**Al-Ishlah: Jurnal Pendidikan**
Vol.15, 4 (December, 2023), pp. 5319-5327
ISSN: 2087-9490 EISSN: 2597-940X, DOI: 10.35445/alishlah.v15i4.2256

# Cognitive Structure Trajectory in Developing Limit Concept Learning in Senior High School

**Simin[1], Mohamad Rif'at[2], Evi Noviani[3]**

[1] Universitas Tanjungpura, Pontianak, Indonesia; simin.tjong@gmail.com
[2] Universitas Tanjungpura, Pontianak, Indonesia; mohammad.rifat@fkip.untan.ac.id
[3] Universitas Tanjungpura, Pontianak, Indonesia; evi_noviani@math.untan.ac.id

**ARTICLE INFO**

*Keywords:*

Limit Concept;
Mathematics;
Learning;
Cognitive Structure;
Trajectory

*Article history:*

Received 2022-05-30
Revised 2023-09-11
Accepted 2023-12-24

**ABSTRACT**

The existing comprehension of the concept of limit is marked by a deficiency in prioritising the enhancement of students' cognitive frameworks. The aim of this study is to examine the formation of cognitive structures while acquiring the concept of limitations. This study utilises qualitative approaches, namely descriptive analysis, to examine the development of cognitive processes in the process of acquiring the concept of boundaries. This study investigates the investigation of cognitive structures to ascertain the process of drawing conclusions, with the aim of creating instructional materials that facilitate comprehension of the concept of constraints. The survey included students who were currently enrolled in the 2021/2022 academic year at three public senior high schools in Pontianak. The study aims to analyse the progression of students' cognitive structures during the acquisition of the concept of limitations. The results revealed that all 14 students showed competence in determining the limit of a continuous polynomial function, specifically in the context of a linear function and a quadratic function. Substitution is commonly used to determine the limit of a linear function and the limit of a quadratic function. Only a single student employs the attributes of the limit function and graph trajectory to solve these two categories of problems. Researchers can conduct further investigation to examine the misconceptions that students have regarding the limit of functions. These misconceptions can be detected by analysing problems that involve substitution and have solutions that are already known. In senior high school, it is advisable to use graphs and tables to teach the concept of limit function since they aid in facilitating the learning process.



**Corresponding Author:**
Simin
Universitas Tanjungpura, Pontianak, Indonesia; simin.tjong@gmail.com

## 1. INTRODUCTION

The cognitive structure trajectory employed in Senior High School (SMA) facilitates the development of limit concept acquisition by providing a structured path for cognitive growth. Catarreira et al. (2017) asserted that the process of learning that takes place within the mind remains the most perplexing enigma in the realm of education. Catarreira et al. (2017) argue that the cognitive structure contains concepts that are not only linked to formal definitions, but also to personal mental representations that individuals create while forming a concept. According to Widada (2016), cognitive theory views students as active individuals who process information. This means that they can provide information that matches their level of knowledge and use the information they acquire to build their understanding.

Before moving on to more advanced forms of learning like discrimination, concept, rule, and problem solving, there are foundational forms like stimulus-response learning. To make it easier to learn more advanced skills, we might group related topics or areas of mathematics into "learning hierarchies." These hierarchies, in turn, define "learning routes" that serve as the foundation for future learning trajectories. At various points along their learning trajectories, students may employ distinct cognitive structures or ways of thinking to arrive at different solutions to mathematical problems. Students' mental processes, including the "how" and "why" of a topic and the objects that shape those processes, are characterised by cognitive structure (Clements, D., 2011).

The National Council of Teachers of Mathematics (NCTM) emphasises the importance of The Learning Principle in classroom mathematics. This principle states that students should acquire mathematical knowledge by comprehending concepts, actively building upon their existing knowledge and experiences (NCTM, 2000). Although the acquisition of mathematical knowledge through comprehension has traditionally been a typical goal of mathematics education, the lack of understanding in mathematical learning has remained a recurring issue. This matter has been extensively examined and debated by educators and psychologists through many research and conversations.

