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Econometric Evidence on Self-Determination Theory in Learning Calculus Among Agribusiness Students

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Abstrak

Teori Self-determination adalah studi tentang minat dan motivasi individu yang memainkan peran penting dalam kinerja yang baik dan produktif dalam pembelajaran. Penelitian ini fokus pada motivasi siswa agribisnis dalam belajar Kalkulus sebagai bagian dari kurikulum mereka. Menggunakan model ekonometrik, penelitian ini mengidentifikasi beberapa faktor motivasi yang signifikan secara statistik. Penelitian ini melibatkan 121 mahasiswa agribisnis sebagai responden menggunakan *stratified random sampling* pada semester pertama tahun ajaran 2019-2020. Hasil penelitian menunjukkan bahwa sebagian besar siswa agribisnis termotivasi dalam belajar kalkulus. Siswa perempuan lebih cenderung termotivasi dibandingkan dengan siswa laki-laki. Wanita lebih fokus pada studi mereka sementara pria dipengaruhi oleh game online. Studi ini mengungkapkan bahwa sikap belajar dan kesehatan adalah faktor motivasi yang signifikan dalam belajar. Selain itu, pengalaman siswa dalam kalkulus membuat mereka kreatif di kelas yang memberikan kontribusi positif bagi minat mereka.

Kata Kunci: teori *self-determination*, model ekonometrik, performa produktif

Abstract

Self-determination theory is a study of individual interest and motivation which plays a vital role in good and productive performance in learning. This study focus on the agribusiness students' motivation in learning Calculus as part of their curriculum. Using econometric models, this study identified some statistically significant factors of motivation. The study employed 121 agribusiness students as respondents using stratified random sampling in the first semester of SY 2019-2020. Results revealed that most of the agribusiness students are motivated in learning calculus. Female student is more likely motivated compared to male students. Females are more focusing on their studies while males are affected by online games. The study revealed that learning attitude and health are significant factors of motivation in learning. Also, students' experience in calculus makes them creative in the classroom which positively contributes to their interest.

Keywords: *self-determination theory, econometric models, productive performance*

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INTRODUCTION

Studying self-determination of students is important in teaching-learning process. Self-determination theory (SDT) is a macro theory of individual interest and motivation that deals with intrinsic tendencies to behave in productive, efficient and effective ways in learning environment (Alabekee et al., 2015; Deci et al., 2017; Gillet et al., 2014). This theory suggests that both students' academic performance and their well-being are influence by the type of interest and motivation they have experience in the classroom (Ryan & Deci, 2017; Schiffrin & Nelson, 2010). If students are motivated, then this type of students likely to look forward to days in school activities to feel alive and well (Ryan et al., 2010). Apparently, positive learning experience in calculus leads to active engagement with the lesson and greater self-determination in achieving good performance (Alabekee et al., 2015).

One of the degree program offered by a university of Visayas region in the Philippines that include calculus as part of their curriculum is Bachelor of Science in Agribusiness (BSAB). Calculus is a branch of applied mathematics that has diverse application in real life that deals with how related things change particularly in business side (Berggren, 2018). Mostly, students who enrolled in this degree program are not Science, Technology, Engineering and Mathematics (STEM) track in the K to 12 Education Curriculum during their senior high school. Hence, these type of students are more likely to encounter difficulties in understanding its topics since they don't have enough background in the subjects (Alabekee et al., 2015). This leads to improper motivation in learning and negatively affects their interest and well-being in finishing their respective degree program. On the average, in the past semesters, about 50% of the agribusiness students failed to pass calculus which is considered as core subjects and unable to proceed some major subjects which requires calculus as prerequisite. In order to address this kind of problem, students must be motivated to learn calculus. In fact, self-determination played a vital part to students to develop knowledge and understanding the said subject (Conchie, 2013; Denson et al., 2015). Kitchen and colleagues (2018) suggests that cooperative and interactive learning strategies contribute to the promotion of higher order thinking for students.

At present, econometric studies on self-determination theory on learning calculus is a bit limited in literature. Hence, this study is conducted to determine the different factors affecting the agribusiness students' motivation in learning calculus. This study assume that level of self-determination and well-being of these students has been attributed to socio-demographic profile, learning experiences, behavioral and social factors (Sahatsathatsana et. al., 2014). The result of this paper will help the agribusiness students in understanding motivation, awareness and self-confidence in learning calculus. Furthermore, this study also serve as guide for effective teaching strategy for calculus teachers and improve existing policy that affects the well-being for both learners and teachers.

