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CALCULUS TEACHER'S COMPETENCIES AS CORRELATES OF STUDENTS' LEARNING EXPERIENCES

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Abstract
The good qualities of a calculus teacher are an asset in producing great results for students and themselves. This study aimed to investigate the different competencies of a calculus teacher as correlates of students' experiences in learning at Visayas State University, Philippines. The study employed selected secondary data from the existing study in literature such as competencies in teaching calculus subjects and different types of learning experiences of students. The study used some descriptive statistical measures to summarize the selected data and employed Spearman rho correlation to predict significant factors (teacher's competencies) that might influence the student's learning experiences. Results showed that teachers' competencies such as "prepared", "knowledgeable", "mastery", "organized", "decent", and "approachable" are highly correlated to the different learning experiences of students at a 1% level of significance. Hence, calculus teachers must be always knowledgeable in a class through rigorous preparation and studying. It is also concluded that teachers must develop a mastery of calculus subjects and apply an organized routine during class discussions to obtain desired academic performance for students. In addition, a well-groomed and professional may be integrated in front of students as well as open-mindedness and good personality to make interactive and stimulating class discussions. It is recommended that calculus teachers may undergo some rigorous training for calculus teaching to become a knowledgeable and competitive educators. Furthermore, teachers who will teach college calculus must be holding at least a master's degree in line with mathematics education or pure mathematics.

Keywords: calculus, learning experiences, regression analysis, teacher's competencies

Introduction
One of the difficult branches of mathematics is calculus. Calculus is a study of mathematical change which is often used by different sciences such as physics, engineering, chemistry, biology, and economics, among others. In the study of Casinillo and Tavera (2021), it is stated that learning calculus topic is a difficult experience, especially for college students. The reason for having difficulty in learning calculus is that students do not possess a good foundation of algebra and

pre-calculus knowledge as prerequisite courses. Another reason why students are not successful in learning calculus subjects is that they lack interest and motivation. Moreover, some negative factors are influencing students' study habits and cognitive behavior which failed. In that case, proper guidance and motivation must be integrated into the classroom environment. The study by Alam (2020) elucidated the cognitive aspect of calculus to take place among students. It suggested some teaching methodologies and pedagogical techniques which are efficient and effective in teaching calculus.

Calculus teaching is a difficult task, especially for heterogeneous students. On the face of it, the study by Alam (2020) stated that a repeated problem in introducing calculus topics (graphing, differentiating, and integrating) to newbies exists due to its difficult nature. Another difficult area in teaching calculus is problem-solving where the theoretical concepts are applied to the realistic application (Auxtero & Callaman, 2020). Likewise, Callaman and Itaas (2020) stated that students are having difficulty understanding math topics since they can't grasp the usefulness and significance of their daily learning experiences. Moreover, in college calculus classes, students and teachers are experiencing a shortage of time due to the volume of topics and entertaining questions in the classroom (Hagman et al., 2017). Additionally, teaching how to draw conclusions and solutions to a mathematical problem has been always a challenging moment for learners (Mangundayao, 2021). So, most of the students have an adverse learning impact in their calculus class due to their challenging experiences (Casinillo & Tavera, 2021). However, teachers' competencies are very crucial in helping the student's academic achievement and attitudes in learning calculus (Lin & Huang, 2017). Possibly, a competitive and high-profile calculus teacher is an effective educator that can lead to a positive learning experience. Hence, this study is realized to investigate the association of teachers' competencies to the student's learning experiences towards calculus.

Although there is research in the literature regarding teachers' competencies (Kuzu, 2020; Burrows et al., 2021; Durandt et al., 2022), its connection to students' learning experiences in calculus is not emphasized. Additionally, determining the association between students' learning experience and teacher's competencies as influencing factors is never been done. Hence, the main purpose of this study is to construct a correlation matrix to identify if teachers' competencies have a significant effect on the learning experience among agribusiness students in their calculus subject. This study may help calculus teachers to elucidate the behavior or attitude of students in learning calculus. Perhaps, the results of this study may help improve the teaching strategies in calculus that address its effectiveness and productive learning procedure. In addition, on the side of students, findings may provide some positive thoughts that will help them survive their calculus subjects in college. Furthermore, the results of this current study may serve as a point of reference for some researchers in mathematics education and contribute informative knowledge to the body of literature.

