Open Access
Lavai-Int. J. Educ.
Vol. 21, No. 33: p.2-13 Dec 2025
https://doi.org/10.5564/lavai.v21i33.4508
ISSN 2410-4507, eISSN 2959-9334

L A V A I
International Journal of Education

Original article

Epistemic beliefs in biology among biology-major university students and high school pupils in Mongolia

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A R T I C L E I N F O

History:
Received: 25 August, 2025
Revised: 11 October, 2025
Accepted: 24 October, 2025

Keywords:
Epistemic beliefs
Interested in Biology
Gender
Studying level

A B S T R A C T

Over the past two decades, a large number of studies have explored students' discipline-specific epistemic beliefs (including biology), a term broadly defined as learners' beliefs about the nature of knowledge and knowing. In current study, we initially examined the level of epistemic beliefs in biology of biology-majoring university students and high school students of Mongolia. We surveyed four main universities of Mongolia and five public high schools with previously developed questionnaire. A total of 588 participants consisted of 388 high school students and 200 university students were examined. The epistemic beliefs in biology questionnaire consists of four factors, Source, Certainty, Development, and Justification. In addition, we used participants' gender, studying level, and interested in biology as our variables. We evaluated influences of these variables on students' epistemic beliefs in biology in this study. We used student's t-test to compare the means of two groups (e.g., gender, level etc.). Findings from this study suggested that biology-majoring university students tended to have more mature views of epistemic beliefs regarding biology than that high school students had (mean scores: university student was 5.44 and high school student was 4.90; $t = 9.52$; $P > 0.001$). Furthermore, there were no differences between university students' epistemic beliefs in terms of all variables (only male students have more mature view on certainty of biological knowledge). Whereas, the high school students' gender, studying level and interested in biology were influenced on their view of epistemic beliefs. For instance, the lower-grade students (9th and 10th) have more mature epistemic beliefs regarding biology than higher-grade students (11th and 12th). In conclusion, low level or less mature overall epistemic beliefs in biology for high school students may be linked with the lack of engaging experimental activities and shortage of equipped laboratory resources in the majority part of Mongolian public schools.

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1. INTRODUCTION

The equal ratio of professions in natural science and social science is crucial for any country's economy around the world. Unfortunately, during last two decades, several studies emphasized the dramatically decreased undergraduate student enrollment in natural sciences (e.g., biology, chemistry, physics) (Mulvey and Nicholson, 2011, p.2; Kennedy et al., 2014, p.35; Khan et al., 2023, p.3). This phenomenon could be explained by the decreased interest of students in learning natural sciences in schools (Montalbano, 2012, p.2). Since, the roles of science (including natural science) and technology are indispensable, educational programs should aim to increase the number of motivated students who enroll in natural science courses (indeed engineering and technology etc.). If this mission accomplishes, the outcomes are crucial to build a knowledge-based economy more competitive and sustainable economic growth (Montalbano, 2012, p.2; Ramsurrun et al., 2025, p.1). Similarly, we are facing a scarcity of natural science professions in Mongolia. For instance, a study showed that the proportion of students who studying in field of natural sciences among all students in Mongolia is continuously decreasing (e.g., number of students who enrolled in biology course decreased by 49.4% since only 2016) (NSO, 2024). Obviously, a numerous number of factors influence to major selection of high school students, one of them could be their epistemic beliefs of a particular subject (e.g., biology).

A broadly used definition of epistemic beliefs refers to learners' beliefs about the nature of knowledge and the nature of knowing (Schommer, 1990, p. 450; Hofer, 2004, p. 131). Furthermore, Hofer and Pintrich (1997, p.81) have suggested that epistemic beliefs can be understood as an exploration of individuals' beliefs about the nature of knowledge and knowing. They also emphasized four dimension of epistemic beliefs, namely certainty of knowledge, development of knowledge, source of knowing and justification of knowing (Hofer and Pintrich, 1997, p.81). Despite, learning can be considered as complex phenomenon, several researchers have showed that students' epistemic beliefs can predict their attitudes, self-efficacy, motivation, metacognition, and achievement (Chen, 2012, p.730; Fulmer, 2014, p.202). In addition, especially in science education, students' epistemic beliefs can positively affect their effective learning, such as on conceptual learning, science inquiry, laboratory practices (Lee et al., 2016, p.3).