In the study of Gillet and colleagues (2014), and Williams and colleagues (2014), it is found that the negative effects of a dislike learning environment are stress, emotional exhaustion, frustration/disappointment, absenteeism and somatic symptom burden. A student with emotional exhaustion in learning may results from the sustained experience of negative attitudes towards the subject and unexplained physical symptoms (Olafsen et al., 2017). Similarly, a student who perceive their studies as stressful and who experience somatic symptoms may be more likely to express intentions to stop their education or shift to the other degree programs (Brown et al., 2016). According to Schiffrin and Nelson (2010), a students who were stress in learning are less likely happy and motivated.

A good teaching strategies in calculus can have the potential to support students' learning motivation and engagement to the classroom setting (Casinillo & Guarte, 2018). Quality

teachers' background and performance will provide a meaningful exposure to a students and influences how students participate, practice, and motivated to belong in class (O'Connell et al., 2017). It is also revealed in the study of Mushtaq and Khan (2012) that the students' motivation and determination in learning is influence by other factors like demographic and economic profile, perception and learning experience of the subjects, and study habits.

Hence, the conceptual framework focus on different factors that directly influence the agribusiness students' motivation in learning calculus with the aid of econometric models. This study is grounded on the findings of Popovic and Lederman (2015) that deals with students' awareness and interest in learning. Generally, the study aimed to explain the student's motivation in learning calculus. Specifically, this study sought the following objectives: (1) to determine the socio-demographic profile, perception of the subject and teacher, and negative learning attitudes of students; (2) to measure the level of motivation of students in learning calculus; (3) to develop models that determine significant factors in the student's self-determination in learning calculus.

METHODOLOGY

The Research Design

This research study considered a design that is inferential in nature that determined statistically significant determinants that influence the motivation of students in learning calculus. This design is based on the early studies of Deci et al. (2017), and Olafsen et al. (2017) which involves the analysis of self-determination theory. In data management, descriptive measures were used such as frequencies, proportions, and percentages for qualitative in nature. For quantitative data, the following descriptive measures were used: mean, standard deviation, minimum and maximum value. In determining the significant factors that influence the student's motivation in learning calculus, an ordered logit models were undertaken using a software called STATA v.14.

The Respondents, Sampling Procedure

The population of interest in this study considered all agribusiness students who currently enrolled calculus subject in Visayas State University (VSU) during the first semester in the school year 2019-2020. The list of the said students was provided by the registrar's office of VSU in which there are four sections of agribusiness students offered in that semester. Hence, the said sections were considered as a strata. Then, sample students were chosen using stratified random sampling by applying simple random sampling method for each stratum. Slovin's formula was used in determining the sample size by setting the margin of error to 5% and computed as follows (Cochran, 1953):

$$n = \frac{N}{1 + Ne^2} \quad (1)$$

where n – is the sample size

N – is the population size

e – is the margin of error, the margin of error can be set by the researcher.

The derived sample size n was allocated for the four sections of class. Alternative students were drawn in case the selected student is not available, refuses to participate in the study or leave

several blanks in the questionnaire. Table 1 shows the frequency distribution of samples and its corresponding percentages.

Table 1. Distribution of participants.

	Number of Students (N)	Sample size (n)	Percentage (%)
Section 1	44	31	70.45%
Section 2	41	29	70.73%
Section 3	45	31	68.88%
Section 4	43	30	69.77%
Total	173	121	69.94%

The Research Instrument, Data Collection, and Ethics

The survey instrument used in this study is a developed semi-structured questionnaire, which contains close-ended and open-ended questions. The first part of the questionnaire is the student’s demographic profile. And the rest of the part of the questionnaire is Likert-type scale which deals the students’ profile, learning experiences, problems encountered and perceptions to calculus teacher. In each item, it is completed by choosing one of ten options, a 1 to 10 scaling, that is, 1-strongly disagree and 10-strongly agree. This questionnaire has undergone pre-testing and reliability test and found out that it was valid and reliable. Table 2 shows the Cronbach’s alpha of the following parts of the questionnaire.

