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# Scientific Epistemological Beliefs About Biology Among Pre-Service Biology Teachers

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**Abstract:** This study investigated pre-service biology teachers' epistemological beliefs about biology. The sample consisted of 200 undergraduates in a biology teacher- education programme. The biology version of Colorado Learning Attitudes about Science Survey (Class-Bio) was administered on the subjects. Data collected were analysed using Z-test of single proportion, t-test of independent samples and Fixed ANOVA model. Findings of the study indicated that epistemological beliefs of the pre-service teachers were similar to those of novices, and entry qualification, as well as Year of study did not significantly influence their epistemological beliefs. It is recommended, among others, that biology teacher educators should explore ways of teaching to improve pre-service biology teachers' epistemological beliefs since such beliefs have been factored in learning outcome/ performance equation.

**Keywords:** Pre-service teachers, epistemological beliefs, teacher education, biology teacher educators.

## 1. INTRODUCTION

Perry (1968) is an advocate and pioneer of research on the nature of knowledge or epistemology. His efforts provided the needed scholarly motivation and impetus to researchers to study the phenomenon. The initial result of the response to his appeal is the bifurcation of conception of epistemology. A group (Perry, 1970; Kegan, 1982; King & Kitchener, 2004) sees epistemologies in a single dimension, as developmental stages which occur hand-in-hand with the individual's cognitive development. Another group (Schommer, 1988, 1990; Schommer & Walker, 1997; Schraw, Dunkle & Bendixen, 1995; Hofer & Pintrich, 1997) sees epistemologies, from a multidimensional perspective, as collections of beliefs. For instance, Schommer (1990) says that beliefs about the nature of knowledge are too complex to be conceptualized in a single dimension. From her multidimensional inclination, she defines personal epistemology as a belief system that is composed of several more or less independent dimensions' (p. 498). Specifically, she hypothesized five epistemological dimensions as follows: Simple Knowledge – knowledge is simple (less sophisticated belief) rather than complex (sophisticated belief); Omniscient Authority – knowledge is handed down by authority (less sophisticated belief) and not derived from reason (sophisticated belief); Certain Knowledge – knowledge is certain (less sophisticated belief) rather than tentative (sophisticated belief); Innate Ability – the ability to learn is innate (less sophisticated) rather than acquired (sophisticated belief); and Quick Learning – learning is quick or not at all (less sophisticated belief) rather than

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gradual (sophisticated belief). She developed Epistemological Beliefs Questionnaire (EBQ) for studies of this phenomenon.

But Hofer and Pintrich (1997) embarked on a critique of Schommer's (1990) hypothesized dimensions and suggested that quick learning and innate ability should not be classified as epistemological dimensions because the two types are more related to nature of learning than nature of knowing. They came up with four epistemological dimensions as follows: Certain Knowledge, Simple Knowledge, Omniscient Authority, and Justification for knowing. Some studies (Kuhn, 1991; Elder, 1999, 2002) have validated the existence of these dimensions while others (Schommer – Aikins, Mau, Brookhart & Hutler, 2000, 2005; Topcu & Vilmaz-Tuzun, 2007) excised Simple Knowledge because it could not survive confirmatory factor analysis.

These studies have tried to provide means of measuring students' epistemological beliefs and relating them to their characteristics though DeBacker, Crowson, Beesley, Thomas, and Hestevold (2008) express trepidation over the challenge of measuring these beliefs. Fujiwara, Laulathaphol and Phillips (2012) reviewed three different instruments for measuring epistemic beliefs in physics, chemistry and biology developed by three groups of researchers in this area of investigation and found that they all share the main idea that good education should result in changes of students' beliefs towards these of the experts. The assumption by the developers of these three instruments, according to Fujiwara et al, is that students should be similar or closer to experts with reference to what they believe about the subject area and how the subject should be learned if they are given good education. The assumption appears very plausible. Nonetheless empirical support is needed, and this is one of the overarching issues addressed in this article. The literature is mute about the relationship between pre-service biology teachers' epistemological beliefs and those of their biology educators in the Nigeria culture despite Hofer's (2006) declaration that culture is a context that can be powerful in affecting beliefs. By implications, studies in the Nigeria context on this should be carried out.

