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# Epistemological Beliefs and Academic Performance in Physics of Grade 12 Filipino STEM Learners

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**Abstract: Epistemological Beliefs and Academic Performance in Physics of Grade 12 Filipino STEM Learners.** **Objectives**: This descriptive-correlational study investigated the existing relationship of epistemological beliefs to the academic performance in Physics of Filipino STEM learners. **Methods**: This study involved a convenient sample of 407 Grade 12 Filipino STEM learners enrollexd in A. Y. 2021-2022. This study used EBAPS to solicit the epistemological views of the students in Physics. **Findings**: Pearson product-moment coefficient revealed that the four non-orthogonal dimensions of epistemological beliefs about Physics, i.e structure of scientific knowledge, nature of knowing and learning, evolving knowledge, source of ability to learn, established significant association to students' academic performance except real-life applicability. Multiple regression analysis revealed that among five dimensions of epistemological beliefs, structure of scientific knowledge and nature of knowing and learning are found to be significant determinants of the students' academic performance in Physics. **Conclusions**: Physics teachers are emphasized to craft an instructional intervention to enhance the students' epistemological beliefs in physics, which in turns affect students academic performance.

**Keywords:** academic performance, epistemological beliefs, STEM learners, physics teacher.

***Abstrak: Keyakinan Epistemologis dan Performa Akademik dalam Fisika bagi Pelajar STEM Kelas 12 di Filipina.*** ***Tujuan:*** *Studi deskriptif-korelasi ini menyelidiki hubungan antara keyakinan epistemologis dengan prestasi akademik dalam Fisika bagi pelajar STEM Filipina.* ***Metode:*** *Penelitian ini melibatkan 407 pelajar STEM Kelas 12 di Filipina tahun ajaran 2021-2022. Penelitian ini menggunakan instrumen EBAPS untuk mengumpulkan pandangan epistemologis siswa dalam Fisika.* ***Temuan:*** *Koefisien product-moment Pearson mengungkapkan bahwa empat dimensi non-orthogonal dari keyakinan epistemologis tentang Fisika yaitu struktur pengetahuan ilmiah, sifat pengetahuan dan pembelajaran, pengetahuan yang berkembang, sumber kemampuan untuk belajar, memiliki hubungan yang signifikan dengan prestasi akademik siswa kecuali pada dimensi real-life applicability. Analisis regresi berganda mengungkapkan bahwa di antara lima dimensi keyakinan epistemologis tersebut, struktur pengetahuan ilmiah dan sifat pengetahuan dan pembelajaran ditemukan sebagai faktor yang berkorelasi paling signifikan terhadap prestasi akademik siswa dalam pelajaran Fisika.* ***Kesimpulan:*** *Guru fisika ditekankan untuk membuat intervensi instruksional guna meningkatkan keyakinan epistemologis pada pelajaran fisika, yang akan mempengaruhi pretasi akademik siswa.*

***Kata kunci:*** *prestasi akademik, keyakinan epistimologis, pelajar STEM, guru fisika.*

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## INTRODUCTION

The academic performance of the students is an essential part of education. It has been considered as the focus to which the whole education revolves. Also termed as academic achievement, it refers to extent of attainment of educational learning goals. It is measured in final grade obtained after accomplishing a course reported in numerical or letter format. On the other hand, there is a wide agreement in the literature that academic performance is the combined results of both cognitive and non-cognitive attributes of the students, as well as the sociocultural context of the learning environment. Students' academic performance is a vital indicator to be considered when defining and planning educational reforms both at nationwide level (e.g., curriculum definition) and at classroom level (e.g., teaching strategy) (Vilia et al., 2017). The performance of the students also determines the quality of graduates who will become productive workers towards national economic and social development (Ali et. al, 2009). Mushtaq & Khan (2012) contended that student's academic performance could be affected by various causes such as social, psychological, and personal factors including economic, environmental.

