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Pre-Service Biology Teachers' Mathematics Anxiety

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Abstrak

Kemampuan kuantitatif dibutuhkan calon guru biologi dalam memahami fenomena biologis. Hal pertama yang perlu dilakukan dalam menyelesaikan masalah ini adalah perlunya eksplorasi kondisi kecemasan matematika calon guru biologi. Penelitian ini bertujuan mengeksplorasi tingkat kecemasan matematika calon guru biologi dan perbedaannya berdasarkan gender dan angkatan masuk kuliah. Data dikumpulkan dengan menggunakan kuisioner AMAS (Abbreviated Math Anxiety Scale). Data dianalisis dengan menggunakan statistic deskriptif, uji anova satu arah, dan uji Kruskal-Wallis. Hasil penelitian menunjukkan calon guru biologi memiliki tingkat kecemasan matematika dan kecemasan belajar matematika berdasarkan angkatan dan gender berada pada kategori sedang. Sementara kecemasan evaluasi matematika berada pada kategori tinggi berdasarkan angkatan dan gender. Hasil penelitian juga menunjukkan tidak terdapat perbedaan kecemasan matematika, kecemasan belajar matematika, kecemasan atas evaluasi matematika berdasarkan gender dan angkatan. Hasil penelitian ini layak menjadi perhatian dalam pendidikan biologi bahwa perlu dikonstruksi suatu desain didaktis ataupun perubahan kurikulum yang mendorong integrasi dan interdisiplinari matematika dan biologi sehingga kecemasan matematika dapat berkurang.

Kata Kunci: Abbreviated Math Anxiety Scale*; Interdisiplinari; Kecemasan Matematika; Pendidikan Biologi.*

Abstract

Quantitative ability is needed by prospective biology teachers in understanding biological phenomena. The first thing that needs to be done in solving this problem is the need to explore the condition of pre-service biology teachers' mathematics anxiety. This study aims to explore the mathematics anxiety level of pre-service biology teachers and their differences by gender and cohort. Data were collected using the AMAS (Abbreviated Math Anxiety Scale) questionnaire. Data were analyzed using descriptive statistics, one-way ANOVA test, and Kruskal-Wallis test. The results showed that pre-service biology teachers had mathematics anxiety levels and mathematics learning anxiety based on cohort and gender were in the medium category. Meanwhile, mathematics evaluation anxiety is in the high category based on cohort and gender. The results also showed that there was no difference between mathematics anxiety, mathematics learning anxiety, anxiety over mathematics evaluation based on gender and cohort. The results of this study deserve attention in biology education that it is necessary to construct a didactic design or curriculum change that encourages integration and interdisciplinary mathematics and biology so that mathematics anxiety can be reduced.

Keywords: Abbreviated Math Anxiety Scale; Biology Education; Interdisciplinary; Mathematics Anxiety.

I. INTRODUCTION

Researchers on biology show that mathematics (quantitative method) is continually used in certain cases. In addition to, there will barely biology domains that are able to be taught without mathematics input and integration (Hoskinson, 2010). In ecology, specifically, mathematics contributes in modeling the function and complex ecosystem stability. Biological systems are emergent systems, displaying complexity at multiple levels of organization. The integration of Mathematics and Biology is not only useful but also important for understanding biological systems (Cohen, 2004). Several studies have been conducted to understand biological phenomena. Mathematical concepts are also used to investigate these issues. Similar as in education, biology graduates obtain one or more Mathematics courses, especially calculus. This fact shows that there is an unavoidable collaboration between Mathematics and Biology. Therefore, to have a good comprehension of biology, excellent mathematical skills are required to master for prospective biology teachers.

However, there is existing general views that mathematics is not fascinating and even frightening course for biology students. These negative attitude results in a low desire for Biology students to be involved in learning activities, to deepen their mathematical (quantitative) abilities. The students have little determination when dealing with difficulties in learning Mathematics, and only desire to study Biology. (Matthews et al., 2010; Poladian, 2013; Wachsmuth et al., 2017). Accordingly, study on the attitudes of undergraduate biology students towards Mathematics is such an important topic. The result of this study is expected to provide information about the attitude of undergraduate biology students towards Mathematics in developing learning, designing curricula and even recruiting prospective undergraduate biology students (Wachsmuth et al., 2017).