Table 2. Reliability test for Likert-type scale questions

	Cronbach’s Alpha	Number of Items
Students’ Profile	0.838	7
Learning Experiences	0.822	5
Problems	0.838	6
Perception to Calculus Teacher	0.963	6

Prior to the conduct of the study, the permission of the department heads and teachers of agribusiness management students was asked. During the calculus class schedule, the students are given the said questionnaire and oriented to answer the following questions without leaving any blanks. Furthermore, the study considers an ethical procedure, hence, the involvement of the said survey was strictly voluntary. The students were educated and assured that all data collected from them were treated with confidentiality and used for the research purposes only.

Determination of Factors Affecting Student’s Motivation using Econometric Modelling

To capture the statistically significant factors that influence the degree of motivation or self-determination of agribusiness students in learning calculus, this study utilized the parallel-lines model, that is, ordered logit (ologit) model. An ologit model is also called ordered logistic regression or proportional odds model that deals with ordinal dependent variables (Williams, 2006). Consider the following linear equation model:

$$Y_i = \beta_0 + \beta_1x_1 + \beta_2x_2 + \dots + \beta_nx_n + u_i \tag{2}$$

where Y_i represents the level of motivation of students (dependent variable), β_0 is the constant term and in ologit model $\beta_0 = 0$, $\beta = (\beta_1, \dots, \beta_n)$ are parameters to be estimated, $X_i = (x_1, \dots, x_n)$ refers to the different determinants (independent variable) of motivation and u_i is the error term. Hence, the ologit model can be written as

$$P(Y_i > j) = g(X_i\beta) = \frac{\exp[\alpha_j + X_i\beta]}{1 + \exp[\alpha_j + X_i\beta]}, \quad j = 1, 2, \dots, M - 1 \quad (3)$$

where α_k is a parameter called thresholds or cut points and it is increasing order, that is, $\alpha_1 < \alpha_2 < \dots < \alpha_{j-1}$ and M is the number of categories of the ordinal dependent (response) variable. The ordinal categories of response variable were coded as follows: 0-Strongly Disagree, 1-Disagree, 2-Neutral, 3-Agree and 4-Strongly Agree. From the above equation (3), it can be determined that the probabilities that Y will take on each of the value $0, \dots, M - 1$ are equal to the following:

$$\begin{aligned} P(Y_i = 0) &= 1 - g(X_i\beta_1), \\ P(Y_i = j) &= g(X_i\beta_{j-1}) - g(X_i\beta_j), \text{ and} \\ P(Y_i = M - 1) &= 1 - g(X_i\beta_{m-2}). \end{aligned} \quad (4)$$

Before the ologit models was undertaken, some common diagnostic test for the econometric models were performed to have a valid and reliable results for interpretation (Greene, 2008; Williams, 2016).

RESULTS AND DISCUSSIONS

The descriptive measures for the demographic and economic profile, learning experiences, problems in learning and perception of calculus teacher is presented in this section. It also presents the students motivation in learning calculus and with the aid of frequency distribution and Chi-square test for uniformity, the students' motivation has been categorized into different levels. To capture the different factors that influence the students' motivation, it uses econometric modelling. Thus, this section presented different models.

Descriptive Statistics for the Different Variables Used in this Study

The average age of the students is closed to 19 years old considering that Calculus is offered to freshmen during first semester (Table 3). And this is the ideal age for freshmen students after the implementation of Senior High School (SHS) in the educational system of the Philippines. There are more females (60%) agribusiness students compare to males (40%). Half of these students' are living in urban areas and the other half in rural areas. The approximate distance of their home town to VSU is closed to 29 km and their allowance per week is closed to 507.69 PhP (Table 3). Dominantly, students with small allowances were residing near campus and students with higher amount of allowance were far from the campus since the students will spend for fare. On the average, only 5 hours was spent for studying calculus. Students were not prioritizing mathematics but rather spend more time to other subjects for the reason that they have other things to consider. Some students were just studying mathematics if exams were approaching. In this batch of agribusiness students, only 10% came from Science, Technology, Engineering and Mathematics (STEM) strand during their senior high school. It means that dominant of these students have lesser exposure to mathematics (Sarmiento & Orale, 2016). Regarding their profile as a student and economic status, their rating is closed to 6.79 which describes them as an average student (Table 3). Average student is not even a stupendous ranker or not even a last ranker in the classroom setting but seen in the middle order or mediocre type. Their learning experience as a whole is considered to be average with the rating closed to 6.28 (Table 3). This refers to the students' interaction and other experience in which learning takes place in any academic settings. Also, they rated the problems as average