In the Philippines, enhancing the students' academic performance has become an elusive educational goal. In the recent report of Trends in International Mathematics and Science Study (TIMSS), it revealed that the country placed significantly lower than any other country that participated in math and science assessment. The Philippines scored 249 in science which is considered as disadvantaged rank among the 58 participating nations. Based from the Program for International Student Assessment (PISA) of the Organization for Economic Cooperation and Development (OECD), a similar scenario is observed. In its report, Philippines ranked second-lowest in mathematics and science among the 79 participating countries. The results detailed that Filipino students scored 353 in mathematics, compared to the OECD average of 489, and science resulted to 357, compared to the OECD average of 483. The National Achievement Test also revealed that Filipino students lagged behind proficiency level placing in low performance especially in Mathematics, Science, and English. This undesirable findings has alarmed the Department of Education to significantly take steps in determining and explaining its sources such as the significant factors that influence such occurrence. In the literature, epistemological beliefs emerged as one of the popular themes to explain the academic achievement of the students (Arslantas et. al., 2016; Lodewyk, 2007; Mistades, 2007; Orleans & Palomar, 2018).

Epistemic beliefs are individuals' views about knowledge and knowing (Berding et al., 2017; Hofer & Pintrich, 1997). Many educational researchers view epistemologies as collection of beliefs that involve multidimensional perspective, including those about the nature of knowledge, the certainty, the source, the justification, the acquisition, and the structure of knowledge. The most popular concept of the epistemological beliefs in science, however, suggests that the educational construct can be captured using five dimensions: (1) structure of scientific knowledge - explains whether physics and chemistry knowledge can be seen of as a collection of loosely connected components or as a coherent, conceptual, highly-structured, and unified whole; (2) Nature of knowing and learning – determines whether learning science is mostly consists of absorbing information or relying critically on developing one's own understanding; (3) Real-life applicability – solicits the students' views of the applicability of scientific knowledge as discrete from the student's own desire to apply science to real life; (4) Evolving knowledge - probes the extent to which students explore between the spheres of absolutism and relativism; (5) Source

of ability to learn - probe students' epistemological views about the efficacy of hard work and effective study habits, as distinct from their confidence and other views about themselves (Elby et al., 2020).

There are various studies who explored the importance of epistemological beliefs in science in developing students cognitive and non-cognitive aspects. The findings of Kapucu and Bahcivan (2015) indicated that attitudes toward other significant physics dimensions as well as self-efficacy in learning physics were significantly and positively related to the scientific epistemological belief dimensions e.g., source and justification revealed by the nature of knowing. Kaya (2017) further revealed that epistemological beliefs accounts for students' goal-orientation. In the study conducted by Kaymak and Ogan-Bekiroðlu (2013) argued that there is a positive link between students' physics epistemological beliefs and their learning gains. Ongowo (2021) also indicated that certainty and justification dimensions of epistemic beliefs were significant predictors of science achievement. This means that students' views on uncertainty and the importance of experiments in supporting knowledge claims strongly impacted their performance in science. A similar study conducted by conducted by Vecaldo (2016), the findings showed that subconstructs of epistemological beliefs such as simple knowledge, fixed ability, and certain knowledge except for quick learning can predict the variation on the academic performance of pre-service teachers. However, Jena and Chakraborty (2018) concluded on their study that epistemological beliefs are not linked with learning style, learning approaches and achievement of university students. The same observation was demonstrated by Köksal (2017) that while there was no epistemological predictor of self-efficacy, only the belief in the "presence of one truth" was a significant predictor of test anxiety.

In line with the review of literature, there is an exiting gap regarding the influence of epistemological beliefs to the academic performance. In comparison in other countries, moreover, there are limited investigations in the Philippines that had been conducted on epistemological beliefs relating them to student achievement (Orleans & Palomar, 2018). Hence, this study examined the relationship of epistemological beliefs of Filipino STEM learners about Physics to their academic performance. It further determined the level of academic performance in Physics of Filipino STEM learners. The sophistication level of epistemological beliefs for Physics of the Filipino STEM learners in terms of structure of scientific knowledge, nature of knowing and learning, real-life applicability, evolving knowledge, and source of ability to learn was also assessed. Salient outcomes obtained from this enquiry; therefore, may not only benefit explain Filipino students' achievements in international and national educational assessments, but also help in understanding the learning process students in the Philippines and those in countries with similar educational, cultural and economic conditions.

## METHODS

### Research Design

This study utilized descriptive-correlational research design to describe and examine the relationship of epistemological beliefs of Filipino STEM learners about Physics to their academic performance. Sousa et al. (2007) defined descriptive correlational studies as design which aims to describe the variables and the relationships that occur naturally between and among them, in this case, the epistemological beliefs and academic performance.