Errors pertaining to the understanding of boundaries and cognitive obstacles in the process of learning frequently arise and pose significant challenges that persist even at more advanced stages. An analysis of students' comprehension of the three fundamental limit concepts reveals varying perspectives on the concept of limits. Students regarded limit situations as distinct entities, with some students able to establish links, albeit in manners that contradicted formal mathematics. However, none of the students possessed a cohesive and comprehensive framework to integrate the three fundamental limit notions. The three fundamental ideas pertaining to limits are: the limit of a sequence, denoted as $\lim_{n\to\infty} a_n$, the limit of function at certain point $\lim_{x\to x_0} f(x)$, limit a function at infinity $\lim_{n\to\infty} f(x)$ (Caifen et al., 2018)

Understanding the concept of limits on the function $\lim_{x\to a} f(x)$, where a is a real number (notated a ∈ R) and f is a function, read as the limit of f(x) as x approaches a. Things that need to be paid attention to are the meaning of approach which means approach, and the use of the limit symbol only in the context of limits. The notation $\lim_{x\to a}$ can be said to be a limit operator, which is applied to the function f. So $\lim_{x\to a} f(x)$ is a real number in f(x) as a result of the operation x approaches a, provided that if the result of the operation is a certain real number. If there is a value of f(x) with a limit operation x approaching a, then that value is expressed as L (as the limit value). So it is said that the limit value of a function is written $\lim_{x\to a} f(x)$, which means f(x) approaches L because the result of the limit operation x approaches a. Furthermore, if the limit value of a function is infinite (∞) or negative infinite (-∞), respectively, it is written $\lim_{x\to a} f(x) = \infty; \lim_{x\to a} f(x) = -\infty$. In certain circumstances the limit value of a function does not exist when x approaches a, for example $\lim_{x\to 0} \frac{1}{x}$, if traced there will be two limit values, namely ∞ or -∞, of course these values cannot be the answer to the limit value because the limit value is single, and it is said $\lim_{x\to 0} \frac{1}{x}$ = does not exist.

Upon analysing the outcomes of high school students' attempts at solving limit concept issues, it becomes evident that the students typically approach limit problems by directly replacing the value of x into the function f(x). In addition, several pupils employ the method of approaching limits from the right and left directions, while others utilise tables or graphs to solve problems related to the notion of limits. Students can comprehend that infinity (∞) and negative infinity (-∞) are distinct numerical quantities.

Each student's cognitive structure trajectory is unique and capable of producing both right and bad answers, according to the aforementioned analysis. For this reason, the concept of boundaries can only be fully understood by taking a variety of paths. Learning cognitive structure trajectories can be better understood by increasing the number of questions, making them more diverse using different models, taking stock of the many trajectories that arise, and then testing them. According to Chagwiza, Maharaj, and Brijlall (2020), certain studies indicate that students encounter challenges while dealing with the notion of function boundaries within the framework of sequences or series. Another challenge lies in determining the numerical value of the function limit and understanding the formal definition of the function limit. Caglayan (2015) employed GeoGebra to illustrate the ε–δ method in defining formal limit functions. For instance, Caglayan taught students that when $\varepsilon > 0$, they can employ graphs to determine the value of δ. This value ensures that if the absolute difference between x and an is less than δ, then the absolute difference between f(x) and L is less than ε. In order to ensure that students observe the visualisation outcomes generated by GeoGebra and provide comprehensive explanations for each stage, it is important to emphasise the reasoning behind these steps. Nagle, C., Tracy, T., Adams, G., & Scutella, D. (2017) suggest using instructional activities to introduce the concept of limits in functions as the anticipated value of a function. Nagle, et al give instances of activities that employ numerical and pictorial representations to elucidate the limits of functions, as well as the concept of the anticipated value of a function.

Education should be organised according to cognitive structure trajectories, equipping instructors with the framework, resources, and tools necessary to convert pedagogical content knowledge from abstract notions into practical components of teaching. The problem is formulated as: "What is the trajectory of the cognitive structure in the process of learning the concept of limits?". The scope of this research is confined to examining the trajectory of students' cognitive structures as they learn the idea of limits in the classroom. The research purpose aims to investigate the trajectories of cognitive structures in the process of learning the idea of limits. This research offers valuable insights that can enhance the comprehension, development, and mathematical abilities of learners by focusing on the trajectory of advanced cognitive structures. These benefits can be applied as a supplementary tool for grasping the concept of limitations in the present and foreseeable future. Furthermore, it can serve as an instructional exercise in the current era.

