young Children's ability to generalise the pattern rule for growing patterns. In H. L. Chick & J. L. Vincent (Eds.), Proceedings of the 29th Conference of the International Group for the Psychology of Mathematics Education (Vol. 4, pp. 305–312).

[116] Warren, E., Miller, J., & Cooper, T. J. (2013). Exploring young students' functional thinking. PNA, 7(2), 75–84.

[117] Williams, S. R. (1991). Models of limit held by college calculus students. Journal for rresearch in Mathematics Education, 22(3), 219–236.Winona Daily News. Retrieved http://www.winonadailynews.com/news/local/ article_457afe3e-0db3-11e1-abe0001cc4c03286.html STEM (2013) retrieved from https://whatis.techtarget.com/definition/STEMscience-technology-engineering-andmathematics

[118] Yu, N. (2018). The K-12 Academic Track Series:STEM retrieved from https://blog.edukasyon.ph/senior-high/the-k-12-academic-track-series-stem/

[119] Zeer, E. F., & Zhurlova, E. Yu. (2017). Navigational aids as tools to support the development of competencies in the implementation of an individual educational trajectory. Obrazovaniye i nauka - Education and Science, 19(3), 77-93.

[120] Bulacan State University Vision, Mission and Goals Retrieved September 8, 2018 from http://www.bulsu.edu.ph/about/vision-mission-and-goals.php

[121] College of Arts and Technology (2018) College Degree Courses You Can Consider as a K-12 Graduate Retrieved on September 4, 2018 from https://www.ciit.edu.ph/k-to12-tracks-and-strands/

[122] Commission on Higher Education (2017). CHED Memorandum Order No. 105 Series of 2017 Retrieved on the 10th day of September, 2018 from CMO-No.-105-s.-2017- Policy-on-the-Admission-of-Senior-High-School-Graduates-to-the-Higher-EducationInstitutions-Effective-Academic-Year-2018-2019.pdf