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# The intersection of epistemic beliefs and gender in argumentation performance

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**ABSTRACT**

This study explores the intersection role of students' epistemic beliefs and gender in argumentative essay writing. In total, 148 undergraduate students from a Dutch university followed an argumentation module, filled out the epistemic beliefs survey, and wrote an argumentative essay. Results showed that students' beliefs about the Internet-specific justification of knowledge did not influence essay performance. On the other hand, beliefs about the nature of scientific knowledge influenced their argumentative essay writing. Overall, there were no gender differences in argumentative essay writing. However, female students outperformed male students in taking a position on the topic. The interaction effects of beliefs about the Internet-specific justification of knowledge and gender in argumentation performance were neutral. There was, however, an intersection effect of students' epistemic beliefs about the nature of scientific knowledge and their gender in argumentation performance. We discuss these results and provide suggestions for future research.

**KEYWORDS**

Argumentative essay writing; epistemic beliefs; gender; higher education; online learning

## Introduction

Writing an argumentative essay is one of the most common genres of writing in higher education (Noroozi et al., 2023). Such writing requires students to contemplate a specific controversial topic, take a side, gather information, and present a critical evaluation of different perspectives on the topic (Kerman, Banihashem, et al., 2022). A high-quality argumentative essay entails a general introduction, a clear position, arguments in favour of and against the position, a response to counterarguments, and a conclusion (Bayat et al., 2022; Kerman, Noroozi, et al., 2022; Noroozi et al., 2016, 2023; Toulmin, 1958; Valero Haro et al., 2019). Scientific evidence suggests that students' argumentation performance in essay writing can be influenced by their epistemic beliefs (e.g. Baytelman et al., 2020; Chan et al., 2011; Noroozi, 2022; Nussbaum et al., 2008) and their gender (e.g. Asterhan et al., 2012; Noroozi et al., 2012, 2020, 2022; Tsemach & Zohar, 2021).

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Epistemic beliefs refer to students' beliefs about knowledge (Schommer, 1990). Such beliefs can include beliefs about the certainty of knowledge (a range between unchanging to evolving nature of knowledge), the source of knowledge (a range between external to internal source of knowledge), and the justification of knowledge (a range between subjectivist to objectivist justification of knowledge) (Hofer & Pintrich, 1997). These epistemic beliefs can affect the way students argue (Baytelman et al., 2020; Nussbaum et al., 2008). For example, Noroozi (2022) found that students with different perceptions of knowledge perform differently in their argumentation performance. Students who believe in the evolving and changing nature of knowledge perform better in argumentation compared to students who believe in the certainty of knowledge (a belief that there is only one truth or certain fact). Similarly, Baytelman et al. (2020) found that the more students have sophisticated epistemic beliefs, the higher quality of argumentation they provide.

Alongside students' epistemic beliefs, gender is another critical factor in argumentation (Asterhan et al., 2012; Tsemach & Zohar, 2021). Asterhan et al. (2012) found that female students provide more high-quality arguments (see Toulmin, 1958) than male students. In another study, Nasri et al. (2018) reported gender differences in the use of stance-taking markers, for example, hedges (e.g. possibly, may, and could), boosters (e.g. definitely, sure, absolutely), and engagement features such as reader pronouns (e.g. we – to show solidarity), and directives (e.g. imperatives and obligations). While female students significantly used more hedges in their essays, male students used more boosters. In some studies, females were found to be more responsive and collaborative as they used affiliative language, while males were more informative and imperative as they used assertive language (e.g. Erkens & Janssen, 2008). Noroozi et al. (2020) found that female students deliver more in-depth and higher-quality argumentation compared to male students. Specifically, female students provided a clearer position on the topic, and also better justified their arguments by using scientific evidence compared to male students.

Although in previous studies, the effects of students' epistemic beliefs and gender on argumentation performance have been separately studied, the review of the literature suggests mixed findings. For example, in a study conducted by Noroozi (2022), the findings showed that students' epistemic beliefs influence their argumentative essay writing without any influence on their peer argumentation activities (Noroozi, 2022). Regarding gender, while Reilly et al. (2019) found higher performance for female students, Jeong and Davidson-Shivers (2006) found higher performance for male students in essay writing. On the contrary, Bastarrica and Simmonds (2019) showed no gender differences in students' argumentation performance. These inconsistent findings, raise the need for further research on the role of epistemic beliefs and gender in argumentative essay writing and peer argumentation. In addition, there is little to no empirical evidence about the intersection role of epistemic beliefs and gender in students' argumentative essay performance. What we know is that gender plays a key role in shaping one's thoughts, and epistemic beliefs are related to gender (Yang et al., 2016). For example, Yang et al. (2016) reported that male students tend to be more certain about knowledge and pay more attention to scientific facts compared to female students. However, what is not clear is how students' epistemic beliefs influence their argumentative essay writing if we see it through the lens of gender differences (Tsemach & Zohar, 2021). From a pedagogical perspective, such a study is important as it can provide guidelines for