## 2. METHODS

This study use qualitative research methodologies, namely descriptive analysis, to investigate the trajectories of cognitive structures in the process of learning the notion of boundaries (Ahyar et al., 2020). This research is a descriptive study that specifically examines the trajectory analysis of cognitive structures in order to draw implications for the development of teaching materials related to the concept of limits in learning. The research participants consisted of students enrolled in the 2021/2022 academic year at SMAN 1 Sanggau Regency, specifically those in class XI Science and class XII Science. The focus of the research is the progression of students' cognitive structures as they learn the concept of limitations. The research procedure is outlined as follows:

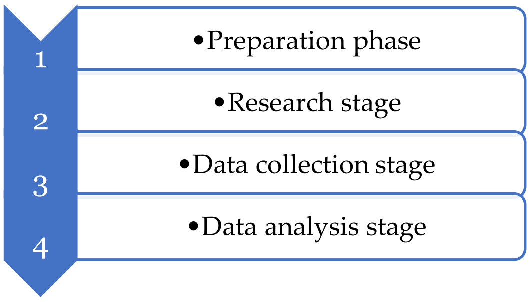


**Figure 1.** Research Procedure

During the preparation stage, the researcher engages in several key activities. These include formulating the problem, conducting a thorough literature review, selecting the study topic, creating a well-defined research timetable, determining the appropriate research tools, developing a data collecting agenda, designing processes for data analysis, and identifying the necessary equipment for the research. During the research phase, the investigator administers a survey and performs observations in the research domain to assess its suitability for conducting research. Subsequently, researchers administered a survey to ascertain the distribution of student diversity. The noticed abilities include the students' aptitude for expressing thoughts and their capacity for introspection.

Test findings pertaining to the idea of limits with specified instruments provide the data source in the data collection stage. In order to get different cognitive structure trajectories in answering limit questions, the researcher first sorted the students' answers and then performed an analysis based on the test findings. The researcher outlined the mental framework of the pupils' limit notion throughout the data analysis phase. In order to better understand how cognitive structures learn about boundaries, the gathered structures are then examined.

Written assessments consisting of essay questions were used to gather data. The researcher hopes to uncover and identify the trajectory of cognitive structures in learning the concept of limitations by selecting this test. This study instrument was developed and utilised to gather data in investigating the progression of students' cognitive structures in acquiring knowledge about the idea of limitations. The selected instrument was a test instrument consisting of essay questions. The test instrument comprises 8 essay questions pertaining to the limitations of algebraic functions with specific attributes. These questions are carefully chosen from a variety of research sources that are directly related and pertinent to this study. The attributes of the research instruments are outlined in Table 1 below:

**Table 1**. characteristics of research instruments

| Instrument Characteristic | Description | Reason | Total of item |
|---|---|---|---|
| Limits continuous function | Limits of polynomial functions in linear form | The problem can be resolved through the utilisation of different approaches, specifically: intuition, graphs, tables, properties of function limitations, and replacement. | 1 |
| | Limits of polynomial functions in quadratic form | The problem can be resolved through the utilisation of different approaches, specifically: intuition, graphs, tables, limit properties, and replacement. | 1 |
| | Limits of continuous rational functions, with implementation of the limit definition towards infinity. | The problem can be resolved through the utilisation of different approaches, specifically: intuition, diagrams, tables, and algebra. | 1 |
| Limits discontinuous function | The limit of a rational function is discontinuous at a certain point, with the implementation of the limit definition going to infinity. | The problem can be solved using different approaches, specifically: intuition, diagrams, tables, and mathematics. | 1 |
| | The limit of a rational function that is discontinuous at a certain point, with the implementation of the limit property: $\lim_{x\to c} f(x)$ there is if and only if $\lim_{x\to c^-} f(x) = \lim_{x\to c^+} f(x)$ | The concept can be elucidated by different approaches, specifically: intuition, diagrams, and tables. | 2 |

| Instrument Characteristic | Description | Reason | Total of item |
|---|---|---|---|
| | The limit of a discontinuous function is determined under certain conditions, with the implementation of the limit properties: $\lim_{x\to c} f(x)$ there is if and only if $\lim_{x\to c^-} f(x) = \lim_{x\to c^+} f(x)$ | The concept can be elucidated by different approaches, specifically: intuition, diagrams, and tables. | 2 |