To date, several studies examined the discipline-specific students' epistemic beliefs during last two decades (e.g., Muis et al., 2006, p.12; Lin et al., 2012, p.797). 'Biology' as one of the main science subjects, some studies already explored students' epistemic beliefs in biology (EBB) such as, Sinatra et al. (2003), Lin et al. (2012) and Sadi and Dağyar (2015). Historically, Weiner and his colleagues were pioneered in development of measurement instruments for

epistemic beliefs in three science areas, including physics, chemistry, and biology (Adams et al., 2008, p.9). Unfortunately, we have a great research and knowledge gap of the discipline-specific (e.g., biology) students' epistemic beliefs in Mongolia.

Therefore, in this study, we aimed to examine students' (both high school and university) epistemic beliefs in biology using questionnaire data gathered from high school and university students. Participants were differed in gender, grade (level), subject major and interest in biology.

2. MATERIALS AND METHODS

Participants:

The participants in this study included 388 high school students (202 male and 186 female students) (also known as pupils) and 200 biology-majoring university undergraduate students (32 male and 168 female students). For high schools' participants, we collected questionnaire data from five different public schools from different geographical regions (e.g., central and eastern), as well as from different levels of administrative unit (e.g., capital city, center of aimag and village or soum). Whereas, we sampled from four different state universities, namely National University of Mongolia, Mongolian National University of Medical Sciences, Mongolian University of Science and Technology and Mongolian National University of Education, for biology-majoring university undergraduate students' epistemic beliefs in biology. The high school students' grade ranged from 9^{th} grade to 12^{th} grade, meanwhile, the university participants' level ranged from 1^{st} level to 5^{th} level. All participants were participated in our questionnaire survey voluntarily. We surveyed the high school students in their classroom with hard copies of our designed questionnaire, whereas, we used Google Forms platform to survey university students.

Instruments:

To measure epistemological beliefs in biology of different levels of students, we used previously developed questionnaire, named as Epistemic Beliefs in Biology Questionnaire (EBBQ) survey (Conley et al., 2004, p186). EBBQ survey then modified by Lin et al. (2012, p.805), especially for biology subject. We structured our survey with four main factors: source, certainty, development, and justification as initially described in Liang and Tsai (2010, p.2). We provided descriptions of factors and variables that used in study in Table 1.

Table 1. Definitions of factors and variables used in this study

A. Four factors: from Lin et al. (2012, p.800)

Factors	**Definition**
Source	'Assessing students' beliefs about biological knowledge residing in external authorities.'
Certainty	Evaluating students' beliefs about the right answer in biological knowledge.
Development	'Assessing learners' beliefs about biological knowledge as an evolving and changing subject.'
Justification	'Examining learners' views on the role of experiments and how an individual learner justifies biological knowledge.'

B. Three variables: from this study

Variables	**Types**	**Definition**
Gender	Male versus Female in both high school and universities	Sex of participants.
Studying level	Grades in high school: 9^{th} and 10^{th} grades used as 'lower grade', 11^{th} and 12^{th} grade used as 'higher grade'. Level in university students: 1^{st}-2^{nd} levels used as 'lower level', 3^{rd} -5^{th} levels used as 'higher level'.	The studying grades or levels of participants in this study.
Interest in biology	High school students: Take exam or not (Yes/No) University students: applied (medicine, biochemistry, biotechnology) and theoretical majoring (biology teacher, ecology etc.)	Exam: high school students were divided into two groups who will take enrollment exam in biology and not.

Data analysis:

The original questionnaire that modified by Lin et al. (2012) consisted of 21 items. Of these, we used 12 items to modify high school student survey. Whereas, we used 19 of these items for university student survey (Table S1). We used a seven-point Likert scale: presented in bipolar strongly agree/strongly disagree statements (e.g., strongly agree – 7, agree – 6, somewhat agree – 5, neutral – 4, somewhat disagree – 3, disagree – 2, strongly disagree – 1). Moreover, a higher score indicates more likely to agree with the sophisticated epistemic beliefs. We evaluated validity and reliability of the questionnaire accordingly. We also used *t*-test to examine any differences in epistemic beliefs with different variables.