teachers on how to support their female and male students with different epistemic beliefs in writing argumentative essays which are seen as a complex learning activity for higher education students. Therefore, this study aims to connect students' epistemic beliefs with their gender concerning their argumentation performance by addressing the following questions.

- RQ1. What is the role of students' epistemic beliefs in argumentative essay writing performance?
- RQ2. What is the role of students' gender in argumentative essay writing performance?
- RQ3. What is the intersection role of students' epistemic beliefs and gender for argumentative essay writing performance?

## Method

### *Participants*

In total, 148 undergraduate students (Female: $N = 101$, 68%; Male: $N = 47$, 32%) participated from a Dutch university. Participants were from two different course domains including Health Sciences ($N = 47$, 32%, Female = 31, Male = 16), and Environmental Sciences ($N = 101$, 68%, Female = 70, Male = 31). To comply with ethical considerations, participants were informed about the research set-up. Participants had the choice to quit the study or request the omission of their data, but none declined participation. Students were assured that their data will be treated anonymously. In addition, ethical approval was obtained from the host university.

### *Study design*

To conduct this experimental study, a module called 'Argumentative Essay Writing' was designed and implemented in the selected courses in the Brightspace platform. Students were requested to follow the module for three consecutive weeks and each week students performed one task. In the first week, students received instructions about the module and filled out the survey about their demographic information such as gender and epistemic beliefs. As the first task for week one, students were asked to write an argumentative essay on topics provided by the teachers. The original draft of the essay was considered the pre-test. In the second week, students were invited to do a peer review of two peers' argumentative essays based on the given argumentative peer review criteria (see Appendix A). The argumentative peer review was considered the second task. Finally, in the third week, students completed their third task by submitting their revised version of the argumentative essay on the Brightspace platform. The revised essay was considered the post-test.

## Measurements

### Epistemic beliefs

Students' epistemic beliefs were assessed in two categories including students' epistemic beliefs about the Internet-specific justification of knowledge (Bråten et al., 2019) and the nature of scientific knowledge (Conley et al., 2004) adjusted by Cheng et al. (2021). The Internet-specific justification of knowledge entailed 12 items to measure three dimensions including (a) personal justification (4 items), (b) justification by authority (4 items), and (c) justification by multiple sources (4 items). All items in this questionnaire were rated on a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5). These items were validated by prior studies (e.g. Kammerer et al., 2021). In this questionnaire, a higher score in each category represents students' epistemic beliefs. A higher score for personal justification represents that students rely mainly on their personal opinions and cognitive sources (i.e. knowledge and reasoning), while a higher score for justification by authority indicates that students care more about the expertise of the authors who provided the Internet-based information. Last, a higher score for justification by multiple sources shows that students rely mainly on Internet information and knowledge, check it from several sources, and compare them (Cheng et al., 2021). Students' beliefs about the nature of scientific knowledge were measured in two categories including certainty of knowledge (6 items) and development of knowledge (6 items). A higher score on the certainty of knowledge indicates that a person believes in the existence of right answers based on scientific knowledge. A higher score on the development of knowledge represents that a person believes in the evolving and changing nature of scientific knowledge (Cheng et al., 2021).

### Argumentative essay writing

To measure the quality of students' argumentative essays, a coding scheme adjusted based on Noroozi et al. (2016) instrument was used. This coding scheme was developed based on high-quality argumentative essay structure (e.g. Toulmin, 1958) and it was comprised of eight elements including (1) an introduction to the topic, (2) taking a position on the topic, (3) arguments for the position, (4) justifications for arguments for the position, (5) arguments against the position (counterarguments), (6) justifications for arguments against the position, (7) response to counterarguments, and (8) conclusion and implications. Students received a point ranging from zero (the lowest quality level) to three (the highest quality level) for each of mentioned elements. All given points for these elements were summed up together and indicated the student's total score for the quality of the written argumentative essay. The quality of students' argumentative essays was assessed in two phases. In the first phase, the original draft of students' essays was assessed as the pre-test, and in the second phase, students' revised essays were assessed as the post-test. To analyse data, five coders cooperated and Fleiss' Kappa statistic was used to determine the inter-rater reliability between the coders. The results showed 75% (Fleiss' Kappa = 0.75 [IC 95%: 0.70–0.81]; z = 26.08; $p < 0.001$) indicating significant agreement among the coders.