which implies that these students often encounter difficulties in learning Calculus. This goes to infer that there are challenges in the learning process which hinders their grasping ability to the topics. Furthermore, the calculus teacher was rated to be above average. This implies that their respective teachers are qualified to their job and doing their responsibilities well. Their Calculus teachers are always prepared and knowledgeable to the topics, and dedicated to their work. This teachers are impacting everything from their classroom learning for the students' long-term success in the future.

Table 3. Descriptive measures (n=121)

VARIABLES	Mean	Standard Deviation	Min.	Max.
Age (in years)	18.89	1.1324	18	26
Male (dummy)	0.40	0.4929	0	1
Urban (dummy)	0.47	0.5012	0	1
Distance of School from Home (km)	29.38	40.9197	0.5	344.2
Allowance (in peso)	507.69	253.272	50	1500
Study hours (per week)	4.87	5.7511	0.5	49
STEM Student	0.09	0.2887	0	1
Students' Profile: Study Habits ^a	6.25	1.7573	3	10
Students' Profile: Learning Attitudes ^a	6.93	1.6819	3	10
Students' Profile: Social Environment ^a	6.89	1.8140	2	10
Students' Profile: Emotional Aspect ^a	6.82	1.8439	1	10
Students' Profile: Health Aspect ^a	7.41	1.9819	2	10
Students' Profile: Mental Aspect ^a	7.09	2.0575	1	10
Students' Profile: Financial Aspect ^a	6.16	2.1409	1	10
Over all Mean for Students' Profile		6.7940		
Learning experience: Creative ^a	6.39	1.9894	2	10
Learning experience: Challenging ^a	8.33	1.8903	3	10
Learning experience: Enjoyable ^a	6.27	2.6802	1	10
Learning experience: Logical ^a	7.22	2.2785	1	10
Learning experience: Rewarding ^a	6.31	2.3095	1	10
Over all Mean for learning experience		6.284		
Problem: Stress ^a	8.27	2.2876	1	10
Problem: Emotional Exhaustion ^a	7.74	2.2676	1	10
Problem: Frustration/Disappointment ^a	7.61	2.3887	1	10
Problem: Absenteeism/tardiness ^a	5.02	2.9196	1	10
Problem: Somatic Symptom Burden ^a	6.04	2.6439	1	10
Problem: Laziness ^a	5.85	2.6946	1	10
Over all Mean for Problem		6.7575		
Calculus Teacher: Prepared ^a	8.03	2.2246	1	10
Calculus Teacher: Knowledgeable ^a	8.34	2.1930	1	10
Calculus Teacher: Mastery ^a	8.15	2.3690	1	10
Calculus Teacher: Organize ^a	8.02	2.3751	2	10
Calculus Teacher: Decent ^a	7.72	2.3882	1	10
Calculus Teacher: Approachable ^a	8.14	2.5176	1	10
Over all Mean for Calculus Teacher		8.0675		

Note: ^a - Scale 1 to 10

Agribusiness Students' Level of Motivation in Learning Calculus

Most of the students are motivated in learning calculus (Figure 1). This implies that students are experiencing a positive atmosphere in the teaching-learning process. Hence, these students leads to an increase in productivity in learning the lessons and creates the drive to work at the best of their abilities. This motivation is due to the fact that calculus is part of their curriculum that needs to be passed. Perhaps, these student are eager to learn and excited since the said subject is offered in their first semester of their freshmen year. Their interest in learning Calculus has several effects on their attitude (Casinillo & Aure, 2018). It directs the students' behavior toward a particular goal in class. It also increases students' time on task and assignments, and improve their level of achievements. Perhaps, motivation enhances their cognitive processing which increase their academic performance in the said subject. However, there are few students who don't like Calculus subjects (Figure 1). This type of students are having difficulty on understanding the topics which negatively affects their motivation in learning. This is due to the fact that this students has no enough background and exposure to the topics of Calculus during their high school days. Perhaps, low level of motivation results to low academic performance.