Studies (Schommer, 1993; Neber & Schommer, 2002; Conley, Pintrich, Vekiri & Harrison, 2004; Lodewyk, 2007) have suggested that epistemological beliefs is a function of students' gender, grade level, age, fields of study, ethnicity, socioeconomic status, academic performance, learning environments, self-efficacy beliefs, learning strategies. But empirical evidence is needed for supporting or not, relationships between these variables and epistemological beliefs among pre-service teachers. Study of epistemological beliefs is significant because such beliefs are found to be important in relation to students' learning outcomes and academic performance (Schommer, 1990, 1993; Hofer, 2000; Nurmi, Aunola, Salmela-Aro & Lindroos, 2003; Heiskanen & Lonka, 2012). It is even more so for pre-service teachers who are being prepared for managing learning environments for others to learn. Findings from such studies can inform teacher educators about how pre-service teachers learn. It was considered rewarding to study pre-service biology teachers' epistemological beliefs and how they are influenced by their level of study and characteristics.

This study addressed the following research questions:

1. Are pre-service biology teachers' epistemological beliefs about biology different from those of experts?
2. Are pre-service biology teachers' epistemological beliefs significantly influenced by their level of study and entry characteristics?

## 2. METHODS

### *2.1 Participants*

The participants (N=200) were students in undergraduate teacher- education programme in Delta State University Abraka, Warri Programme in Nigeria. Their teaching subject of study was biology. The target population was made up of all Year 2 through Year 4 biology undergraduates in the programme. Years 2, 3 and 4 had 70, 70

and 60 participants respectively, and of the 200 participants, 117 were females while 83 were males. These sizes represented the proportion of females to males. Their entry characteristics varied also because some entered into the programme with West African School Certificate (WASC) or its equivalent while the rest were admitted with Nigeria Certificate in Education (NCE) which is an intermediate teaching qualification that is much higher than WASC. Each of these entry levels had 100 participants. The participants were selected using stratified random sampling techniques with Year of study and entry qualification as strata.

### *2.2 Instrument*

The biology version of Colorado Learning Attitudes about Science Survey (CLASS-BIO) was developed by Semsar, Knight, Birol, and Smith (2011). The dimensional structure was determined using principal component analysis after investigating the suitability of the data for factor analysis by Fujiwara et al. (2012). They arrived at five factors which are: Factor 1: Enjoyableness of Learning Biology (11 items; a = 0.834); Factor 2: Memorization of Knowledge (10 items; a = 0.677); Factor 3: Method of Learning Biology (8 items; a = 0.659); Factor 4: Difficulty of Learning Biology (5 items; a = 0.454); Factor 5: Approach to Learning Biology (4 items; a = 0.258). These factors explained 17.96%, 6.08%, 4.91%, 4.12% and 3.87% respectively of the variance. This instrument was selected for use in this study on the basis of its psychometric credentials though the last two factors had internal consistency measures that are below threshold value of 0.60 as suggested by Nunnaly (1981). The participants were requested to show how they agreed or disagreed on a five-point Likert scale ranging from 4 (Strongly Agree) to 1 (Strongly Disagree) for positively stated items. The scoring was reversed for negatively stated items. Test-retest reliability coefficient which indicates stability of items was determined for each of the factors and for the entire instrument using a sample of 42 pre-service biology teachers not included in this study. The results are 0.71, 0.69, 0.82, 0.64 and 0.73 for Factors 1, 2, 3, 4 and 5 respectively.

### *2.3 Data Collection and Analysis*

One of the researchers administered the instrument to the subjects who willingly responded to the items. Four of the copies of the instrument were found unusable and to replace these, another set of four copies were administered to four subjects with similar demographic characteristics and who were not in the original sample of 200 subjects. The researcher explained the purpose of the study and provided answers to question by the subjects during this process of administration of the instrument.

Sing descriptive and inferential procedures. Descriptive analysis provided values for means and standard deviation measures while the inferential involved the use of Z-test for a single proportion, t-test of difference in means of independent samples and one-way ANOVA, all observed at the 0.05 alpha level. A threshold value or benchmark was used to determine the items in which the subjects' beliefs approached those of the experts. The value was calculated using Tekin's formula as cited by Berber (2013). The use of formula involved the calculation of the interval width of the scale to determine the limits of the scale. The formula is:

a = interval width/number of groups (response options)

where a = coefficient of interval. Using this formula,

a = [(4-1)/4] = 0.75.