Studies on the attitude of undergraduate biology students on mathematics have been largely conducted (Matthews et al., 2013; McGinnis et al., 2002; Poladian, 2013; Wachsmuth et al., 2017). One of the topics in attitudes towards Mathematics is Mathematics anxiety, a feeling of tension and anxiety that interferes the ability to manipulate numbers and solve math problems in both ordinary and academic life (Richardson & Suinn, 1972; Afriansyah & Turmudi, 2022).

Mathematics anxiety can be seen as a response to thoughts, feelings and uneasiness and tense actions in learning Mathematics. In line with this definition,

mathematical anxiety includes increased physiological reactions, negative cognition and substandard performance when a mathematical stimulus is presented (Hopko et al., 2003). Several studies include math stimulus in forms of number test and math topics (Hopko et al., 2003; Núñez-Peña et al., 2013; Richardson & Suinn, 1972). Mathematics anxiety needs to be viewed and analyzed since it is able to predict learning outcome and math achievement (Cargnelutti et al., 2017; Vukovic et al., 2013). There are, however, a few studies on mathematics anxiety, particularly in prospective biology teachers (McGinnis et al., 2002). In addition, these studies are still focused on students majoring in Biology, not in general on prospective Biology teacher students (Biology education). In the Indonesian context, mathematical anxiety has been widely studied (e.g, Prahmana et al., 2019; Rawa & Mastika Yasa, 2019; Rizta & Antari, 2018; Suratmi et al., 2017; Vitasari et al., 2010). Yet, there is no study that focuses on investigating mathematics anxiety among prospective biology teachers.

This study aims to explore the level of Mathematics anxiety for prospective biology teachers. This study is deemed to be essential due to mathematics and biology are inseparable. Besides, mathematical anxiety is a predictor of learning outcomes and achievement in Mathematics. Therefore, this study will investigate Mathematics anxiety for prospective biology teachers at a private university in Tangerang.

II. METHOD

This study used quantitative method with survey research. This method was selected because it is suitable for explaining the current and past condition (Cohen et al., 2018).

The respondents in this study were 122 prospective Biology teachers (23 males, 99 females) in Universitas Pelita Harapan, Tangerang. The respondents were taken from classes of 2020, 2019, 2018, and 2017. The profile of respondents is displayed in the Table 1.

Table 1.
Respondent Profile

Sex	2017		2018		2019		2020		Total	
	f	%	f	%	f	%	f	%	f	%
Male	11	24.5	4	7.7	5	21.7	3	10.7	23	8.9
Female	34	75.5	22	92.3	18	78.3	25	89.3	99	81.1
Total	45	100	26	100	23	100	28	100	122	100

The class of 2019 is currently taking calculus subjects, while classes of 2018 and 2017 have already taken calculus, statistics for educational research and essential mathematics subjects. This means that these students have taken courses related to Mathematics. Meanwhile, the class of 2020 has yet to

study subjects specifically related to Mathematics. Yet, they have experience of studying Mathematics at high schools.

The data collected in this study were quantitative data concerning on Mathematics anxiety level of prospective biology teachers. The anxiety was measured by AMAS (Abbreviated Math Anxiety Scale) (Hopko et al., 2003). This measurement scale was used due to its simplicity and proven to be valid and reliable psychometrically.

AMAS consists of nine items clustered into two dimensions of Mathematics anxiety; anxiety in learning Mathematics (5 items) and anxiety in the evaluation/assessment of Mathematics (4 items). The AMAS uses a five-point Likert scale ranging from 1 (low anxiety) to 5 (high anxiety). AMAS questionnaire could be seen as in Hopko et al. (2003), and this study was then translated into Bahasa Indonesia.

After validity and reliability test was conducted, AMAS was proven to valid, the Pearson correlation obtained ranged from 0,574 to 0,77 and the significance value of $\alpha = 0{,}05$. The Cronbach's Alpha value obtained was 0,877 (higher than 0,5) meaning that the questionnaire has high internal consistency (reliability).