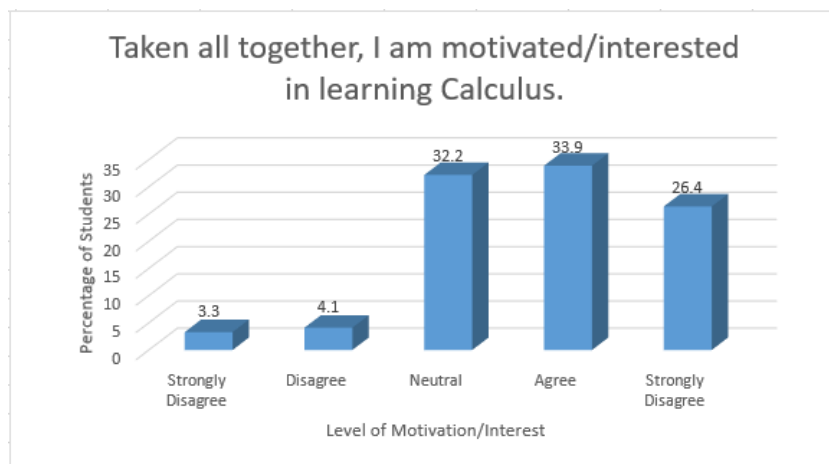


Figure 1. Level of Motivation/Interest in Learning Calculus ($n = 121$)

Evidence of Interest in Learning Calculus through Econometric Models

Table 4 shows that the four ordered logit models are significant and presents the statistically significant factors of interest or motivation of agribusiness students in learning calculus. According to Millman (1981), teacher is considered the most important factor in the learner's educational environment, thus, the four models contains perception to Calculus teacher as one of the predictors. In fact, the over-all perception to Calculus teacher is significant in the four models. It implies that the students' level of motivation is derived from the teacher. It is worth noting that in the teaching-learning environment, good teachers are the most important factor that contributes to students' level of achievement in the classroom, more important than facilities, and other school resources. The result is consistent to the study of Petrie and McGee (2012), and Chien (2017) that deals with teacher and a learner.

In model 1 ($\chi^2 = 17.95, p\text{-value} = 0.0216$), it is revealed that female student is more likely interested in learning calculus. The result is parallel to the study of Khaleel (2017) that reveals that female students tend to care more about studies than male students. Nowadays, male students are interested in games in their phones and computers which negatively affects their interest in learning. Model 2 ($\chi^2 = 23.88, p\text{-value} = 0.0024$) reveals that positive attitude affects the interest of students in learning calculus. Hence, it implies that with a positive behavior towards the topics in Calculus results to being open minded and active in learning. This agrees to the study of Awang and Colleagues (2013) which says that positive learning attitude of

students plays a very important role in the learning process. Also, the model shows that being healthy students leads to other interest like sports and physical activities. Student's attention is diverted to external activities which harmfully disturbs their motivation in class discussions. It goes to infer that interest in learning Calculus is negatively affected and this result is inconsistent with the study of Babatunde (2017) that deals with health and academic performance.

Model 3 ($\chi^2 = 16.78, p\text{-value} = 0.0189$) reveals that problems encountered in learning experience does not contribute effects on their interest. This implies that the students' motivation in learning Calculus is independent on the challenges in the teaching-learning process. Also, the said model shows that their perception to calculus teacher is significant considering perception to problems held constant. This means that despite of the difficulties of students in learning process they are motivated to learn if they are properly guided by the teacher. Students performs well with self-determination if the teacher will properly educate them about their abilities and competencies in the classroom (Mushtaq & Khan, 2012). In model 4 ($\chi^2 = 26.87, p\text{-value} = 0.0007$), it reveals that being creative in the classroom setting increases their interest in learning. This implies that students are relating or involving their imagination into new ideas or work during class discussion. With their creativity, something new and somehow valuable is formed in their mind which positively increase their motivation in learning calculus. This agrees to the study of Davies (2006) that deals with creative teaching and learning as a new paradigm. Further, the model reveals that perception to teachers is still significant. This implies that their respective teacher promotes growth related to the development of original thought in learning. Perhaps, calculus teacher uses to impart learning in efficient way and focus on the effect of teaching methods on students based on outcomes. This is consistent to the study of Kettler and colleagues (2018) that focus on creativity in the classroom.