Accordingly, 1.00 to 1.75 interval was defined 'Strongly Disagree, 1.76 – 2.50 interval was defined as 'Disagree', 2.51 – 3.25 was defined as 'Agree' and 3.26 – 4.00 was regarded as 'Strongly Agree'. A threshold value of 2.88 (the mid-point of 'Agree') was used as a benchmark for determining the closeness of the subjects' beliefs to the beliefs by experts. Group mean on any item that is lower than this benchmark is classified as belief by novices.

## 3. RESULTS

Research question 1 states, 'Are pre-service biology teachers' epistemological beliefs about biology different from those of the experts? Results of descriptive analysis are presented in table 1.

**Table 1: Means, Standard deviation and remark on the items. N = 200**

| S/N | Item | Mean | SD | Remark |
|---|---|---|---|---|
| | **Factor 1: Enjoyableness of Learning Biology** | | | |
| 1. | If I had plenty of time, I would take a biology class outside of my major requirements just for fun. | 2.89 | 1.25 | Expert |
| 2. | I enjoyed figuring out answers to biology questions. | 3.30 | 1.37 | Expert |
| 3. | My curiosity about the living world led me to study biology. | 3.37 | 1.09 | Expert |
| 4. | I enjoyed explaining biological ideas that I learn about too my friends. | 3.39 | 1.42 | Expert |
| 5. | It is valuable use of my time to study the fundamental experiments behind biological ideas. | 3.17 | 1.62 | Expert |
| 6. | I want to study biology because I want to make a contribution to the society. | 3.42 | 1.31 | Expert |
| 7. | I think about the biology I experience in everyday life. | 3.30 | 1.72 | Expert |
| 8. | When I am not pressed for time, I will continue to work on a biology problem until I understand why something works the way it does. | 3.19 | 1.33 | Expert |
| 9. | Learning biology changes my ideas about how the natural world works. | 3.39 | 1.41 | Expert |
| 10. | When solving a biological question, it helps me to picture where the process occurs in the organism of cell. | 3.47 | 1.07 | Expert |
| 11. | It is possible to explain biological ideas with everyday language. | 2.92 | 0.48 | Expert |
| | **Factor 2: Memorization of Knowledge** | | | |
| 12. | Biological principles are just to be memorized. | 2.90 | 1.17 | Expert |
| 13. | I do not spend more time than a few minutes stuck on a biology question before giving up or seeking for help. | 2.73 | 0.61 | Novice |
| 14. | If I get stuck on a biology question, there is no chance I will figure it out on my own. | 2.74 | 0.63 | Novice |
| 15. | To learn biology, I only need to memorize facts and definitions. | 2.94 | 0.54 | Expert |
| 16. | I do not expect the rules of biological principles to help my understanding of the ideas. | 2.83 | 0.98 | Novice |
| 17. | I am more interested in biological facts rather than the ideas underlying these facts. | 2.39 | 0.67 | Novice |
| 18. | If I don't remember a particular approach needed for a question on an exam, there's nothing much I can do (legally) to come up with it. | 2.46 | 0.79 | Novice |

| | | | | |
|---|---|---|---|---|
| 19. | For me, biology is primarily about learning known facts as opposed to investigating the unknown. | 2.77 | 0.82 | Novice |
| 20. | If I want to apply a method or idea used for understanding one biological problem to another problem, the problems must involve very similar situation. | 2.93 | 1.13 | Expert |
| 21. | There is usually one correct approach to solving a biology problem. | 2.83 | 1.04 | Novice |
| | **Factor 3: Method of Learning Biology** | | | |
| 22. | When studying biology, I relate the important information to what I already know rather than memorizing it the way it is presented. | 3.05 | 0.99 | Expert |
| 23. | It is important for the government to approve new scientific idea before they can be widely accepted. | 1.73 | 0.49 | Novice |
| 24. | To understand biology, I sometimes think about my personal experiences and relate them to the topic being analysed. | 3.10 | 1.21 | Expert |
| 25. | The general public misunderstands many biological ideas. | 3.03 | 1.02 | Expert |
| 26. | Reasoning skills used to understand biology can be helpful to my everyday life. | 3.47 | 1.07 | Expert |
| 27. | There are times I think about or solve a biology question in more than one way to help my understanding | 3.22 | 1.05 | Expert |
| 28. | Logic and reasoning skills are not important for understanding biology. | 2.80 | 0.96 | Novice |
| 29. | If I get stuck on answering a biology question on my first day, I usually try to figure out a different way that works. | 2.99 | 0.83 | Expert |
| | **Factor 4: Difficulty of Learning Biology** | | | |
| 30. | Nearly everyone is capable of understanding biology. | 2.65 | 0.72 | Novice |
| 31. | Knowledge in biology consists of many disconnected topics. | 2.59 | 0.94 | Novice |
| 32. | Mathematical skills are important for understanding biology. | 2.63 | 1.01 | Novice |
| 33. | When I am answering a biology question I find it difficult to put what I know into my own words. | 2.63 | 0.97 | Novice |
| 34. | After I study a topic in biology, I feel that I understand it, I have difficulty applying that information to answer questions on the same topic. | 2.42 | 0.61 | Novice |
| | **Factor 5: Approach to Learning Biology** | | | |
| 35. | When I do not understand a biological question, I will draw it (e.g. on a paper, chalkboard) to help myself understand it. | 2.81 | 0.84 | Novice |