### *Analysis*

Since students participated in two different courses, first we needed to control the effect of students' domain knowledge on their argumentation performance. Second, to answer research question one, we used the Pearson correlation coefficient test to see if there was a linear relationship between students' epistemic beliefs and their argumentative essay performance. We also used a multiple linear regression test to explore how students' epistemic beliefs influence their argumentative essay performance. Third, to answer research question two, we performed a multiple linear regression test to investigate the role of students' gender in their argumentative essay writing performance. The reason why a multiple linear regression test was used for both research questions one and two is that there were multiple independent and dependent variables in our study, and this analysis was appropriate to model the linear relationships between the independent and dependent variables (Sen & Srivastava, 1990). Fourth, to answer research question three, we conducted a hierarchical regression test to investigate the intersection role of epistemic beliefs and gender in students' argumentative essay writing. The rationale behind the adoption of this test is that the hierarchical regression test was suitable for understanding the influences of different clusters (females' epistemic beliefs and males' epistemic beliefs) on dependent variables (argumentative essay writing) as well as understanding the interaction between them (Richardson et al., 2015).

## Results

### *RQ1: What is the role of students' epistemic beliefs in argumentative essay writing performance?*

There was no significant relationship between students' epistemic beliefs about the Internet-specific justification of knowledge including personal justification ($r = 0.039$, $p > 0.05$), justification by authority ($r = 0.174$, $p > 0.05$), and multiple sources ($r = 0.062$, $p > 0.05$) with their argumentative essay writing performance. Only, students' justification by authority was positively correlated ($r = 0.244$, $p < 0.05$) and could predict ($F(3,110) = 3.29$, $p < 0.05$) their arguments in favour of the position. Students' beliefs about the certainty of knowledge were negatively ($r = -0.251$, $p < 0.05$), and the development of knowledge were positively ($r = 0.207$, $p < 0.05$) correlated to their argumentative essay writing performance (Table 1). The results showed that students' epistemic beliefs about the nature of scientific knowledge could predict overall argumentation performance in essay writing ($F(3,110) = 3.80$, $p < 0.05$) (see Appendix B).

Table 1. The correlations between students' epistemic beliefs and argumentative essay writing performance.

| | Intro. | Posit. | Argu fav. | Just fav. | Argu agai. | Just agai. | Res argue agai. | Conc. | Overall |
|---|---|---|---|---|---|---|---|---|---|
| Personal | −0.096 | −0.005 | 0.020 | 0.008 | 0.068 | 0.073 | −0.041 | 0.074 | 0.039 |
| Authority | −0.066 | 0.138 | **.244*** | 0.122 | 0.052 | 0.054 | −0.061 | 0.102 | 0.174 |
| Multiple | −0.042 | 0.066 | 0.173 | 0.031 | −0.020 | 0.055 | −0.110 | 0.061 | 0.062 |
| Certainty | −0.001 | −0.004 | −0.069 | −0.123 | −0.182 | **−.271*** | −0.083 | −0.095 | **−.251*** |
| Developing | −0.071 | 0.141 | **.254*** | **.186*** | 0.018 | 0.139 | −0.108 | 0.131 | **.207*** |

($P < 0.05$)*.

Table 2. The role of gender in argumentative essay writing performance.

| Essay elements | Gender | Gender differences |
|---|---|---|
| Introduction to the topic | Female | $F(1,146) = 0.03$, $p = 0.84$ |
| | Male | |
| | Total | |
| Taking a position on the topic | Female | $F(1,146) = 9.64$, $p < 0.01$* |
| | Male | |
| | Total | |
| Arguments in favour of the position | Female | $F(1,146) = 0.16$, $p = 0.70$ |
| | Male | |
| | Total | |
| Justifications for arguments for the position | Female | $F(1,146) = 0.57$, $p = 0.44$ |
| | Male | |
| | Total | |
| Arguments against the position | Female | $F(1,146) = 3.34$, $p = 0.06$ |
| | Male | |
| | Total | |
| Justifications for arguments against the position | Female | $F(1,146) = 0.87$, $p = 0.35$ |
| | Male | |
| | Total | |
| Response to counterarguments | Female | $F(1,146) = 1.15$, $p = 0.28$ |
| | Male | |
| | Total | |
| Conclusion and implications | Female | $F(1,146) = 0.52$, $p = 0.46$ |
| | Male | |
| | Total | |
| Overall argumentative essay writing | Female | $F(1,146) = 0.00$, $p = 0.98$ |
| | Female | |
| | Male | |

($P < 0.05$)*.