## 3. FINDINGS AND DISCUSSION

The selection of students as research participants is a collaborative decision made by the principal and mathematics subject instructors, ensuring alignment with the research objectives. The students who are the subjects are shown in Table 2 below:

**Table 2**. Distribution of Student Resources as Research Subjects

| Subject | School | Number of students | Total of students |
|---|---|---|---|
| Class XI Science students for the 2021/2022 academic year | SMAN 1, Kabupaten Sanggau | A11, A12, A13, A14 | 4 |
| Class XII Science students for the 2021/2022 academic year | SMAN 1, Kabupaten Sanggau | A21, A22, A23, A24 | 4 |
| Class XI Science students for the 2021/2022 academic year | SMA Gembala Baik, Pontianak | B11, B12, B13, B14, B15 ,B16 | 6 |

Trajectory building of students' cognitive structures in solving algebraic function limit problems was obtained from 8 questions. These eight questions are standard from various related studies (Juter, 2006; Juter, 2007; Pulungan, 2018) and from the Calculus book (Varberg, D., Purcell, E., & Rigdon, 2010). These questions are presented in Table 3 below:

**Table 3**. Questions according to Source

| Soal (Instrumen Penelitian) | Sumber | Alasan | Karakteristik/Atribut (Validitas Wajah) |
|---|---|---|---|
| 1. Determine value $\lim_{x\to 3} (2x+3)$ | (Juter, 2006) | The questions are compatible with this research. | Fungsi $f(x) = 2x + 3$ merupakan fungsi linear dengan dua suku yang bentuk umumnya adalah $f(x) = ax + b$ ; $a \neq 0$, fungsi ini kotinu pada bilangan real R. |
| 2. Determine value $\lim_{x\to -2} (x^2+2x-1)$ | Varberg, D., Purcell, E., & Rigdon (2010). | The questions are compatible with this research. | Fungsi $f(x) = x^2 + 2x - 1$ merupakan fungsi kuadrat yang bentuk umumnya adalah $f(x) = ax^2 + bx + c$ ; $a \neq 0$, fungsi ini kotinu pada bilangan real R. |
| 3. Determine value $\lim_{x\to\infty} \frac{x^2}{x^2+1}$ | (Juter, 2007) | The questions are compatible with this research. | Fungsi $f(x) = \frac{x^2}{x^2+1}$ adalah fungsi rasional yang kotinu pada bilangan real R. |
| 4. Determine value $\lim_{x\to\infty} \frac{x^3-2}{x^3+1}$ | Juter (2006). | The questions are compatible with this research. | Fungsi $f(x) = \frac{x^3-2}{x^3+1}$ adalah fungsi rasional yang diskotinu di $x$ = -1. |

| **Soal (Instrumen Penelitian)** | **Sumber** | **Alasan** | **Karakteristik/Atribut (Validitas Wajah)** |
|---|---|---|---|
| 5. Determine value $\lim_{x\to 0} \frac{1}{x}$ | Varberg, D., Purcell, E., & Rigdon (2010). | The questions are compatible with this research. | Fungsi $f(x) = \frac{1}{x}$ adalah fungsi rasional yang diskotinu di $x = 0$. |
| 6. Determine value $\lim_{x\to 1} \frac{x^2+x}{x^2-1}$ | Juter (2006). | The questions are compatible with this research. | Fungsi $f(x) = \frac{x^2+x}{x^2-1}$ adalah fungsi rasional yang diskotinu di $x = 1$. |
| 7. The function f is expressed by: $f(x) = \begin{cases} x \text{ for } 0 \leq x < 1 \\ x+1 \text{ for } x \geq 1 \end{cases}$ investigate: $\lim_{x\to 1} f(x)$ ! | Pulungan (2018). | The questions are compatible with this research. | Fungsi *f(x)* yang telah ditentukan dengan syarat, fungsi ini diskontinu di *x*=1. |
| 8. Is known: $f(x) = \begin{cases} 3 \text{ for } x = 1 \\ x+1 \text{ for } x \neq 1 \end{cases}$ Determine the value $\lim_{x\to 1} f(x)$ ! | Varberg, D., Purcell, E., & Rigdon (2010). | The questions correspond to the material on limits of discontinuous functions which are compatible with this research. | Fungsi *f(x)* yang telah ditentukan dengan syarat, fungsi ini diskontinu di *x*=1. |