Objectives of the study

The main idea of this study is to elucidate the association between teachers' competencies and students' learning experiences in calculus with the aid of

Spearman correlation. Henceforth, the specific objectives of this study are the following:

1. to estimate the level of the different learning experiences of students in a calculus class;
2. to measure the perception of students towards the different competencies of their calculus teachers; and
3. to determine the influence of calculus teachers' competencies on students' experiences in learning calculus.

Conceptual framework of the study

To attain a successful society now and in the forthcoming, educators need to have competencies and a good foundation of knowledge in mathematics and science (Rech et al., 1993; Burrows et al., 2021). Using specific teaching strategies and technologies in mathematics can be a stimulating experience for students especially if the calculus teacher possesses good qualities in teaching complicated concepts (Burrows et al., 2021). Kuzu (2020) stated that mathematics competencies are very crucial and have a great effect on teaching efficiency and presenting the lessons. Some studies found that teaching strategies and competencies are associated with the student's motivation and learning experiences (Casinillo & Guarte, 2019; Casinillo & Casinillo, 2020). Additionally, Burgos and Godino (2022) found out that to foster effective learning in mathematics, cognitive analysis and assessing the students' mathematical problem-solving skills are competencies that teachers must have. Hence, teachers' competencies such as preparation, knowledge, mastery, organization, decent and approachability are considered as correlates of students' learning experiences. Figure 1 shows the conceptual model of this current study.

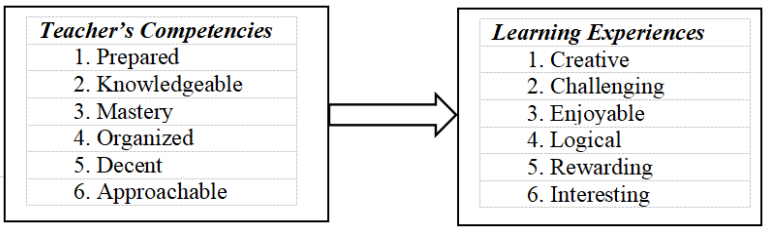

Figure 1. Conceptual model

Methods

A descriptive-correlational research design was chosen to answer the specific objectives of this current study. In that case, this study employed some descriptive statistics and inferential methods in analyzing the variables of interest. The subjects of this study are bonafide Bachelor of Science in Agribusiness (BSA) students of Visayas State University, Visca, Baybay City, Leyte, Philippines. The study used selected secondary data from the paper of Casinillo and Casinillo (2020) entitled "Econometric Evidence on Self-Determination Theory in Learning Calculus Among Agribusiness Students." This study deals with econometric models to predict some determinants that influence the students' interest in learning calculus. However, the study is only limited to students' motivation in learning and does not focus on teachers' perspectives, particularly, the teachers' competencies in teaching calculus. Thus, the study has chosen the following students' learning experience

that follows a Likert scale (1-10): (1) Creative, (2) Challenging, (3) Enjoyable, (4) Logical, (5) Rewarding, and (6) Interesting. The said learning experiences of students were considered dependent variables. As for the independent variables, the study has chosen the different competencies of their calculus teacher as follows: (1) Prepared, (2) Knowledgeable, (3) Mastery, (4) Organized, (5) Decent, and (6) Approachable. The teacher's competencies also follow a Likert scale, that is, a scale of 1 to 10. The students were asked to rate the said learning experiences and teachers' competencies as 1 is the lowest (very unsatisfied) and 10 is the highest (very satisfied). Table 1 summarizes the students' responses.

Table 1. Interval of perception scores and their corresponding interpretation

Perception Scores	Interpretation
1.00 – 2.80	Very Unsatisfied
2.81 – 4.60	Unsatisfied
4.61 – 6.40	Neutral
6.41 – 8.20	Satisfied
8.21 – 10.00	Very satisfied

The two sets of variables namely the student's learning experiences and the teacher's competencies have undergone reliability testing which assesses the reliability of an additive rating scale composed of the items specified (Likert, 1932) with the aid of Cronbach's alpha (Cronbach, 1951). Table 2 shows that the two sets of variables are reliable.

Table 2. Reliability test

Set of Variables	No. of Items	Average Inter item Covariance	Scale Reliability Coefficient
Learning Experiences	6	2.7731	0.8641
Teacher's Competencies	6	4.4797	0.9631

The collected variables in this study have undergone clearing and formatting in Microsoft excel to fit in the statistical software called STATA version 14.0. As for data analysis and extraction, the study employed descriptive statistics such as median, mean $(\bar{x})$, standard deviation (s), minimum and maximum value, and coefficient of variation $(C.V.)$ In determining the relationship of variables, a Spearman rho correlation coefficient was used since the data are ordinal and tested at a 1% level of significance. For the interpretation of correlation coefficients, the same argument with the rule of thumb used in the study of Casinillo and Guarte (2018) was employed. Table 3 shows the interval of the correlation coefficient and its degree of relationship.