| | | | | |
|---|---|---|---|---|
| 36. | To understand biology, I discuss it with friends and other students. | 3.24 | 0.93 | Expert |
| 37. | The subject of biology has little relation to what I experience in the real world. | 2.24 | 0.81 | Novice |
| 38. | Learning biology that is directly relevant to or applicable to human health is not worth my time. | 2.76 | 0.94 | Novice |

Table 1 indicates that biology epistemological beliefs held by pre-service biology teachers resemble beliefs by experts in biology education, with reference to Factor 1: 'Enjoyableness of Learning Biology'. But under Factor 2: 'Memorization of Knowledge' the pre-service teachers had similar beliefs to novices' beliefs in only 3 out of 10 items. This result suggests that the pre-service teachers do not have effective biology learning skill. In Factor 3: 'Method of Learning Biology' the pre-service teachers' beliefs were similar to experts' beliefs in 6 out of 8 items. It would seem this result contradicts the suggestion made from the result with respect to factor 2.

The table also indicates, with respect to Factor 4: 'Difficulty of Learning Biology', that pre-service teachers' beliefs reflected those of novices in all the items. This means that the pre-service teachers are experiencing some difficulties with learning biology. Factor 5 addresses Approach to Learning Biology. Responses to 3 out of the 4 items that make up this factor reflected beliefs by novices. This means that their approach to learning biology is different from the approach expected of them by the experts.

To test the first hypothesis which states that the proportion of items in which the pre-service biology teachers epistemological beliefs agree with experts' beliefs is significantly not greater than 0.50, a Z-test for a single proportion (Joe, 2005) was applied and observed at the 0.05 alpha level. The results of the exercise indicate that the calculated Z-ratio of 0.62 is less than the tabled or critical Z value. The hypothesis of no difference was therefore not rejected. This means that 21 items in which the pre-service biology teachers epistemological beliefs are classified as novices' beliefs are not significantly more than 17 items in which their beliefs resemble those of the experts.

Hypothesis 2 states that there is no significant influence of entry qualification on pre-service biology teachers' epistemological beliefs about biology. The results of the t-test of independent samples carried out are shown in table 2.

**Table 2: t-test of difference in mean epistemological beliefs according to entry qualifications**

| Entry Qualification | N | $\overline{X}$ | SD | $t_{cal}$ | $t_{tabled}$ |
|---|---|---|---|---|---|
| NCE | 100 | 112.95 | 11.04 | 1.42* | 1.98 |
| SSCE | 100 | 110.82 | 11.16 | | |

* Not significant at 0.05 alpha level.

Table 2 indicates that there is no significant influence of entry qualification on pre-service biology teachers' epistemological beliefs [$t_{(198)} = 1.42$, $p > 0.05$]. By implication, whatever difference that existed between the two group means was due to chance. The null hypothesis was therefore not rejected.

Hypothesis three states that there is no significant influence of level (Year) of study on pre-service biology teachers' epistemological beliefs about biology. A fixed ANOVA model was used to test the significance of any difference across the 3 groups involved and the results are shown in tables 3 and 4.