3. RESULTS

The responses of university and high school participants were summarized in Table 2. We have divided participants' responses of EBBQ into four factors, such as source, certainty, development and justification. In addition, the overall reliability (Cronbach's alpha) coefficient of four factors was 0.78 (ranged from 0.67 - 0.88), suggesting the moderate to higher reliability in assessing the students' epistemic beliefs in biology in Mongolia. According to Table 1, the biology-majoring university students scored over 5 (somewhat agree) for all factors, suggesting that higher level of (known as mature) epistemic beliefs in biology, meanwhile, high school students scored significantly lower than university students' scores. Among the factors, *Justification* and *Source* received higher scores than other two factors at both of university and high school levels (Table 2).

Table 2. Factor means and differences between university students and high school students of EBBQ

Factors	Mean US (SD)	Mean HS (SD)	*t* test
Factor 1: Source	5.54 ±0.82	5.03 ±1.48	9.68***
Factor 2: Certainty	5.01 ±1.3	4.50 ±1.52	8.49***
Factor 3: Development	5.32 ±1.01	4.64 ±1.45	9.34***
Factor 4: Justification	5.89 ±0.87	5.45 ±1.43	10.4***

US = university students; HS = high school students; Overall alpha = 0.78; Significance: * P = 0.05; **P < 0.05; ***P < 0.001

The influence of gender on students' epistemic beliefs in biology: We examined the level of gender influence on university and high school students' epistemic beliefs in biology alternatively (Table 3). Our findings showed that gender do not influence on biology-majoring university students' epistemic beliefs in biology in terms of three factors. Only, the mean score of *Certainty* for male students was significantly higher than female students' score (Table 3). Whereas, the high school girls responded with higher scores than those for boys in terms of all factors. Our results strongly suggested that high school female students tented to have more mature epistemic beliefs in biology.

The influence of studying level on students' epistemic beliefs in biology: In this study, we endeavored to examine equal number students from high school grades and university levels. For high school participants, we teste relatively equal number of students from lower and higher grades. Unfortunately, we

examined unequal number of students from lower and higher levels (the majority of university participants were belonged to lower level). For university participants, Table 4 indicated that mean score of *Source* for students who studying in lower-level (1st and 2nd) significantly higher than those for students who studying in higher-level (3rd – 5th) (Table 4).

Table 3. Factor means by gender differences of EBBQ

Factors	Male mean (SD)	Female mean (SD)	*t* test
University students mean differences			
Source	5.87 ±0.77	5.77 ±0.89	0.92
Certainty	5.36 ±0.94	4.93 ±1.02	4.54**
Development	5.48 ±1.19	5.29 ±1.34	1.47
Justification	5.89 ±0.79	5.90 ±0.82	0.07
High school students mean differences			
Source	4.92 ±1.61	5.14 ±1.34	-2.48**
Certainty	4.35 ±1.62	4.65 ±1.41	-3.26**
Development	4.54 ±1.50	4.74 ±1.41	-1.95*
Justification	5.27 ±1.60	5.61 ±1.24	-4.62**

Significance: * P = 0.05; **P < 0.05; ***P < 0.001

Table 4. Factor mean differences between lower and higher level students of EBBQ

Factors	Lower mean (SD)	Higher mean (SD)	*t* test
University students mean differences: lower n = 125; higher n = 75			
Source	5.58 ±0.81	5.47 ±0.83	1.97*
Certainty	4.97 ±1.31	5.04 ±1.34	0.81
Development	5.38 ±1.19	5.22 ±1.34	1.52
Justification	5.89 ±1.00	5.89 ±1.01	0.01
High school students mean differences: lower n = 201; higher n = 187			
Source	5.18 ±1.36	4.88 ±1.59	3.44**
Certainty	4.62 ±1.43	4.38 ±1.60	2.67*
Development	4.65 ±1.44	4.63 ±1.47	0.20
Justification	5.56 ±1.39	5.32 ±1.47	3.26**

Significance: * P = 0.05; **P < 0.05; ***P < 0.001

There were no significant differences observed for other factors. Unlike university students, the mean scores of *Source*, *Certainty* and *Justification* for high school students who studying in lower-grades (9th and 10th) significantly higher than mean scores of students who studying in higher-grades (11th – 12th) (Table 4). This findings indicating that the lower-level (or grade) students also

tended to have more mature views of epistemic beliefs in biology in both university and high school level.