### Participants

There are 457 Filipino Grade 12 Learners enrolled in academic year 2021-2022,

specializing in Science, Technology, Engineering and Mathematics (STEM) strand who voluntarily participated in the study. The study is dominantly participated by female learners which comprised 56.7% of the total respondents, while 43.3 % are male. The respondents' ages range from 16 to 20 years where the mean age is 17.71 years. Majority of the respondents are 18 years old (60.4%), followed by 17 years old (33.5%), and the remaining 6.1% are above 18 years old. The study involved STEM learners both from public (65.4%) and private (34.6%) institutions.

**Instrument**

The Epistemological Beliefs Assessment for Physical Science (EBAPS) was used to probe the students' epistemologies, their views about the nature of knowledge and learning in Physics. This instrument was adapted from the work of Elby et al. (2020). The instrument was further validated by experts from the field of science education to determine the appropriateness of the survey in terms of (1) content; (2) format; (3) response system; (4) language; and (5) suitability for the sample. The final form is composed of 30 forced-choice items which assesses the students' epistemological stance in the following five non-orthogonal dimensions: Structure of scientific knowledge, Nature of knowing and learning, Real-life applicability, Evolving knowledge, and Source of ability to learn. Table 2 shows the number and distribution of items of the instrument according to the five dimensions.

**Table 1.** Distribution of items according to five dimension

| Dimension | Number of Items | Items |
|---|---|---|
| Structure of scientific knowledge | 10 | 2. 8. 10. 15. 17. 19. 20. 23. 24. 28 |
| Nature of knowing and learning | 8 | 1. 7. 11. 12. 13. 18. 26. 30 |
| Real-life applicability | 4 | 3. 14. 19. 27 |
| Evolving knowledge | 3 | 6. 28. 29 |
| Source of ability to learn | 5 | 5. 9. 16. 22. 25 |

In order to interpret the results, this study also adapted the suggested scoring scheme of the EBAPS. The scoring scheme is non-linear to account for question-by-question variations. It is rated on a scale of 0 – "unsophisticated" to 4 – "most sophisticated." Further, the academic performance in Physics was determined using their first semester grade of A.Y. 2019-2020.

**Data Collection**

The questionnaire was programmed via Google Forms and was distributed using electronic mailing sources. The researcher asked assistance from selected STEM teachers to disseminate the research instrument to the target respondents. The instruments was sent with an informed consent form disclosing the ethical considerations of the study. It stated that the collected data and information about the participants would be only used for the sole purposes of the study. It also specified that utmost confidentiality will be observed. Submission of their responses signified their consent. The instrument was distributed in the first semester of academic year 2020-2021.

**Data Analysis**

To determine the level of sophistication of the respondents' epistemological beliefs in Physics, descriptive statistics such as mean and standard deviation were used. In order to quantify and interprets the students' epistemological beliefs, the following scale was used: Extremely Sophisticated 3.5–4.0;

Highly Sophisticated 3.4–3.0; Moderately Sophisticated 2.9–2.4; Poorly Sophisticated 2.3–1.6; Unsophisticated 1.5–0. The researcher employed Pearson product-moment of correlation coefficient (Pearson r) to assess the association of the five non-orthogonal dimensions of epistemological stance in Physics to the academic performance of the respondents

## ■ RESULTS AND DISCUSSION

This study examined the relationship of epistemological beliefs of Filipino STEM learners about Physics to their academic performance. It further determined the level of academic performance in Physics of Filipino STEM learners. The sophistication level of epistemological beliefs for Physics of the Filipino STEM learners in terms of structure of scientific knowledge, nature of knowing and learning, real-life applicability, evolving knowledge, and source of ability to learn was also assessed.

Table 2 shows the distribution of the respondents according to their academic performance in Physics. The overall mean academic performance of the respondents is 87.83 which can be interpreted as "Very Satisfactory." The table further reveals that majority (45.30%) of the respondents have an academic performance within the grade scale of 85 to 89 which has a verbal description of "Very Satisfactory." It is also evident that the lowest evaluation of the student is "Fairly Satisfactory" which is still considered as passing grade. This implies that the respondents has performed very satisfactorily since no failing grades were tallied.