Table 4. Econometric models for agribusiness students' interest and its influencing determinants (n=121)

INDEPENDENT VARIABLES	MODEL 1	MODEL 2	MODEL 3	MODEL 4
Age (in years)	0.0525 (0.1509)			
Male (dummy)	-0.6791* (0.3751)			-0.8311** (0.3583)
Urban (dummy)	-0.2261 (0.3499)			
Distance of School from Home (km)	0.0054 (0.0047)			
Allowance (in peso)	-0.0009 (0.0007)			
Study hours (per week)	-0.0009 (0.0291)			
STEM Student	-0.6364 (0.5529)			
Students' Profile: Study Habits ^a		-0.1544 (0.1414)		
Students' Profile: Learning Attitudes ^a		0.3476** (0.1619)		
Students' Profile: Social Environment ^a		0.1721 (0.1383)		
Students' Profile: Emotional Aspect ^a		0.0444 (0.1112)		

Students' Profile: Health Aspect ^a		-0.3472** (0.1451)		-0.1697* (0.1030)
Students' Profile: Mental Aspect ^a		0.1424 (0.1380)		
Students' Profile: Financial Aspect ^a		0.0761 (0.0908)		
Learning experience: Creative ^a				0.2905** (0.1328)
Learning experience: Challenging ^a				0.0302 (0.1103)
Learning experience: Enjoyable ^a				0.1109 (0.1011)
Learning experience: Logical ^a				0.0045 (0.1107)
Learning experience: Rewarding ^a				-0.0236 (0.1252)
Problem: Stress ^a			-0.1231 (0.1185)	
Problem: Emotional Exhaustion ^a			0.1083 (0.1304)	
Problem: Frustration/ Disappointment ^a			0.0827 (0.1131)	
Problem: Absenteeism/tardiness ^a			-0.0226 (0.0823)	
Problem: Somatic Symptom Burden ^a			-0.0861 (0.0899)	
Problem: Laziness ^a			-0.1049 (0.0845)	
Over all perception to Calculus Teacher ⁱ	0.2338*** (0.0813)	0.1652* (0.0917)	0.2298*** (0.0800)	0.1594* (0.0914)
Pseudo R-squared	0.0559	0.0748	0.0522	0.0871

Note: Standard errors are in parenthesis. ^a - Scale 1 to 10

*p < 0.10

**p < 0.05

***p < 0.01

CONCLUSIONS

This study focus on the investigation of different factors that significantly influence the motivation of students in learning calculus. In fact, motivation is an important element in the better learning process which is a substantial goal of educational system. Results showed that most of the agribusiness students are motivated to learn Calculus despite of challenges that they face in the classroom. Students' learning behavior towards the said subject is directed to their education needs and goals. Perhaps, a female student is more likely motivated than male in Calculus discussion and having a good confidence level in dealing class activities. To date, most of the male students are distracted by external factors like online games and that they may feel that they have no interest in academics. The study also revealed that being a healthy student is having a keen interest in the non-academics like sports and other physical activities which negatively affects their motivation in learning Calculus. Unmotivated students won't retain

information, they won't participate and they may be disruptive in class discussions. Moreover, the study showed that the teacher is the most important factor in the students' motivation. Teachers are the one who facilitate student's interest by developing knowledge, skills and attitudes towards learning calculus. Creative teaching also motivates them to think new ideas and generate new perspective in the classroom environment. Hence, teachers must have a positive attitude, good personal qualities and good creative teaching strategies towards their students. Further, in order that mathematics can be exciting, teacher must give more examples in real life situations.

It is recommended that teachers must set some expectations and making reasonable demands to encourage students to participate in class by offering some incentives or rewards. In this procedure, this will give the students a sense of accomplishment and encourage them to make effort with a goal in mind. For future research, it is strongly recommended that similar study should be conducted in a university that offers Agribusiness programs with larger population of students to come up with rigorous information about the motivation in learning calculus and its influencing factors. Furthermore, academic performance of students must be included in the analysis which is a potential limitation of the current study.

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