The influence of majoring differences on students' epistemic beliefs in biology: In this section, we used majoring differences in university students as applied and theoretical academic track. Whereas, we used this term for high school students who will take the university entrance exam in biology (as interested in biology) and do not take any biology (as not interested in biology) exams after their graduation. According to Table 5, there were no significant differences among the mean scores of four factors between applied and theoretical majoring university students (but all mean scores were > 5). Although, high school students who will take enrollment exam in biology (group names as interested in biology), scored significantly higher scores for *Source*, *Certainty* and *Justification* compared to those who will not take that exam (Table 5).

Table 5. Factor means of interested in biology of high school and applied and theoretical biology majoring student in university, EBBQ

Factors	Applied mean (SD)	Theoretical mean (SD)	*t* test
University students mean differences: applied n= 63; theoretical n = 137			
Source	5.54 ±0.80	5.54 ±0.87	0.09
Certainty	5.03 ±1.33	4.91 ±1.30	1.47
Development	5.27±1.03	5.44 ±0.95	1.49
Justification	5.89 ±0.85	5.90 ±0.90	0.27
High school students mean differences: interested n = 114; non-interested n = 274			
Factors	Interested mean (SD)	Non-interested mean (SD)	*t* test
Source	5.36 ±1.39	4.90 ±1.50	5.05***
Certainty	4.67 ±1.49	4.43 ±1.53	2.50*
Development	4.72 ±1.49	4.61 ±1.44	0.91
Justification	5.72 ±1.26	5.33 ±1.48	5.23***

Significance: * P = 0.05; **P < 0.05; ***P < 0.001

4. DISCUSSION

We initially examined epistemic beliefs in biology of biology-majoring students from four main universities, and high school students from five public schools in Mongolia. To date, several studies investigated students' epistemic beliefs in biology together with factors that influence their beliefs, as well as relationships between students' epistemic beliefs in biology and their approaches to learning biology (e.g., Sinatra et al., 2003, p.513; Muis et al., 2006, p.12; Adams et al.,

2006, p.9; Lin et al., 2012, p.797; Fujiwara et al., 2012, p.194; Sadi, 2015, p.1062; Lee et al., 2016, p.3). For instance, Fujiwara et al. (2012, p.187) emphasized that students' epistemic beliefs about particular science subject (e.g., biology) is more likely shaped from their past learning experiences, which is not yet fully explored. The past learning experiences of university students could be explained by their high school biology learning experiences. Thus, we have explored the both high school and university students' epistemic beliefs in biology in this study.

Several previous studies have highlighted that a factor Justification had accounted for the higher mean scores for students' epistemic beliefs in biology, as well as considered as positive predictor of students' learning conceptions and learning strategies (Lin et al., 2012, p.800; Lee et al., 2016, p.14). Similarly, we found that factors Justification and Source received significantly higher mean scores (5.89 and 5.54 respectively) than those for other two factors. Furthermore, our results showed that high school students have significant lower epistemic beliefs in biology compare to biology-majoring university students. Such immature epistemic beliefs about biology among high school students (especially those in higher grades) may have influenced the decreased number of students who majoring in biology in universities in Mongolia. For high school students' epistemic beliefs in biology, Sadi (2015, p.1072) investigated relationships between high school students' epistemic beliefs in biology and conceptions of learning in biology. They found some positive relationships between factors and lower-level of conceptions of learning in biology Sadi, 2015, p.1069). To date, they have not measured the mean factor scores of students' epistemic beliefs in biology for comparison.