**Table 3: Mean and Standard deviation**

| Group | N | Mean | SD |
|---|---|---|---|
| Year 2 | 70 | 110.11 | 11.16 |
| Year 3 | 70 | 111.66 | 10.21 |
| Year 4 | 60 | 114.22 | 10.04 |

**Table 4: Fixed ANOVA Summary of Difference in Mean Beliefs**

| Source of Variance | Sum of Squares | Df | Mean of Squares | F-cal | F-crit | Decision |
|---|---|---|---|---|---|---|
| Between Groups ($SS_b$) | 549.30 | 2 | 274.65 | 2.46 | 3.07 | Ho Not rejected |
| Within Groups ($SS_w$) | 21981.10 | 197 | 111.58 | | | |
| Total ($SS_t$) | 22530.40 | 199 | 113.22 | | | |

The results in tables 3 and 4 indicate that level (Year) of study did not significantly influence pre-service biology teachers' epistemological beliefs about biology [$F_{(2, 197)} = 2.46$, $p > 0.05$]. By implication, the null hypothesis that there is no significant influence of level of study was not rejected. This means that there is no difference in epistemological beliefs about biology by pre-service biology teachers irrespective of their level of study.

## 4. DISCUSSION

One of the questions raised in this study was intended to determine whether the epistemological beliefs of pre-service biology teachers about biology resembled those of experts in biology education. The results obtained with respect to this question, indicated that for Factor 1 which centred on Enjoyableness of Learning Biology, the responses to all the items resemble epistemological beliefs by experts in biology education. The results here are heart-warming because if pre-service biology teachers' epistemological beliefs reflect that they enjoy learning biology, they will have interest in learning the subject. Interest is one of the greatest motivational factors in learning (Igwebuike, 2008, 2013). The results are also heart-warming because a common presumption by three groups that worked on measurement instruments for personal epistemological beliefs in three subject areas – Physics, chemistry and biology, as highlighted by Fujiwara, et al (2012), is that the students should become similar or closer to the experts in terms of their belief system about a subject area and its learning if they receive good education. The results of this study therefore provide empirical evidence that supports the view that the presumption is true though specifically with reference to Enjoyableness of Learning Biology. An implication of this is that biology teacher educators in the teacher education programme should be aware of this positive revelation and explore further on how to make teaching biology to the pre-service teachers more enjoyable.

With respect to Memorization of Knowledge (Factor 2), pre-service biology teachers' epistemological beliefs resemble those by novices. One of the items states 'I do not expect the rules of biological principles to help my understanding of the ideas'. It is not encouraging for the pre-service biology teachers to agree to such a statement that precludes the use of biological principles while grappling with the understanding of biological

phenomena. This can be explained in part, by the fact that teacher educators use transmissive or mere expository method of teaching pre-service teachers (Igwebuike & Okandeji, 2009; Igwebuike, Okandeji & Ekwevugbe 2013). An implication of this result is that biology teacher educators should explore ways of improving their teaching so as to involve them with activities that will emphasize the place of concepts and principles in learning biology.

It is gratifying to observe that the pre-service biology teachers' beliefs were close to experts' beliefs with respect to Factor 3 in which responses contradicted the conclusions on Factor 2 – Memorization of Knowledge. This contradiction provides adequate challenge needed for further investigation of this phenomenon. Biology teacher educators should be wary of the findings that pre-service biology teachers beliefs about Difficulty of Learning Biology completely resemble beliefs by novices. An explanation of this would have been provided by the fact that the sample was composed across levels of study and Year 2 pre-service teachers who did not have enough encounters with the study of biology would be responsible for this anomaly. But this explanation is not plausible and cannot be sustained because this study too has provided empirical evidence that Year of study did not significantly influence pre-service biology teachers' epistemological beliefs about biology.

With respect to Factor 5 which centres on Approach to Learning Biology, the results obtained are in consonance with those from Factor 4. The discussion of the findings of Factor 4 also holds for Factor 5. Biology teacher educators in the programme should be sensitized about the epistemological beliefs of their students which are the same with those of novices. They should explore ways of developing in their students effective approaches to learning biology.

No difference was found between the proportion of the items in the questionnaire in which the pre-service biology teachers' epistemological beliefs were close to experts' beliefs and the proportion of the items in which their beliefs were those of the novices. This result contradicts the presumption by designers of the measurement instruments for epistemological beliefs that students' beliefs should be close to experts' beliefs if they are given good education, as highlighted by Fujiwara, et al. (2012). It was expected by the researchers that pre-service biology teachers' epistemology would be close to those of experts considering the fact that they have been in the biology teacher education for two, three or four years as the case may be. As argued before, an explanation would have been provided, speculatively, by the fact that a period of two years is too short for the programme to make a significant impact on the epistemological beliefs of those pre-service teachers in this category. It can be reasoned that this factor would have affected the result. But the study, as mentioned earlier, provides empirical evidence which shows that there is no difference in epistemological beliefs across the Years of Study. It is the method of teaching the pre-service biology teachers that can be implicated. Lecturers in the programme, as mentioned earlier, strictly use transmissive and expository method for teaching the pre-service teachers (Igwebuike & Okandeji 2009; Igwebuike, Okandeji & Ekwevugbe, 2013). An implication of this is that such lecturers should explore more effective ways of teaching biology to the pre-service teachers.