Table 3. Interpretation of correlation coefficient

Range of correlation coefficient (r)	Degree of relationship
$0.0 < \|r\| < 0.3$	Weak
$0.3 < \|r\| < 0.7$	Moderate
$0.7 < \|r\| \leq 1.0$	Strong

Results and Discussion

Descriptive statistics

It is revealed in Table 4 that, on average, calculus class is being "creative" as students have rated it as "satisfied" ($\bar{x} = 6.39, s = 1.99$). This implies that calculus teacher has motivated their students to think of new ideas that relate to the topic. Being creative student results in being an active learner which develops their thinking skills and cognitive attitude in the classroom environment. This finding is parallel to the existing studies in the literature that deal with creative learning and behavior (Beghetto, 2017; Gordon, 2020). On average, calculus is very challenging ($\bar{x} = 8.33, s = 1.89$) to students as they rated as "very satisfied" with the challenge they experience (Table 4). Almost all agribusiness students are struggling to pass their calculus courses. In the study of Casinillo and Tavera (2021), it is stated that most of them are not STEM strand graduates during their senior high school. This means that most of them have less exposure which resulted in a weak foundation of calculus topics.

In addition to that, there are factors also that negatively influence their learning behavior in mathematics. The result is also supported by the median score of 9. It means that 50% of the students have rated a score of 10 (scale of 1 to 10) as to how challenging to learn calculus. In connection, students are not enjoying ($\bar{x} = 6.27, s = 2.86$) their calculus journey as they struggle to learn (Table 4). Similar arguments are found in the literature that calculus subject is challenging and not enjoyable to study (Mokhtar et al., 2013; Casinillo & Casinillo, 2020). Moreover, one of the reasons why they are baffled by calculus subject is its logical nature. It requires problem-solving skills and inquiring mind as well as the confidence to find the solution to a problem until it is solved (From et al., 2020). Most of these students are not in line with the logical and analytic procedure of the calculus subject. That is why most of them are not an enthusiast of learning calculus. Hence, it is not surprising for them that learning calculus is not rewarding ($\bar{x} = 6.31, s = 2.31$) as shown in Table 4. Furthermore, Table 4 shows that, on average, learning calculus can be interesting ($\bar{x} = 7.03, s = 2.66$) for agribusiness students. As a college students, it is necessary to put interest in their studies especially if the subject is part of their curriculum program. Casinillo and Tavera (2021) suggested that motivating students may progress their learning process and academic performance in calculus. In other words, interest is one of the keys to surviving calculus class.

Students have rated their teacher as "satisfied" with how prepared ($\bar{x} = 8.03, s = 2.22$) their calculus teacher during their class discussion (Table 4). A teacher needs to be prepared and ready in class to properly impart their knowledge. Preparation for interactive teaching targeted a student's participation attitude and active discussion so that instruction and information take place at the same time (Cronhjort et al., 2018). Moreover, students are "very satisfied" with how "knowledgeable" ($\bar{x} = 8.33, s = 2.19$) their teacher on calculus topics (Table 4). On average, 50% of the students have given a perception score of 10 (scale of 1 to 10) on the knowledge they have shown during the lecture. In that case, calculus teachers are considered outstanding regarding their understanding and information of what calculus is all about. The coefficient of variation also indicates a 26.29% of inconsistency in students' responses which is the lowest among other competencies. This implies that students are more likely convince that their calculus teacher is

knowledgeable about the subject. The students were also "satisfied" with the "mastery" ($\bar{x} = 8.15, s = 2.37$) of their teacher because of their lecture-discussion (Table 4). It is worth noting that a teacher's knowledge and mastery of calculus have a high impact on students' conceptual understanding. Likewise, teacher's organization ($\bar{x} = 8.02, s = 2.38$) in lecture-discussion is rated as "satisfied" as shown in Table 3. This suggests that teachers are following a structure or procedure in doing their lectures to make the topic understandable to students. Caughlan et al. (2013) stated that organized lectures and practices can positively influence student achievement and engagement.