### *RQ2: What is the role of students' gender in argumentative essay writing performance?*

No significant effects of students' gender on their argumentative essay writing performance were reported ($F(1,146) = 0.00$, $p = 0.98$). However, female students showed a higher argumentative essay writing performance in terms of taking a position on the topic compared to male students ($F(1,146) = 9.64$, $p < 0.05$) (Table 2).

### *RQ3: What is the intersection role of students' epistemic beliefs and gender for argumentative essay writing performance?*

The overall intersection role of epistemic beliefs about the Internet-specific justification of knowledge and gender for argumentative essay writing was neutral ($F(4,109) = 0.32$, $p = 0.86$). However, an intersection role of the Internet-specific justification of knowledge and gender was found in the arguments in favour of the position ($F(4,109) = 2.48$, $p < 0.05$). Male students' beliefs about the Internet-specific justification of knowledge in all categories were positively correlated with their arguments in favour of the position (personal justification, $r = 0.492$, $p < 0.05$; justification by authority, $r = 0.492$, $p < 0.05$; justification by multiple sources, $r = 0.492$, $p < 0.05$) (Table 3). In addition, the intersection role of beliefs about the nature of scientific knowledge and gender in argumentative essay writing performance was significant ($F(3,110) = 3.24$, $p < 0.05$) (see Appendix C). Female students' beliefs

**Table 3.** The correlations between male and female epistemic beliefs and argumentative essay writing.

| | Intro. | Posit. | Argu fav. | Just fav. | Argu agai. | Just agai. | Res argue agai, | Conc. | Overall |
|---|---|---|---|---|---|---|---|---|---|
| Personal-Male | −0.106 | −0.126 | **.492*** | 0.284 | −0.162 | 0.007 | −0.134 | −0.019 | 0.071 |
| Personal-Female | −0.089 | −0.018 | −0.100 | −0.107 | 0.163 | 0.091 | 0.031 | 0.100 | 0.030 |
| Authority-Male | −0.311 | 0.017 | **.547*** | −0.026 | −0.052 | −0.084 | −0.010 | 0.085 | 0.055 |
| Authority-Female | −0.010 | 0.150 | 0.179 | 0.154 | 0.098 | 0.085 | −0.056 | 0.103 | **.206*** |
| Multiple-Male | −0.340 | −0.287 | **.484*** | −0.067 | −0.094 | −0.243 | −0.202 | −0.199 | −0.278 |
| Multiple-Female | 0.032 | 0.124 | 0.105 | 0.040 | 0.025 | 0.123 | −0.045 | 0.143 | 0.151 |
| Certainty-Male | 0.171 | 0.231 | 0.068 | −0.233 | −0.381 | −0.304 | −0.310 | 0.211 | −0.215 |
| Certainty-Female | −0.050 | −0.033 | −0.110 | −0.070 | −0.166 | **−.275*** | −0.042 | −0.200 | **−.268*** |
| Developing-Male | −0.245 | −0.136 | 0.266 | 0.158 | 0.073 | 0.151 | −0.161 | −0.153 | 0.008 |
| Developing-Female | −0.013 | **.206*** | **.280*** | 0.182 | 0.040 | 0.149 | −0.042 | **.262*** | **.297*** |

($P < 0.05$)*.

about the certainty of knowledge was negatively correlated to their argumentative essay writing performance ($r = -0.268$, $p < 0.05$), while it was positively correlated to their development of knowledge ($r = 0.297$, $p < 0.05$).