Entry qualifications of the pre-service biology teachers did not exert influence on the epistemological beliefs about biology. This contradicts the findings of a study by Fujiwara et al (2012) that undergraduate students' past learning experiences had an influence on forming and developing their epistemic beliefs about biology. It was expected that there would be a difference because pre-service biology teachers that entered the programme after passing through the NCE biology programme had different learning experiences from those of the pre-service teachers that joined with WASC or its equivalent. The difference expected would have been in favour of those who entered the programme with NCE (biology) qualification. This is largely because NCE programme in biology provides more rigorous

biology laboratory activities than the WASC experience. Speculatively, this anomalous result can be explained by the fact that they were all subjected to the same learning experience in the programme and this helped to level out the assumed initial difference in pre-entry learning experiences. It is likely that the result would be different if this comparison is made at the incipient part of the programme. Future studies on this can be conceptualized to incorporate this type of comparison.

Year of Study did not influence the pre-service teachers' epistemological beliefs. Year of Study is also a factor of learning experiences. It is therefore not surprising that it did not influence their epistemological beliefs though initially the researchers expected a difference. This is largely because of the longer period of study of biology by those at the higher levels. The result contradicts that by Fujiwara, et al. (2012) which indicates that past learning experiences have an influence on forming and developing epistemological beliefs by undergraduate students. In addition, Perry (1970) and Lonka and Lindblom-Ylanne (1996) have suggested that at the beginning of a programme, students hold epistemological beliefs that point to the need to have clear facts and answers but more advanced students hold more relativist conceptions in which knowledge is assessed in a specific context. This, at least, means that there is a difference in epistemological beliefs resulting from differences in the level of study. The anomalous result of the current study can also be explained by ineffectual method of teaching used by the lecturers in the programme.

Compositely, the findings of this study warrant expression of serious trepidation over the preparation of pre-service biology teachers in this programme. Lecturers or biology teacher educators should be made to be aware of this. They should be encouraged to explore contemporary teaching approaches that will lead to development of epistemological beliefs that will be similar to those of experts in biology especially in the light of the expressed positive relationships between epistemological beliefs and learning outcome/academic performance (Schommer, 1990, 1993; Hofer, 2000; Nurmi et al, 2003).

## 5. CONCLUSION

The results obtained from this study support the conclusion that pre-service biology teachers' epistemological beliefs about biology were similar to those by novices except in the area of Enjoyableness of Learning Biology. There is evidence too to conclude that entry qualification and Year (level) of Study in the programme did not influence pre-service biology teachers' epistemological beliefs about biology. Future studies of Nigerian population should embark on both exploratory and confirmatory factor analysis of the instrument used in this study. This study did not embark on that and the negligence is declared a weakness of this study. In addition, the scope of study should be enlarged to improve on the generalizability of findings. Future studies should also relate pre-service teachers' epistemological beliefs in biology to their cognitive and affective achievements. More causative factors and their interaction effects should be studied, in addition.

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## REFERENCES

Conley, A. M., Pintrich, P. R., Vekiri, I., & Harrison, D. (2004). Changes in epistemological beliefs in elementary science students. Contemporary Educational Psychology, 29:186-204.

Debacker, T. K., Crowson, H. M., Beesley, A. D., Thomas, S. J. & Hestevold, N. L. (2008). The challenge of measuring epistemic beliefs: An analysis of three self-report instruments. Journal of Experimental Education, 76(3): 281-312.

Elder, A. D. (1999). An exploration of fifth grade students' epistemological beliefs in science and an investigation of their relation to science learning. A doctoral thesis, University of Michigan, Michigan.

Elder, A. D. (2002). Characterizing Fifth grade students' epistemological beliefs in science. In P. R. Pintrich (Ed.). Personal epistemology: The psychology of beliefs about knowledge and knowing (pp. 347-364). Magwah, N. J., USA: Lawrence Erlbaum Associates.