Additionally, students are "satisfied" with the decency ($\bar{x} = 7.72, s = 2.39$)of their teacher (Table 4). A decent teacher provides delight appearance or manner in front of their students. A pleasing and charming teacher also can catch up the attention of students as well as a neat appearance during class discussion. The personal attributes of a teacher are appreciated and considered a factor in a productive learning environment (Casinillo & Guarte, 2018). Lastly, their teacher is rated as "satisfied" with how approachable they are to their students (Table 4). This implies that teachers are open to students' inquiries and imaginative ideas. Furthermore, calculus teacher has shown compassion and cooperation to their students as well as appreciating students' point of view on the topics. In the study of Jasmi and Hin (2014), it is stated that an approachable teacher can build trust and care for students which is part of academic motivation.

Table 4. Descriptive statistics of students' learning and teacher's competencies

Variables	$\bar{x} \pm s$	median	min	max	*C.V.* (%)	Interpretation[b]
Learning Experiences						
Creative[a]	6.39±1.99	7	2	10	31.14	Satisfied
Challenging[a]	8.33±1.89	9	3	10	22.69	Very satisfied
Enjoyable[a]	6.27±2.68	7	1	10	42.74	Neutral
Logical[a]	7.22±2.28	8	1	10	31.58	Satisfied
Rewarding[a]	6.31±2.31	6	1	10	36.61	Neutral
Interesting[a]	7.03±2.66	8	1	10	37.84	Satisfied
Teacher's Competencies						
Prepared[a]	8.03±2.22	9	1	10	27.65	Satisfied
Knowledgeable[a]	8.33±2.19	9	1	10	26.29	Very satisfied
Mastery[a]	8.15±2.37	9	1	10	29.08	Satisfied
Organized[a]	8.02±2.38	9	2	10	29.68	Satisfied
Decent[a]	7.72±2.39	8	1	10	30.96	Satisfied
Approachable[a]	8.14±2.52	9	1	10	30.96	Satisfied

Note: a - Scale of 1 to 10, b - See Table 1 for details.

Correlation Analysis

Surprisingly, all teacher's competencies are highly significant (p-value<0.01) correlated to students' learning experiences in calculus (Table 4). Although the correlation is weak to moderate (See Table 3 for details), still it shows a strong likelihood that teachers' competencies are determinants to the student's learning development in calculus. However, these results are reasonable given that teachers have a big part in students' learning development. The weak to moderate correlation can be attributed to the large coefficient of variation (at least 25%) of students'

perception scores. Firstly, the preparedness of a calculus teacher is highly significant to the learning experiences at a 1% level. Preparedness is the ability to respond effectively in every situation in the classroom setting. If the teacher is prepared, then goals and plans for the learning procedure will be realized (Cronhjort et al., 2018). The teacher can properly monitor their students and more like entertain questions related to the subject matter. Thus, it develops students' creativity and logical understanding in class. The teacher can also make the class challenging yet rewarding for students by giving them mathematical problems in real situations. Additionally, the preparation of teachers will outcome in lively and interactive students which results in an enjoyable and interesting class. Teaching mathematics has a lot of issues in classroom management, hence, the teacher must be prepared to resolve the possible problems and other concerns of students (Fiore, 1999).

Table 4 shows that knowledge and mastery of calculus teachers is a highly significant factor in learning experiences at a 1% level. The teacher is one of the sources of knowledge in the subject, hence, they must be knowledgeable and with good mastery of the subject. In that case, a knowledgeable teacher can easily express ideas and extract information whenever it is necessary. This shows that it can influence the creativity of students and their logical thinking skills. The knowledge and mastery of a teacher can also create a positive learning atmosphere that makes the classroom enjoyable and interesting at the same time. However, a knowledgeable teacher is idealistic that provides challenging mathematical problems yet rewarding in nature. Sitzmann and colleagues (2010) stated that self-assessment of content knowledge influences students' cognitive learning as well as motivation and satisfaction. In the study of Schipper et al. (2020), it is stated that knowledge and mastery will take teachers to an inquiry stance and make collaborative ideas to develop a classroom environment and improve students' academic achievement. A knowledgeable teacher can easily make a creative environment for students to discuss new and interesting ideas (Casinillo & Casinillo, 2020).

In addition, organized teaching can positively influence the student's learning experiences in calculus at a 1% level of significance (Table 4). Wang and colleagues (2015) found that organized and clear classroom management and instructions can affect the development of cognitive behavior and higher-order thinking skills of students. Likewise, Ausubel (1963) and Titsworth (2001) pointed out that organized lectures and structural learning can foster and progress motivation learning experiences. Teachers that use a routine procedure in their teaching strategy can elevate students' familiarization and study habits in the learning process (Chappell & Killpatrick, 2003; Wang et al., 2015; Casinillo & Casinillo, 2021).