## Discussion

This study explored the intersection role of students' epistemic beliefs and gender in their argumentative essay writing performance. Overall, the findings showed that students' different epistemic beliefs about the Internet-specific justification of knowledge (including personal justification of knowledge, justification by authority, and multiple sources) did not influence their overall argumentation performance in essay writing. However, students who had multiple sources of justification of knowledge performed better in terms of arguments in favour of the position. This finding did not align with the results of most prior studies in which students' epistemic beliefs were associated with their argumentation performance (e.g. Baytelman et al., 2020; Muis et al., 2021; Noroozi, 2022; Nussbaum et al., 2008). However, our result is supported by findings of a few studies where no significant relationship between students' epistemic beliefs and argumentation performance was reported (e.g. Noroozi & Hatami, 2019). We expected to see that students with justification by authority and multiple sources' beliefs perform better since this was a scientific argumentation in a higher education context and it was expected from students to provide scientific justifications for their argumentation in favour or against the position (Baytelman et al., 2020; Cheng et al., 2021). The literature suggests that scientific argumentation performance may require students to check out the authority of the source of knowledge on the Internet, whether the knowledge is provided by an expert or not. Also, since high-quality argumentative essay writing requires considering different aspects of controversial issues, it is expected that students consider multiple sources of knowledge for extending their argumentative perspective in essay writing. However, these expectations were not confirmed by this study except for arguments in favour of the position. A plausible reason for this overall contradictory finding with previous studies could be related to the specific instructions provided to all students at the start

of this study, which might have caused an alleviation of the effects of students' epistemic beliefs about the Internet-specific justification of knowledge on their argumentative essay writing performance. All students had to read the textual instructions on how to follow the module and how to write a high-quality argumentative essay. All students also had a choice to look at practical examples of good argumentative essay writing. These guidelines and practical examples might be the reason for our contradictory findings.

We found that students' beliefs about the development of knowledge were positively correlated to their performance in argumentative essay writing, while students' beliefs about the certainty of knowledge were negatively correlated. This finding is consistent with most prior studies where an influential role of epistemic beliefs on argumentation performance in essay writing was reported (e.g. Baytelman et al., 2020; Muis et al., 2021; Noroozi & Hatami, 2019). This finding suggests that good argumentation requires belief in the relativeness of knowledge. Therefore, students who believe that knowledge is certain, might not be able to see the other side of the coin and possible rebuttals. On the contrary, students who believe that knowledge has an evolving nature are more able to expand their views beyond what they believe and foresee potential rebuttals of their claims.

Our findings showed no gender differences in argumentative essay writing. However, in taking a position on the topic, female students outperformed male students. This finding, in general, is in line with a few prior studies where no gender differences were reported for argumentation performance (e.g. Asterhan, 2018), and in contrast with main previous studies (e.g. Noroozi et al., 2020; Noroozi, 2022; Reilly et al., 2019; Tsemach & Zohar, 2021). Although the overall performance of female and male students was not significantly different, female students performed better than male students in taking a position on the topic. One plausible reason for females' outperformance in taking a position on the topic could be related to their personality (M. Zhang et al., 2019; Weisberg et al., 2011). Females are more organised and disciplined than males and they pay more attention to the orderliness and details of things (Costa et al., 2001). This might explain why female students followed the structure of argumentative essay writing better than male students. In addition, if we consider the mean score of the overall argumentative essay writing and other elements of argumentative essay writing, including justifications for arguments for the position and conclusion and implications, it can be noted that females performed slightly better than males. Although this outperformance was not significant, still this might suggest implications for learning, namely that male students need more support than female students in their argumentative essay writing, particularly for taking a position on the topic.

Furthermore, the findings showed a difference in the justification by an authority in favour of females' argumentative essay performance. However, our findings revealed that the interaction effects of epistemic beliefs about the Internet-specific justification of knowledge and gender on argumentative essay writing were neutral. This means that, overall, female and male students' beliefs about the Internet-specific justification of knowledge did not influence their argumentative essay writing performance. This finding implies that even though females and males shape their thoughts and beliefs in different ways (Yang et al., 2016), this is not an influential factor when students with different beliefs use the Internet as a source of knowledge to write their argumentative essays. A possible reason to explain this neutral finding could be related to the concentration of

the argumentative essay on the structure of the elements of a high-quality argumentative essay, instead of solely considering the quality of the given content in the essay. In other words, this finding can imply that if the assessment of students' performance in essay writing is focused solely on the structure of the essay instead of the content, then it can be expected that female and male students with different epistemic beliefs about the Internet-specific justification of knowledge perform similarly.

Finally, the intersection role of epistemic beliefs about the nature of scientific knowledge and gender in argumentative essay writing performance was significant. We found that female students with beliefs about the nature of scientific knowledge could perform better in their argumentative essays compared to male students with beliefs about the nature of scientific knowledge. A plausible reason to explain this finding could be related to female and male differences in ways of thinking (Yang et al., 2016). Female students are expected to be more sceptical and they normally provide more sophisticated reasoning (Noroozi et al., 2020; Reilly et al., 2019). Previous studies suggest that students with sophisticated epistemic beliefs about the structure of knowledge can generate high-quality arguments (Baytelman et al., 2020).