Question $\lim_{x\to 3} (2x+3)$ can be interpreted $\lim_{x\to 3} f(x)$ with the function $f(x) = 2x + 3$. In this case function $f(x) = 2x + 3$ is a linear function with two terms whose general form is $f(x) = ax + b$ ; $a \neq 0$, This function is a continuous function on the real number R.

Question resolution $\lim_{x\to 3} (2x+3)$, the intuition is that x is close to 3 but not equal to 3, meaning that the limit of x is close to 3, meaning that 3 can be approached from the left or right so that we get the limit of the function *f(x)* di 3, so *f(x)* close to 9 and it is said that the limit value is equal to 9 and is written $\lim_{x\to 3} (2x+3) = 9$. Answer 9 is correct because based on the definition of limit, namely if x approaches the value 3 then there must be a single limit value in R in the function *f(x).*

Look at Graph 1., the blue arrow shows the x value is close to 3, this situation shows the value $\lim_{x\to 3} (2x+3)$ is 9.

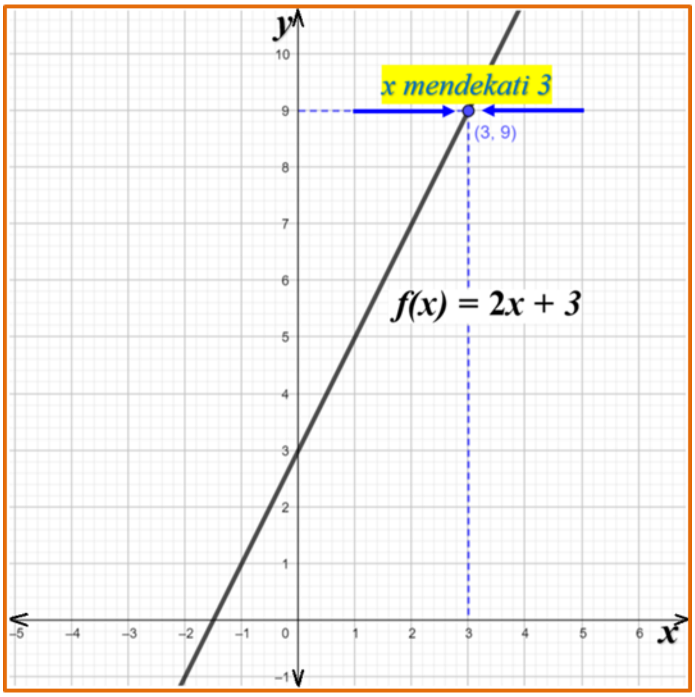


**Figure 2.** Problem Solving

Following is the table *f(x)* = 2*x* + 3 in determining value $\lim_{x \to 3} f(x)$.

**Tabel 4.** Problem Solving

*x makin mendekati 3 dari kiri* → ← *x makin mendekati 3 dari kanan*

| *x* | 2,9 | 2,99 | 2,999 | 2,9999 | … | 3 | … | 3,0001 | 3,001 | 3,01 | 3,1 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *f(x)* | 8,8 | 8,98 | 8,998 | 8,9998 | … | 9 | … | 9,0002 | 9,002 | 9,02 | 9,2 |

*f(x) makin mendekati 9* → ← *f(x) makin mendekati 9*

It is important to observe that as the x value approaches 2.9, it becomes more closer to 3. Similarly, the function value f(x) also approaches 9. The same trend can be observed when the x value approaches 3.1, as it gets closer to 3, the function value f(x) similarly gets closer to 9. This phenomenon is sometimes referred to as $\lim_{x \to 3} (2x + 3)$= 9.