Fujiwara, T., Laulathaphol, P., & Phillips, B. J. (2012). Thai university students' scientific epistemic beliefs: Relationships with past learning experiences. Procedia-Social and Behavioural Sciences, 69:187-196.

Heiskanen, H., & Lonka, K. (2012). Are epistemological beliefs and motivation strategies related to study engagement in higher education? Procedia-Social and Behavioural Sciences, 69:306-313.

Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. Contemporary Educational Psychology, 25:378-405.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. Review of Educational Research, 67:88-140.

Hofer, B. K. (2006). Domain specificity of personal epistemology: Resolved questions, persistent issues, new models. International Journal of Educational Research, 45(1): 85-95.

Igwebuike, T. B. (2008). Curriculum planning and development: Principles and practice. Warri, Nigeria: COEWA Publishers.

Igwebuike, T. B. (2013). Epistemic motivation for conceptual change in integrated science classrooms in non-Western cultures. International Institute for Science Technology and Education: Developing Country Studies, 3(1): 43-50.

Igwebuike, T. B., & Okandeji, C. O. (2009). Traditional and contemporary conceptions of teaching: Implications for revamping teacher education programmes in Nigeria for Vision 20-2020. Text of paper presented at the 2009 Annual Conference of the School of Education, College of Education, Warri – Nigeria, 17-19 June.

Igwebuike, T. B., Okandeji, C. O., & Ekwevugbe, A. O. (2013). Teacher educators' conception of teaching and learning in teacher education institutions. International Journal of Research Studies in Education, 2(2): 43-52.

Joe, A. I. (2005). Fundamental statistics for education and behavioural science. Ibadan, Nigeria: Krafts Books Limited.

Kegan, R. (1982). The evolving self: Problem and process in human development. Cambridge, MA: Harvard University Press.

King, P. M., & Kitchener, K. S. (2004). Reflective judgement: Theory and research on development of epistemic assumptions through adulthood. Educational Psychologist, 39:5-18.

Kuhn, D. (1991). The skills of argument. New York: Cambridge University Press.

Lodewyk, K. R. (2007). Relations among epistemological beliefs, academic achievement, and task performance in secondary school students. Educational Psychology, 27(3): 307-327.

Lodewyk, K.R.(2007).Investigating relations between academic achievement and epistemological beliefs in secondary school students. Educational Psychology , 27,1-21.

Lonka, K. & Lindblom-Ylanne, S. (1996). Epistemologies, conceptions of learning, and study practices in medicine and psychology, Higher Education, 31:5-24.

Neber, H., & Schommer – Aikins, M. (2002). Self-regulated science learning with highly gifted students. The role of cognitive, motivational, epistemological and environmental variables. High Ability Studies, 13(1): 59-74.

Nunnally, J. C. (1981). Psychometric Theory. New Delhi: Tata-McGraw Hill Publishing Co.

Nurmi, J. E., Salmela-Aro, K., & Lindroos, M. (2003). The role of success expectation and task avoidance in academic performance and satisfaction: Three studies on antecedents, consequences and correlates. Contemporary Educational Psychology, 28:59-91.

Perry, W. G. Jr. (1968). Patterns of development in thought and values of students in a liberal arts college: A validation of a scheme. Cambridge, M. A.: Bureau of Study Counsel, Harvard University. (ERIC Document Reproduction Services No ED 024315).

Perry, W. G., (1970). Forms of intellectual and ethical development in the college years: A scheme. New York: Holt, Rinehart & Winston.

Schraw, G., Dunkle, M. E., & Bendixen, L. D. (1995). Cognitive processes in well - structured and ill-structured problem solving. Applied Cognitive Psychology, 9, 523-538.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. Journal of Educational Psychology, 83(3), 498-504.

Schommer, M. & Walker, K. (1997). Epistemological beliefs and valuing school: Considerations for college admission and retention. Research in Higher Education, 38, 173-186.

Schommer, M. & Walker, K. (1995). Are epistemological beliefs similar across domains? Journal of Educational Psychology, 87(3), 424-432.

Schommer, M. (1988). Dimensions of tacit epistemology and comprehension. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, L. A.

Semsar, K., Knight, J.K., Birol, G., & Smith, M.K. (2011). The Colorado Learning Attitudes about Science Survey (CLASS) for use in Biology. CBE Life Science Education, 10(3), 268-278