For the two dimensions, anxiety over learning Mathematics and anxiety over evaluation of Mathematics, the Cronbach's Alpha obtained was 0.92 and 0.856 respectively, meaning that those dimensions acquire high level of internal consistency. Thus, the questionnaire can be used in this study. The AMAS questionnaire was distributed using Microsoft Forms. The average time to complete this questionnaire is 5 minutes 46 seconds. Participants have been informed that the respondent's data would be anonymized and used only for scientific purposes

The data was analyzed using descriptive statistics and inferential. To answer the first research question, descriptive statistic was used by calculating mean value and standard deviation. The analysis was conducted by grouping the Mathematics anxiety into four groups; low, moderate, high, extremely high group (Maloney et al., 2010). This category was created using the quartile score of Mathematics anxiety for prospective Biology teachers. Those who have scores lower than the lower quartile were grouped into low anxiety. Scores between lower and middle quartiles correlated to moderate anxiety. After that, score with middle and upper quartiles corresponded with high anxiety. Finally, scores above the upper quartile were in extremely high anxiety.

To answer the first research question, mean and standard deviation was calculated for the total of Mathematics anxiety (the two dimensions). This analysis was also carried out based on

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academic year and gender. The one-way ANOVA test was used to answer the second research question. A one-way ANOVA test was conducted to see differences in Mathematics anxiety for prospective Biology teacher candidates based on academic year and gender. Analysis was performed using SPSS 20.0 application.

III. RESULT AND DISCUSSION

The result of this study was explained within two parts. The first part describes the level of Mathematics anxiety. Then, the second part explains the differences of anxiety level based on gender and academic year.

A. Description of Mathematics Anxiety Level

The result of descriptive data regarding with Mathematics Anxiety can be seen as in Table 2.

Table 2.
Respondent Level

	Mathematics Anxiety				Anxiety of Learning Mathematics				Anxiety of Mathematics Evaluation			
	Min	Max	Mean	Std. Dev	Min	Max	Mean	Std. Dev	Min	Max	Mean	Std. Dev
Total	12.0	45.0	30.15	5.86	6.00	25.0	14.58	3.70	6.00	20.0	15.57	2.88
A. 2017	18.0	45.0	29.69	6.42	7.00	25.0	14.36	3.99	8.00	20.0	15.33	3.17
A. 2018	12.0	42.0	30.39	6.78	6.00	23.0	14.50	4.29	6.00	20.0	15.89	2.94
A. 2019	15.0	38.0	29.22	5.53	6.00	19.0	13.70	3.31	9.00	19.0	15.52	2.61
A. 2020	22.0	38.0	31.43	4.08	11.0	20.0	15.75	2.69	9.00	20.0	15.68	2.65
Man	12.0	42.0	30.30	7.36	6.00	22.0	14.91	4.27	6.00	20.0	15.39	3.65
Woman	15.0	45.0	30.11	5.50	6.00	25.0	14.51	3.57	8.00	20.0	15.61	2.69

From the data seen in Table 2, the total average score of Mathematics anxiety grouped by academic year and gender is in the range of 29.22 to 31.43 (the score scale of Mathematics anxiety ranges from 9 to 45). In terms of anxiety dimensions, the average total anxiety score for learning Mathematics, based on academic year and gender, is between 13.70 to 15.75 (the score for anxiety learning Mathematics ranges from 5 to 25). While the total average score of Mathematics evaluation anxiety, according to academic year and gender, is between 15.33 to 15.89 (the score for learning anxiety in Mathematics ranges from 5 to 20). The data on average anxiety scores based on these two dimensions show that the average anxiety of Mathematics evaluation is greater than that of learning Mathematics. This result means that the level of anxiety in Mathematics evaluation is higher than that of learning Mathematics anxiety seen from academic year and gender.

The results of the mathematics anxiety for prospective Biology teacher are displayed in Table 3. As seen from Table 2 and Table 3, the researcher had

obtained the overall result of Mathematics anxiety for prospective Biology teachers viewed from dimensions of anxiety, academic year, and gender. In total, the mathematics anxiety of prospective Biology teachers was at moderate level. In terms of academic year, the class of 2020 had high level of anxiety. While the other academic years, they were in moderate level of math anxiety. In terms of gender, the respondents were in moderate level of anxiety. Meanwhile, seen from the dimension of anxiety, only the class of 2020 had a high level of anxiety when learning Mathematics. The rest of academic years were at moderate level. Contrastively, in terms of anxiety of Mathematics evaluation, both seen from the academic year and gender, they were at high level of anxiety. Compared between the two dimensions, the anxiety level of Mathematics evaluation is higher than that of learning Mathematics, based on academic year and gender.