Problem solving $\lim_{x \to 3} (2x + 3)$ can be solved using the following "properties of algebraic function limits":

$\lim_{x \to 3} (2x + 3) = \lim_{x \to 3} (2x) + \lim_{x \to 3} 3$

$= 2. \lim_{x \to 3} x + \lim_{x \to 3} 3$

$= 2.3 + 3$

$= 9$

So, the value of $\lim_{x \to 3} (2x + 3) = 9$.

Next is the solution $\lim_{x \to 3} (2x + 3)$ by substituting values $x = 3$, $\lim_{x \to 3} (2x + 3) = 2.3 + 3 = 9$. In general it is said if $x = c$ (limit $x$ in $c$) substituted into the function *f(x)* will be of certain value (*f*(c) = *L*) so that $\lim_{x \to c} f(x) = f(c)$ (Manullang et al., 2017; Loc, N. et al., 2019).

Various ways to solve problems $\lim_{x \to 3} (2x + 3)$ found by researchers to date and is presented for education at the high school/equivalent level up to university level. Many book authors call this method of solving an intuitive solution (Arnellis et al., 2019).

**Table 5.** How to Solve Question from Various Sources

| Question (Research Instrument) | Sourse | Explanation | Keywords |
|---|---|---|---|
| $\lim_{x \to 3} (2x + 3) = 9$ | (Manullang et al., 2017), Varberg, D., Purcell, E., & Rigdon (2010) | By taking a value close to 3 but not equal to 3 then *f(x)* not far from 9. | Intuition |
| | (Manullang et al., 2017), Varberg, D., Purcell, E., & Rigdon (2010) | Constructing graphs, visualizing functions *f(x)* in finishing $\lim_{x \to 3} (2x + 3) = 9$. | Graph |
| | (Manullang et al., 2017), Varberg, D., Purcell, E., & Rigdon (2010) | Create a function table *f(x)* to see patterns and clarify information in solving $\lim_{x \to 3} (2x + 3) = 9$. | Table |
| | (Manullang et al., 2017), Varberg, D., Purcell, E., & Rigdon (2010) | Using "limit properties of algebraic functions" in solving $\lim_{x \to 3} (2x + 3) = 9$. | Properties of Limits |
| | (Juter, 2006), (Manullang et al., 2017), Varberg, D., Purcell, E., & Rigdon (2010) | By replacing x with 3 we get $\lim_{x \to 3} (2x + 3) = 2.3 + 3 = 9$ | Substitution |

Of all the answers given by students, in general, only 6% (5 student answers) answered questions using graphical trajectories, even though all instruments can be done using graphs. Graphs can be used to help understand a situation, very useful when needing to identify continuity and discontinuity types of a function. Graphs can provide insight and produce conceptually valid answers (Aisyah, 2006). Only 14% of students' answers used tables (12 student answers), even though all question instruments could also be done using tables. Tables created with numerical estimates are very useful in understanding a situation. Using tables to determine function limits also produces conceptually valid answers.

In general, students solve questions by substitution, but there are certain cases or questions where substitution cannot be used directly (Nurdiyanto et al., 2019). The use of forced substitutions directly for certain cases will produce answers that give rise to student misconceptions. Likewise, algebraic strategies and the use of function limit properties can only be used in solving function limit problems in certain cases and conditions.

## 4. CONCLUSION

All students (14 students) were able to solve the limits of continuous polynomial functions in the form of linear functions and quadratic functions. Trajectories that appear in solving limits of linear functions and limits of quadratic functions generally use substitution. There was only 1 student each who used the properties of function limits and graph trajectories in solving these two types of problems. All students can also solve limits of continuous rational functions, by implementing the definition of the limit towards infinity. The trajectories that appear in problem solving generally use algebraic strategies. There is 1 student who uses intuition. All students can also solve rational limits that are discontinuous at a certain point, by implementing the definition of the limit towards infinity. The trajectories that appear in problem solving generally use algebraic strategies. This research only explains characteristics characterized by a lack of focus on the development of students' cognitive structures in a qualitative descriptive manner. For further research, it is recommended to use different methods and samples with different levels of education.