**Table 2.** Frequency of learners according to academic performance in physics

| Rating | Frequency | Percent (%) | Interpretation |
|---|---|---|---|
| 90-100 | 160 | 35.01 | Outstanding |
| 85-89 | 207 | 45.30 | Very Satisfactory |
| 80-84 | 85 | 18.60 | Satisfactory |
| 75-79 | 5 | 1.09 | Fairly Satisfactory |
| Below 75 | 0 | 0 | Did Not Meet Expectations |
| Total | 457 | 100 | |

Table 3 presents the sophistication level of students-respondents' epistemological beliefs in Physics according to five non-orthogonal dimensions. It can be seen on the table that the level of sophistication of their epistemological beliefs can be interpreted as "Poorly Sophisticated" as revealed by the overall mean (M=2.32, SD=0.30). Three dimensions which are structure of scientific

**Table 3.** Sophistication level of epistemological beliefs in physics according to five dimensions

| Epistemological Beliefs | Mean | Std. Deviation | Interpretation |
|---|---|---|---|
| 1. Structure of scientific knowledge | 1.96 | 0.45 | Poorly Sophisticated |
| 2. Nature of knowing and learning | 2.21 | 0.47 | Poorly Sophisticated |
| 3. Real-life applicability | 2.56 | 0.67 | Moderately Sophisticated |
| 4. Evolving knowledge | 2.25 | 0.72 | Poorly Sophisticated |
| 5. Source of ability to learn | 3.00 | 0.56 | Highly Sophisticated |
| Overall Mean | 2.32 | 0.30 | Poorly Sophisticated |

Legend: *Extremely Sophisticated 3.5–4.0; Highly Sophisticated 3.4–3.0; Moderately Sophisticated 2.9–2.4; Poorly Sophisticated 2.3–1.6; Unsophisticated 1.5 – 0.*

knowledge, nature of knowing and learning, and evolving knowledge were all interpreted as "Poorly sophisticated." The source of ability to learn obtained the highest mean value of 2.25 (SD=0.72). This implies that the students considers the value of hard work and good study habits as distinct from self-confidence and other beliefs about themselves.

**Table 4.** Correlation analysis of academic performance as outcome variable

| Epistemological Beliefs | r-value | Sig. | Interpretation |
|---|---|---|---|
| 1. Structure of scientific knowledge | .197** | .000 | Significant |
| 2. Nature of knowing and learning | .248** | .000 | Significant |
| 3. Real-life applicability | .053 | .262 | Not Significant |
| 4. Evolving knowledge | .098* | .037 | Significant |
| 5. Source of ability to learn | .110* | .019 | Significant |

**Correlation is significant at the 0.01 level (2-tailed)
*Correlation is significant at the 0.05 level (2-tailed)

Table 4 presents the correlation analysis of academic performance as outcome variable. It clearly shows that structure of scientific knowledge (r=.197, p=.000) and nature of knowing and learning (r=.248, p=.000) established a significant association to academic performance at 1% level of significance. Similarly, evolving knowledge (r=.098, p=.037) and source of ability to learn (r=.110, p=.019) demonstrated significant relationship to academic performance as revealed by their r-values and p-values at an alpha level of 5%. The real-life applicability, however, is not significantly related to academic performance. This indicates that students' intent to apply the scientific knowledge in real-life situations is not connected to their academic performance.

The study of Arslantaº (2016) established similar results where he found out that not all subdimensions of epistemic beliefs are correlated with the grade point average of the teacher candidates. The results revealed that the epistemological beliefs related to talents emerged to have the most significant related to the students' achievement. Sadi (2015) further uncovered that epistemological beliefs are directly and positively related to the student's conception of learning. The results also added that sophisticated epistemological beliefs may be associated with the higher-level of learning conception and self-efficacy. Thus, it can be inferred that matured epistemological beliefs is associated with better academic performance.