Table 3.
Respondent Level

Category	Mathematics Anxiety		Anxiety of Learning Mathematics		Anxiety of Mathematics Evaluation	
	F	%	f	%	F	%
Low	11	24.5	4	7.7	5	21.7
Moderate	34	75.5	22	92.3	18	78.3
High	45	100	26	100	23	100

B. Differences of Mathematics Anxiety Level

Prior to find the differences in anxiety levels, the assumption test was firstly conducted for parametric statistics. The normality assumption test and variance homogeneity were tested at the univariate level. The assumption of normality was tested using the Shapiro-Wilk test for all data groups (Mathematics total anxiety score, Mathematics learning anxiety score, Mathematics evaluation anxiety score). The statistic value of Shapiro-Wilk test for total score of Mathematics Anxiety was 0,987 ($p = 0.285 > 0.05$), 0.985 ($p = 0.216 > 0.05$) for anxiety of learning Mathematics score, 0,936 ($p = 0.00 < 0.05$) for Mathematics evaluation score. These values show that the data of Mathematics anxiety and anxiety of learning Mathematics were normally distributed. On the other hand, the data of anxiety of Mathematics evaluation score was not normally distributed.

After the normality test was carried out, the variance homogeneity test was carried out with the Levene test. This homogeneity test was taken from the data on Mathematics anxiety and Mathematics learning anxiety. The result of Levene test for Mathematics Anxiety based on the data from academic year, the Levene

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statistic value obtained was 1.934, with p = 0.128 > 0.05. While from the gender, the Levene statistic value was 2.797, with p =0.097 > 0.05, meaning that the data group were from homogeneous distribution.

Furthermore, the Levene test for Anxiety of Learning Mathematics also shows that the data derived from a homogeneous distribution based on class (Levene statistic = 1.471, p = 0.226>0.05) and gender (Levene statistic = 1.36, p = 0.246 > 0.05). Thus, data on Mathematics anxiety level and Mathematics learning anxiety were tested using one-way ANOVA parametric statistics, while data on Mathematics evaluation anxiety level was tested using the Kruskal-Wallis's test.

To see differences in Mathematics anxiety based on class and gender, a one-way ANOVA test was carried out. The results of the analysis showed that there was no difference in the level of Mathematics anxiety based on class $(F_{(3,118)} = 0{,}74; p = 0.53 > 0{,}05)$. The one-way ANOVA test also showed no difference in the level of Mathematics anxiety based on gender $(F_{(1,120)} = 0{,}02; p = 0.887 > 0{,}05)$.

Tests for differences in learning anxiety based on academic year and gender were also carried out using one-way ANOVA. The results of the analysis showed that there was no difference in the level of anxiety in learning Mathematics by academic year $(F_{(3,118)} = 1{,}447; p = 0.233 > 0{,}05)$. The one-way ANOVA test also showed no difference in the level of anxiety in learning Mathematics based on gender $(F_{(1,120)} = 0{,}226; p = 0.636 > 0{,}05)$.

To find out differences in the anxiety of Mathematics evaluation based on academic year and gender, the Kruskal-Wallis's test was carried out (because the assumption of normality was not suitable for parametric statistics). The results of the analysis showed that there was no difference in the level of anxiety in Mathematics evaluation based on the academic year $(\chi^2_{(3;0,05)} = 0{,}439; p = 0.932 > 0{,}05)$. The Kruskal-Wallis tests also showed that there was no difference in the level of anxiety in Mathematics evaluation based on gender $(\chi^2_{(1;0,05)} = 0{,}005; p = 0.942 > 0{,}05)$.

C. Discussion

This study has resulted three findings. Firstly, except for the class of 2020, the prospective Biology teachers, seen from academic year and gender, have moderate level of mathematics anxiety and anxiety of learning mathematics. On the other hand, anxiety of mathematics evaluation is in high level based on academic year and gender. This shows that the prospective Biology teachers have high anxiety when completing mathematics assessment or evaluation. This finding is in line with several literatures and previous researchers that reveal that prospective Biology teachers have mathematics anxiety (e.g, Matthews et al., 2013;

McGinnis et al., 2002; Poladian, 2013; Wachsmuth et al., 2017). Even though, the undergraduate Biology students realize the importance of mathematics in studying Biology, the anxiety of learning math still exists. This happens due to teachers see Mathematics as a difficult subject and require greater efforts (perceived cost) (Andrews et al., 2017; Eaton & Highlander, 2017; Tamba, 2021; Thompson et al., 2013; Wachsmuth et al., 2017).