## REFERENCES


Ahyar, H., Andriani, H., & Sukmana, D., J. (2020). *Metode Penelitian Kualitatif & Kuantitatif* (Issue Maret).

Aisyah, N. (2006). Pendekatan Pemecahan Masalah Matematika. In *Pembelajaran Matematika Sekolah Dasar* (pp. 1–34).

Arnellis, Suherman, & Amalita, N. (2019). Implementasi Learning Trajectory Kalkulus Berbasis Realistic Mathematics Education untuk Meningkatkan Kemampuan Berpikir Matematis Tingkat Tinggi Siswa SMA Kota Padang. *Jurnal Menara Ilmu*, *XIII*(6), 11–18.

Caglayan, G. (2015). Math majors' visual proofs in a dynamic environment: the case of limit fungsi of a function and the ϵ–δ approach. International journal of mathematical education in science and technology, 46(6), 797-823.

Caifen, W., Hailun, F., & Rongrong, C. (2018). The Research on Graduate Students' Understanding of Three Basic Limit Concepts. *American Journal of Education and Learning*, *3*(2), 100–107. https://doi.org/10.20448/804.3.2.100.107

Catarreira, S., M., V., Lopes, V., G., Garcia, L., M., C., & Gonzalez, R., L. (2017). Evaluation of Changes in Cognitive Structures after the Learning Process in Mathematics. *International Journal of Innovation in Science and Mathematics Education*, *25*(2), 17–33.

Clements, D., H. (2011). Learning Trajectories: Foundations for Effective, Research-Based Education. *PME-NA 2011*, 365–372.

Chagwiza, C. J., Maharaj, A., & Brijlall, D. (2020). Formulating a Modified Genetic Decomposition for the Concept of 'Limit fungsi of a Sequence'. African Journal of Research in Mathematics, Science and Technology Education, 24(3), 333-3

Juter, K. (2006). Limits of functions : Students solving tasks. *Australian Senior Mathematics Journal*, *20*(1), 15–30.

Juter, K. (2007). Students' Consept Development of Limits. *CERME Journal*, *5*(5), 2320–2329.

Loc, N., P., Tong, D., H., & Duy, V., K. (2019). Using The Information Processing Theory Into Teaching Mathematics: A Case Study Of "Vector"Concept. *International Journal of Scientific & Technology Research*, *8*(09), 1612–1616.

Manullang, S., Kristianto, A., Hutapea, T., A., Sinaga, L., P., Sinaga, B., Marianus, M., & Sinambela, P., N. (2017). *Buku Guru Matematika* (A. Lukito, M. Darwis, Turmudi, & N. Priatna (eds.); Edisi Revi). Kementrian Pendidikan dan Kebudayaan RI.

Nagle, C., Tracy, T., Adams, G., & Scutella, D. (2017). The notion of motion: covariational reasoning and the limit fungsi concept. International Journal of Mathematical Education in Science and Technology, 48(4), 573-586.

NCTM. (2000). *Principles and Standards for School Mathematics*. Key Curriculum Press.

Nurdiyanto, T., Rafida, I., & Zulkardi. (2019). Penerapan Model Generative Learning untuk Meningkatkan Hasil Belajar Peserta Didik pada Materi Limit Kelas XI MIPA 1 SMA Negeri 2 Palembang. *Lentera Sriwijaya: Jurnal Ilmiah Pendidikan Matematika*, *1*(1), 38–54.

Pulungan, S. (2018). *Analisis Kemampuan Kognitif Siswa pada Materi Limit Fungsi di Kelas XI SMK Al-Hasanahsibuhuan*. Institut Agama Islam Negeri Padangsidimpuan.

Varberg, D., Purcell, E., & Rigdon, S. (2010). *Kalkulus (Edisi kesembilan Jilid 1)*. Erlangga.

Widada, W. (2016). Profile of Cognitive Structure of Students in Understanding the Consept of Real Analysis. *Journal of Mathematics Education*, *5*(2), 83–98. https://doi.org/10.22460/infinity.v5i2.215