## Limitations

First, due to the authentic setting of this study in a real educational setting, we had an unbalanced proportion of female and male students where female students outnumbered male students. Although this distribution of female and male participants at the host university is a typical representation of the population of this study, this might not be a good representation of the population of female and male students in other contexts. For such reason, we should cautiously interpret and generalise the results. For future studies, we suggest considering a balanced number of female and male students to provide more generalisable results.

Second, at the start of this study, students were provided with instructions on how to write an argumentative essay. This might have influenced the relationship between students' epistemic beliefs and argumentative essay writing. For future studies, to decrease the bias, we suggest that students should not be provided with such instructions.

Third, we controlled the effects of students' course domain knowledge on their argumentation performance to only focus on the effects of epistemic beliefs about the Internet-specific justification of knowledge, gender, and their interaction effects on argumentative essay writing. For future studies, it is suggested to investigate the role of students' course domain knowledge in similar studies.

Fourth, we did not explore the role of epistemic beliefs and gender in the argumentative peer review process. Future studies could explore how students' epistemic beliefs and gender might influence their argumentative peer review performance.

Last but not least, students' argumentative essay writing performance was considered as an individual task in this study. Some studies have shown that collaborative reasoning is an effective instructional strategy to expand students' way of thinking and improve critical thinking skills (Bayat et al., 2022; X. Zhang et al., 2016). Future research should investigate how male and female students with different epistemic beliefs perform when they engage in collaborative reasoning as a group task.

## Conclusion and implications for future research and practice

The findings of this study revealed that how students approach and define knowledge can impact their argumentation and that the impact differs between female and male students. Furthermore, the findings contribute to the existing literature by providing insights into how the interaction effects of epistemic beliefs and gender influence students' argumentation performance in essay writing. Those insights suggest implications for educators regarding how to guide, facilitate, and scaffold students' argumentative essay writing as a complex learning activity in higher education.

We found that students with beliefs in justification by authority provide better arguments. This finding suggests that teachers should encourage students to look for knowledge on the Internet which is validated by the expertise of the author. It was also found that students with beliefs in the certainty of knowledge provided low-quality justifications of counterarguments. This indicates that when students believe in only one absolute and certain fact, they cannot provide multiple justifications for the counterarguments. Good argumentation requires acknowledging multiple perspectives. According to this finding, teachers should encourage students to evaluate facts from different perspectives.

Our findings regarding females' higher performance compared to males in taking a position on the topic in the argumentative essay, indicates that females more clearly stated their positions compared to males. For teachers, this means that males need more support than females in their argumentation performance, particularly regarding taking a clear position on the topic. For example, teachers should provide detailed instructions on position statements for male students and should give them more opportunities to practice how to state a position in an argumentation.

Female students, with beliefs in the development of knowledge, performed better than male students with the same beliefs. A pedagogical implication for teachers is that believing in the evolving and changing nature of knowledge is important for formulating a good argumentation and in this regard male students need more support than female students. This means that teachers should first identify what kind of epistemological beliefs male and female students have. Then, male students with beliefs in the development of knowledge should be provided with good examples of how scientific knowledge has evolved over time and how scientific controversial issues have been addressed or resolved through argumentation.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

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# Appendix

## Appendix A. Argumentative peer review criteria

| Argumentative essay elements | Argumentative essay checker question prompt |
|---|---|
| Introduction to the topic | To what extent did your peer present a clear introduction to the topic in terms of motivation, importance, and the societal aspect of the issue at hand? What are your suggestions? Please explain. |
| Taking a position on the topic | To what extent did your peer present a clear position on the topic in favour or against the topic? What are your suggestions? Please explain. |
| Arguments for the position | To what extent did your peer provide arguments in favour of her/his own position on the topic? What are your suggestions? Please explain. |
| Justifications for arguments for the position | To what extent did your peer provide justifications (facts, evidence, examples, figures, experiences, etc.) for arguments in favour of her/his position? What are your suggestions? Please explain. |
| Arguments against the position (counterarguments) | To what extent did your peer provide arguments against her/his position (counterarguments) on the topic? What are your suggestions? Please explain. |
| Justifications for arguments against the position | To what extent did your peer provide justifications (facts, evidence, examples, figures, experiences, etc.) for arguments against her/his own position? What are your suggestions? Please explain. |
| Response to counterarguments | To what extent did your peer respond (using justified arguments) to various counterarguments against her/his position? What are your suggestions? Please explain. |
| Conclusion and implications | To what extent did your peer come to a conclusion (restating her/his position) followed by a clear implication (suggestion and/or plan of action) for the position? What are your suggestions? Please explain. |