**Table 5.** Regression analysis of academic performance as outcome variable (N = 407, $R^2$ = 0.074, Adjusted $R^2$ = 0.064)

| | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | Interpretation |
|---|---|---|---|---|---|---|
| Variables | B | SE | Beta | | | |
| (Constant) | .748 | .263 | | 2.844 | .005 | |
| 1. Structure of scientific knowledge | .197 | .083 | .123 | 2.371 | .018 | Significant |
| 2. Nature of knowing and learning | .285 | .074 | .183 | 3.865 | .000 | Significant |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1. | Real-life applicability | .030 | .053 | .028 | .569 | .569 | Not Significant |
| 2. | Evolving knowledge | .008 | .047 | .008 | .159 | .874 | Not Significant |
| 3. | Source of ability to learn | .098 | .059 | .076 | 1.657 | .098 | Not Significant |

Table 5 presents the results from regression analysis considering academic performance as an outcome variable. Based on the t-values and p-values, dimensions 3, 4, and 5 of epistemological stance are found to be not significant predictors of students' academic performance in Physics. Dimensions 4 and 5 which are *evolving knowledge* (t=2.371, p=.018) and *source of ability to learn* (t=3.865, p=.000) are reveled to significantly influence the students' academic performance. This signifies that the variation in the academic performance cannot be fully explained by the difference in the students' epistemological beliefs about Physic. It further indicates that students can get satisfactory academic performance despite poor sophistication level of their epistemological views about Physics. In fact, the table further revealed that it is only 6.4% variation of the students' academic performance can be accounted to the students' epistemological beliefs about physics, assuming all other variables are held constant.

In the study conducted by Vecaldo (2016), the findings showed that subconstructs of epistemological beliefs such as simple knowledge, fixed ability, and certain knowledge except for quick learning can predict the variation on the academic performance of pre-service teachers. This result supports the present outcome since it also concluded that the epistemological beliefs cannot fully explain the academic performance of the students as revealed on the results. On the other hand, the study of Gumandam and Mangila (2021) revealed that no significant relationship exists between the epistemic beliefs of the teacher to the students' academic achievement. This suggests that the epistemological beliefs of the teachers do not have close impact to the students' academic achievement. The results of the study do not support the claims of Orlean and Palomar (2018) and Mistades (2017) that epistemological beliefs play a vital role in developing students' achievement in classroom.

## ■ CONCLUSIONS

Epistemological beliefs have emerged to be a popular theme to explain the academic performance of the students. The present study investigated the relationship of epistemological beliefs of Filipino STEM learners about Physics to their academic performance. It further determined the level of academic performance in Physics of Filipino STEM learners. The sophistication level of epistemological beliefs for Physics of the Filipino STEM learners in terms of structure of scientific knowledge, nature of knowing and learning, real-life applicability, evolving knowledge, and source of ability to learn was also assessed. The result revealed that the respondents has performed very satisfactorily in Physics course based on their academic grade since no failing grades were tallied. Moreover, the level of sophistication of epistemological belief about physics registered as poor. In terms of the relationship, the findings revealed that the epistemological beliefs of the students generally do not explain the variation of the academic performance of the students. However, it can be noted that the subconstructs, structure of

scientific knowledge and nature of knowing and learning, emerged to significant predict academic performance of the study.

In the light of the salient findings of the study, it is recommended for the physics teachers to craft an instructional intervention to enhance the students' epistemological beliefs in physics, which in turns affect the performance of the students in the class. The intervention must put emphasis in reinventing the student's views about the nature and structure of knowledge in physics, which helps them to better understand the forms of learning in physical science courses like physics, thereby, improving their conception of learning; hence, students, academic achievement is improved. Since the student's epistemological beliefs varies from one context to another, the teacher must also take into account the social learning context where the learning process takes place. For future research directions, it is suggested to explore the differences that may exist among the students' epistemological beliefs in terms of gender, grade level, academic tracks among others.

This study encounters some limitations in terms of generalizing the result. The participants involved were only 407 STEM students from one Schools Division Office in the Philippines indicating certain limitation in terms of sociocultural contexts. It is suggested for future research to explore same nature of study in a different learning climate. Furthermore, the survey was assumed that the respondents answer it sincerely, however, the instrument was administered via online platform; hence, the students' responses are susceptible to various distractors such as technological and emotional interferences of the students while answering the instrument. It is recommended to conduct qualitative exploration to verify the veracity of the students' respondents on the survey, and provide a richer and thicker description of students' epistemological beliefs.

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