Moreover, a decent and approachable teacher can significantly influence students' learning experiences in calculus class at a 1% level (Table 4). In the study of Casinillo and Guarte (2018), it is mentioned that a good personality and positive attitude are very important in classroom management which represents professionalism. A well-groomed and well-respected teacher can easily influence students' learning attitudes in the classroom. Additionally, being an approachable teacher results in interactive learning behavior wherein students can ask questions and participate in the lecture-discussion. Moreover, a positive attitude from a teacher will create a productive learning atmosphere. In that case, students can

experience a stimulating class environment due to the good qualities of a teacher (Burrows et al., 2021). In other words, a decent and approachable teacher can develop students' problem-solving skills and cultivate an interest in learning calculus even if it is challenging.

Table 4. Spearman correlation analysis of students' calculus learning experiences and teacher's competencies

Teacher's Competencies	***Learning Experiences***					
	Creative[a]	Challenging[a]	Enjoyable[a]	Logical[a]	Rewarding[a]	Interesting[a]
Prepared[a]	0.2443*	0.3378*	0.3959*	0.3025*	0.4276*	0.3578*
	(0.0069)	(0.0002)	(0.0000)	(0.0007)	(0.0000)	(0.0001)
Knowledgeable[a]	0.2542*	0.3265*	0.3159*	0.2995*	0.3574*	0.3938*
	(0.0049)	(0.0003)	(0.0004)	(0.0008)	(0.0001)	(0.0000)
Mastery[a]	0.3108*	0.3074*	0.3506*	0.3534*	0.3831*	0.4179*
	(0.0005)	(0.0006)	(0.0001)	(0.0001)	(0.0000)	(0.0000)
Organized[a]	0.2705*	0.2804*	0.4570*	0.3780*	0.4407*	0.4447*
	(0.0027)	(0.0018)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Decent[a]	0.3099*	0.3000*	0.3763*	0.3647*	0.4520*	0.3667*
	(0.0005)	(0.0008)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Approachable[a]	0.2633*	0.2673*	0.3699*	0.3541*	0.3874*	0.3559*
	(0.0035)	(0.0030)	(0.0000)	(0.0001)	(0.0000)	(0.0001)

Note: a - Scale of 1 to 10, * - highly significant at 1% level, p-values are in parenthesis.

Conclusion and Recommendations

This current study aims to elucidate the effect of teachers' competencies concerning the students' different learning experiences in calculus classes. Results revealed that the competencies of calculus teachers such as "prepared", "knowledgeable", "mastery", "organized", "decent", and "approachable" are significantly and positively correlated to the students' experiences such as "creative", "challenging", "enjoyable", "logical," "rewarding", and "interesting." This implies that calculus teachers must be well-educated during the class discussion through rigorous preparation and studying of the subject. Conclusively, teachers must develop a mastery of calculus topics and apply an organized procedure during their lectures. Additionally, a well-groomed, neat, attractive, and professional-looking may be integrated in front of their students so that respectfulness takes place and achieve a healthy learning environment. Likewise, open-mindedness and a good personality as a teacher result in an interactive and stimulating discussion. To cultivate students' interest in class, teachers must give some incentives or additional points for meritorious performance. In that case, students can have a sense of rewarding tasks to work with and set a goal in their minds. Encourage students to develop good study habits and motivate them to do learning activities that develop critical thinking skills. Moreover, teachers are encouraged to use examples (real-life problems) that are related to their degree program so that students can appreciate the subject. To obtain all these things, it is recommended that calculus teachers may undergo rigorous training and seminars concerning calculus teaching to become knowledgeable, flexible, creative, passionate, and competitive educators. In addition, it is also recommended that teachers who will teach college calculus and other higher mathematics subject must

hold at least a master's degree in line with mathematics education or pure mathematics.

Limitations and future works

The possible limitation of this current study is the number of students (small sample size) and the available data (not suitable for online learning). Hence, this study recommends that another survey should be realized during the scenario of distance learning. Moreover, it is suggested that regression models may be constructed to determine the approximate increase (or decrease) of the dependent variable concerning the independent variable. Additionally, teachers' perception regarding online learning in teaching calculus is also part of the picture and needed to be included in the analysis to further support the existing results. Furthermore, socio-demographic variables and online learning experiences might be incorporated into the regression models to get a piece of richer information.

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