## Appendix B. The role of epistemic beliefs in argumentative essay writing performance

| Epistemic beliefs | Argumentative essay | Epistemic beliefs category | Epistemic beliefs differences |
|---|---|---|---|
| Beliefs about the Internet-specific justification of knowledge | Introduction to the topic | Personal | F(3,110) = 0.38, $p = 0.76$ |
| | | Authority | |
| | | Multiple | |
| | | Total | |
| | Taking a position on the topic | Personal | F (3,110) = 0.94, $p = 0.42$ |
| | | Authority | |
| | | Multiple | |
| | | Total | |
| | Arguments in favour of the position | Personal | F(3,110) = 3.29, $p < 0.05$* |
| | | Authority | |
| | | Multiple | |
| | | Total | |
| | Justifications for arguments for the position | Personal | F(3,110) = 0.62, $p = 0.60$ |
| | | Authority | |
| | | Multiple | |
| | | Total | |
| | Arguments against the position | Personal | F(3,110) = 0.38, $p = 0.76$ |
| | | Authority | |
| | | Multiple | |
| | | Total | |
| | Justifications for arguments against the position | Personal | F(3,110) = 0.23, $p = 0.87$ |
| | | Authority | |
| | | Multiple | |
| | | Total | |
| | Response to counterarguments | Personal | F(3,110) = 0.47, $p = 0.70$ |
| | | Authority | |
| | | Multiple | |
| | | Total | |
| | Conclusion and implications | Personal | F(3, 110) = 0.44, $p = 0.72$ |
| | | Authority | |
| | | Multiple | |
| | | Total | |
| | Overall argumentative essay writing | Personal | F(3,110) = 1.18, $p = 0.31$ |
| | | Authority | |
| | | Multiple | |
| | | Total | |

(*Continued*)

(Continued).

| Epistemic beliefs | Argumentative essay | Epistemic beliefs category | Epistemic beliefs differences |
|---|---|---|---|
| Beliefs about the nature of scientific knowledge | Introduction to the topic | Certainty | $F(3,110) = 0.42$, $p = 0.73$ |
| | | Development | |
| | | Total | |
| | Taking a position on the topic | Certainty | $F(3,110) = 0.88$, $p = 0.45$ |
| | | Development | |
| | | Total | |
| | Arguments in favour of the position | Certainty | $F(3,110) = 2.73$, $p < 0.05$* |
| | | Development | |
| | | Total | |
| | Justifications for arguments for the position | Certainty | $F(3,110) = 1.79$, $p = 0.15$ |
| | | Development | |
| | | Total | |
| | Arguments against the position | Certainty | $F(3,110) = 1.91$, $p = 0.12$ |
| | | Development | |
| | | Total | |
| | Justifications for arguments against the position | Certainty | $F(3,110) = 3.22$, $p < 0.05$* |
| | | Development | |
| | | Total | |
| | Response to counterarguments | Certainty | $F(3,110) = 0.79$, $p = 0.49$ |
| | | Development | |
| | | Total | |
| | Conclusion and implications | Certainty | $F(3,110) = 1.18$, $p = 0.31$ |
| | | Development | |
| | | Total | |
| | Overall argumentative essay writing | Certainty | $F(3,110) = 3.80$, $p < 0.01$* |
| | | Development | |
| | | Total | |

($P < 0.05$)*.