Two of previous studies (Lin et al., 2012, p.800; Fujiwara et al., 2012, p.194;) have examined the variations of mean factor scores of epistemic beliefs in biology, between participants' gender, age, interest in biology, high school types and subject major. Consistent with our study, Lin et al. (2012, p.801) found that mean scores of Source and Certainty for male university students significantly higher than those for female students. This finding may suggests that female university students have less mature epistemic beliefs in biology in terms of Certainty of biology knowledge. In addition, Karabenick and Moosa (2005, p.390) found that male students had more trust in authority of biology (as Source of biology knowledge) than female students in Oman. Therefore, such gender differences could be influenced by their religion, more broadly sociocultural context to which students belong. In Mongolia, it seems that religion does not influence the gender difference in students' epistemic beliefs in biology. Instead, this might be explained as sexual minority students' group (male students in female dominant environment). A previous study found that sexual minority students scored higher on intellectual and academic success, compared to their

non-sexual minority group (Amodeo et al., 2020, p.10). Interestingly, contrast with biology-majoring university students, the female high school students tended to have more mature epistemic beliefs in biology than male students had (respect to the all factors). Similarly, Aydemir et al. (2013, p.1316) highlighted that high school students' gender had a great influence on favor of female students in terms of Justification/Development of biological knowledge. Otherwise, there were inconsistency for the effect of gender on high school students' epistemological beliefs.

Subsequently, our findings showed that lower-level university students tended to have a more mature view regarding the authority of biological knowledge, whereas the mean scores for the other three factors did not differ significantly. Inconsistent with this study, Lin et al. (2012, p.804) showed more immature views on four factors of epistemic beliefs in biology than higher level undergraduate students. This phenomenon explained by more year spent majoring in biology (Lin et al., 2012, p.804). For lower-level university students more mature view on authority of biological knowledge, this pattern may be explained by the fact that subjects in lower level are typically supported by textbooks and instructional materials with more experimental activities, at least in Mongolian universities. In addition, our findings showed that lower-grade high school students (9th and 10th) have more mature epistemic beliefs regarding biology than lower-grade students (11th and 12th). Aydemir et al. (2013, p.1316) found similar patterns in their study. In contrast, Conley et al. (2004, p.198) highlighted the positive relationship between maturity views of epistemic beliefs in biology and increase in grade of high school students.

Eventually, we found no significant differences among the mean scores of four factors between applied and theoretical majoring university students. However, a previous study emphasized that theoretical biology-majoring students tend to have more mature beliefs in learning biology than applied biology students (Lin et al., 2012, p.804). We have divided high school participants into two distinct groups: i) those interested in biology or take enrollment exam in biology, and ii) those not interested in biology or no enrollment exam in biology, to examine potential differences. More in detail, the students those interested in biology (mean score = 5.11) have more mature epistemic beliefs regarding biology than those who not interested in biology (mean score = 4.81). Consistent with this findings, Fujiwara et al. (2012, p.193) found that students with low interest in biology was significantly lower epistemic beliefs than students with high interest in biology. This pattern explained by the students who interested in biology (also consider as preparing majoring in biology) spend more time for effective learning in biology.

In conclusion, overall mean scores of all factor for biology-majoring university students' epistemic beliefs in biology were higher than 5 (somewhat agree). This

finding indicates biology-majoring university students have more mature views on epistemic beliefs in biology. There were no factors that consistently different between our variables (gender, level, academic track) in university students. Whereas, the high school students tended to have less mature views in overall epistemic beliefs in biology, which could be linked with the shortage of engaging experimental lessons and inadequate laboratory resources in the majority part of Mongolian public schools.

ACKNOWLEDGEMENTS

Author would like thank to high school biology teachers who were helped during the questionnaire surveys. Also authors express their grateful to the research students Khulan and Erdene-Oyun for their great support during the questionnaire surveys.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

AUTHOR CONTRIBUTION

Otgontsetseg Khuderchuluun: Conceptualization; Data curation; Writing-original draft. **Erdenetushig Purevee**: Conceptualization; Methodology. **Onolragchaa Ganbold**: Conceptualization; Visualization; Formal analysis; Writing review & editing.

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