The second finding is that there is no difference in the level of mathematics anxiety, mathematics learning anxiety and mathematics evaluation anxiety based on class. This finding is in accordance with the findings of previous researches which reveal that there is no difference in Mathematics anxiety based on grade level. (Rahayu et al., 2019). However, other prior researchers result differently that there is difference in Mathematics anxiety based on grade level (Birgin et al., 2010). Nevertheless, these studies take a different context, do not focus on prospective Biology teachers. Therefore, it appears that context influences anxiety levels.

The third finding shows that there is no difference in the level of math anxiety, math learning anxiety and math evaluation anxiety based on gender. This finding is in accordance with the findings of previous research which reveal that there is no difference in Mathematics anxiety between males and females (Birgin et al., 2010; Rahayu et al., 2019). However, other previous studies have revealed different things. These studies showed differences in Mathematics anxiety level based on gender (Devine et al., 2012; Taylor & Fraser, 2013). In the result of Rubinsten et al. (2012) by using the implicit instrument (not using a questionnaire) showed that Mathematics anxiety in women was higher than in men. The inconsistency between these findings suggests that Mathematics anxiety needs to be better defined and measured (Birgin et al., 2010) providing the facts that many studies have used math anxiety measurement instruments that have not been tested psychometrically (Hopko et al., 2003).

This research contributes to the knowledge and research on Mathematics anxiety in two ways. Although the findings are consistent with previous research regarding with Mathematics anxiety in undergraduate Biology students, (Matthews et al., 2010; McGinnis et al., 2002; Poladian, 2013; Suratmi et al., 2017; Wachsmuth et al., 2017), this study reveals the more specific facts to the context of prospective Biology teachers that they do have Mathematics anxiety. Even though the demands for quantitative abilities in prospective Biology teachers

are lower in subjects and careers, Biology teacher candidates still experience Mathematics anxiety. This can occur due to several factors; prospective teachers do not see the relationship between biology and mathematics, the curriculum is not integrated, and sees mathematics as difficult and requires greater effort (perceived cost). (Andrews et al., 2017; Eaton & Highlander, 2017; Tamba, 2021; Thompson et al., 2013; Wachsmuth et al., 2017). Secondly, the anxiety of prospective Biology teachers is higher in the mathematics evaluation compared to the anxiety in learning Mathematics. This illustrates that Mathematics evaluation is often not in accordance with the expectations of prospective Biology teachers. Thus, the implication is the importance of focusing more attention to the evaluation of mathematics in calculus courses for Biology (subjects studied by prospective mathematics teachers). Lecturers need to construct a form of assessment that can reduce anxiety over the evaluation of mathematics. In addition, the results of this study provide an implication that the distribution of study groups and learning assistance does not need to make gender a major consideration. This is because the results of this study indicate that there is no difference in math anxiety based on gender.

Nevertheless, this research has limitations. The above findings must be viewed within the following limitations. First, the instrument (questionnaire) used is AMAS and created without making modifications, only translated to Bahasa Indonesia. Therefore, there may be a special context that cannot be disclosed in this study. This is in line with various previous studies which modified or revised the Mathematics anxiety instrument according to the country context (e.g, Milovanović & Branovački, 2020; Núñez-Peña et al., 2013) shows that Mathematics anxiety is in accordance with the context faced by the participants. Second, the sample size is disproportionate because the number of female participants is far greater than that of male participants. This is one of the limitations in this research.

IV. CONCLUSION

This study reveals three findings regarding the mathematics anxiety of prospective Biology teachers. First, they have moderate level of Mathematics anxiety and anxiety of learning Mathematics based on academic year and gender. On the other hand, the anxiety of Mathematics evaluation is in the high category based on academic year and gender. Second, there is no difference in math anxiety, math learning anxiety, and math evaluation anxiety based on gender. Third, there is no difference in math anxiety, math learning anxiety, and math evaluation anxiety based on grade level.

The results of this study provide implications for further research. The further research on the causes of

Mathematics anxiety is necessary to do. Investigating the causes of higher-level Mathematics evaluation anxiety than Mathematics learning anxiety is also interesting to do. The research findings have implications for Biology learning practices. Based on research findings, it is important to develop an interdisciplinary relationship between Mathematics and Biology so that prospective Biology teachers see the importance of Mathematics and their mathematical abilities in solving biological phenomena develop. In such a way, Math anxiety will reduce.

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