## Appendix C. The intersection role of epistemic beliefs and gender for argumentative essay writing performance

| | Argumentative essay elements | Gender | Epistemic beliefs category | Interaction effects of epistemic beliefs and gender |
|---|---|---|---|---|
| Beliefs about the Internet-specific justification of knowledge | Introduction to the topic | Female | Personal | $F(4,109) = 0.32$, $p = 0.86$ |
| | | | Authority | |
| | | | Multiple | |
| | | | Total | |
| | | Male | Personal | |
| | | | Authority | |
| | | | Multiple | |
| | | | Total | |
| | Taking a position on the topic | Female | Personal | $F(4,109) = 2.26$, $p = 0.06$ |
| | | | Authority | |
| | | | Multiple | |
| | | | Total | |
| | | Male | Personal | |
| | | | Authority | |
| | | | Multiple | |
| | | | Total | |
| | Arguments in favour of the position | Female | Personal | $F(4,109) = 2.48$, $p < 0.04$* |
| | | | Authority | |
| | | | Multiple | |
| | | | Total | |
| | | Male | Personal | |
| | | | Authority | |
| | | | Multiple | |
| | | | Total | |
| | Justifications for arguments for the position | Female | Personal | $F(4,109) = 0.84$, $p = 0.50$ |
| | | | Authority | |
| | | | Multiple | |
| | | | Total | |
| | | Male | Personal | |
| | | | Authority | |
| | | | Multiple | |
| | | | Total | |
| | Arguments against the position | Female | Personal | $F(4,109) = 1.01$, $p = 0.40$ |
| | | | Authority | |
| | | | Multiple | |
| | | | Total | |
| | | Male | Personal | |
| | | | Authority | |
| | | | Multiple | |
| | | | Total | |

(*Continued*)

(Continued).

| | Argumentative essay elements | Gender | Epistemic beliefs category | Interaction effects of epistemic beliefs and gender |
|---|---|---|---|---|
| | Justifications for arguments against the position | Female | Personal | $F(4,109) = 0.17$, $p = 0.95$ |
| | | | Authority | |
| | | | Multiple | |
| | | | Total | |
| | | Male | Personal | |
| | | | Authority | |
| | | | Multiple | |
| | | | Total | |
| | Response to counterarguments | Female | Personal | $F(4,109) = 1.30$, $p = 0.27$ |
| | | | Authority | |
| | | | Multiple | |
| | | | Total | |
| | | Male | Personal | |
| | | | Authority | |
| | | | Multiple | |
| | | | Total | |
| | Conclusion and implications | Female | Personal | $F(4,109) = 0.35$, $p = 0.83$ |
| | | | Authority | |
| | | | Multiple | |
| | | | Total | |
| | | Male | Personal | |
| | | | Authority | |
| | | | Multiple | |
| | | | Total | |
| | Overall argumentative essay writing | Female | Personal | $F(4,109) = 0.32$, $p = 0.86$ |
| | | | Authority | |
| | | | Multiple | |
| | | | Total | |
| | | Male | Personal | |
| | | | Authority | |
| | | | Multiple | |
| | | | Total | |
| Beliefs about the nature of scientific knowledge | Introduction to the topic | Female | Certainty | $F(3,110) = 0.28$, $p = 0.84$ |
| | | | Development | |
| | | | Total | |
| | | Male | Certainty | |
| | | | Development | |
| | | | Total | |

(*Continued*)

(Continued).

| Argumentative essay elements | Gender | Epistemic beliefs category | Interaction effects of epistemic beliefs and gender |
|---|---|---|---|
| Taking a position on the topic | Female | Certainty | F(3,110) = 2.69, $p < 0.05$* |
| | | Development | |
| | | Total | |
| | Male | Certainty | |
| | | Development | |
| | | Total | |
| Arguments in favour of the position | Female | Certainty | F(3,110) = 2.69, $p < 0.05$* |
| | | Development | |
| | | Total | |
| | Male | Certainty | |
| | | Development | |
| | | Total | |
| Justifications for arguments for the position | Female | Certainty | F(3,110) = 1.74, $p = 0.16$ |
| | | Development | |
| | | Total | |
| | Male | Certainty | |
| | | Development | |
| | | Total | |
| Arguments against the position | Female | Certainty | F(3,110) = 2.55, $p < 0.05$* |
| | | Development | |
| | | Total | |
| | Male | Certainty | |
| | | Development | |
| | | Total | |
| Justifications for arguments against the position | Female | Certainty | F(3,110) = 3.05, $p < 0.05$* |
| | | Development | |
| | | Total | |
| | Male | Certainty | |
| | | Development | |
| | | Total | |
| Response to counterarguments | Female | Certainty | F(3,110) = 2.50, $p = 0.06$ |
| | | Development | |
| | | Total | |
| | Male | Certainty | |
| | | Development | |
| | | Total | |
| Conclusion and implications | Female | Certainty | F(3,110) = 0.76, $p = 0.51$ |
| | | Development | |
| | | Total | |
| | Male | Certainty | |
| | | Development | |
| | | Total | |
| Overall argumentative essay writing | Female | Certainty | F(3,110) = 3.24, $p < 0.05$* |
| | | Development | |
| | | Total | |
| | Male | Certainty | |
| | | Development | |
| | | Total | |

($P < 0.05$)*.