2026 ASEE ANNUAL CONFERENCE June 21–24, 2026 | Charlotte Convention Center, NC
Host Sponsor UNC Charlotte
Paper ID #51783

WIP: Graduate Student Epistemological Beliefs: PreService Faculty views on Learning Engineering

Mr. Duncan H Mullins, University at Buffalo, The State University of New York

Duncan Mullins is a Fifth year PhD Candidate in Engineering Education, part of UB's Inaugural cohort of students. He has a master's in chemical engineering and a love of teaching.

WIP: Graduate Student Epistemological Beliefs: PreService Faculty views on Learning Engineering

Introduction

Graduate students are well-trained in the mechanisms and practices of research. But even as faculty-to-be, they are rarely prepared for the pedagogical skills they will need in these faculty roles. Further, the epistemology of engineering graduate students is under-studied, particularly in terms of their views toward learning and teaching.

This work is developed to provide better foundational knowledge understanding the epistemological beliefs of PreService Faculty (PSF), which the authors define as engineering graduate students intent on pursuing a faculty position after their degree. This foundational literature will inform the field as to the views of PSF towards what it means to learn engineering or how this can be facilitated. PSF views on these topics can be well examined through the lens of epistemological beliefs.

Epistemological beliefs are deeply held, rarely consciously known, and highly influential on every action in teaching [1], [2], [3], [4], [5], [6]. Epistemological beliefs considers how the views an individual holds about knowledge and knowing can develop across various dimensions, rather than specific stages of nuance. Further, this model captures the inconsistent and contextual nature of beliefs, which can vaEpistemological beliefs have been leveraged as a framework to evaluate numerous adjacent populations, including undergraduate students [7], [8], [9], [10], [11], [12], [13], engineering faculty [14], [15], [16], [17], and preservice teachers [18], [19], [20], [21], [22], [23]. Additionally, these beliefs have been shown to have significant influence on the teaching actions of classroom educators and faculty [4], [11], [24], [25], [26], [27], [28], [29], [30], [31], [32], [33], [34], [35]. Given these factors, it is essential to better understand the epistemological beliefs of PSF in order to provide better pedagogical preparatory experiences.

Understanding PSF epistemological beliefs around learning engineering will help in determining how to provide opportunities to develop or refine those beliefs, as well as providing more tailored professional development opportunities for these PSF. Moreover, engineering as a discipline brings its own unique characteristics (such as a strong focus upon the impact of knowledge or the emphasis on discovering a physical reality) which poses a need for more discipline-specific training when compared to the ones available in other STEM (Education) counterparts.

This work asks the question: “What do PSF consider to be the phenomenon of ‘Learning Engineering’?”

Methods

This work used a modified descriptive phenomenological inquiry, drawn from Husserlian traditions [36], [37], [38], [39], alongside detailed analytic procedures to develop a preliminary model describing how PSF view the phenomenon of ‘Learning Engineering.’

Participants

12 PreService Faculty were recruited at a large US, NorthEastern Urban university. Participants were asked to self describe, and their range of demographics are presented below.

Table 1: Participant Demographics

Participant (selected pseudonym)	Program	Year in program	Pronouns	Ethnicity	Background degrees	Other facets
Alexandra	AE PhD	Third	They/them; "any pronouns with respect"	White	BS AE, MS Material Science	Queer, Neurodivergent (ADHD)
Ariana	CBE PhD	First	she/her/hers	Black	BS CBE	None
Batman	ME PhD	Fourth	He/him/his	Asian	BS ME, Math	None
Elizabeth Johnson	BME PhD	Second	she/her/hers	White	BS CBE	none
Jack	ME PhD	Third	he/him/his	Indian, Portuguese	BS ME, MS AE	None
Josh Allen	EE PhD	Third	he/him/his	caucasian; polish descent	BS and MS EE	None
Leslie Knope	Engr Ed PhD	First	she/her/hers	Caucasian	BS ME	Non-traditional; industry experience; married; older
Moh	BME PhD/MD	Fifth	he/him/his	Asian: Indian Descent	BS BME, MS BME	Vegas born, midwest raised; immigrant parents
Sam	Engr Ed PhD	First	he/him/his	Asian: Indian	BS ME, MS ME, PhD ME	previously faculty; doing second phd
Sora	CBE PhD	First	she/her/hers	Middle Eastern	BS CBE	spiritual. Arabic speaker,
Will	BME PhD	First	He/him/his	Chinese, Ecuadorian	BS BME	None
Zack	ME PhD	Third	he/him/his	White	BS ME/AE, MS ME	None

Phenomenological inquiry

Data for this project was collected via three phases [40], [41], [42]. All participants completed the full phase sequence prior to compensation; this consisted of a pre-interview priming question, asking them to define in their own words the phenomenon of consideration. They were asked to “describe in your own words what you consider it means to “Learn Engineering.” Participants were required to send this 12 hours before the interview, though 24 hours was requested. Participants were also informed in advance of an activity they would be requested to engage within during the interview, where they would describe how they planned to teach a specific population some specific topic. They got to choose the topic, population, area of focus, and were informed they would be asked about their personal understanding of the topic, whether the learners were voluntary or mandated, and the level of the learner. All these follow-up questions were only used if the participant did not cover the information during their description of the context, importance, and teaching of the topic.

After the interview, at least 24 hours later, they were sent a post-interview task which asked them to detail a narrative of a time they distinctly recall experiencing ‘Learning engineering,’ complete with emotions, reflective insights, and how they knew the phenomenon was occurring. Participants were provided an example narrative, of the author’s own experience with the phenomenon of ‘baking a pie’ to give scaffolds as to the type of language, description, and intentional reflection desired, yet not pre-dispose them in any way for their own narrative. These three pieces of data were leveraged for triangulating of analysis. Each participant thus contributed a pre-interview description, an interview with an educational activity, and a post-interview narrative to the data corpus.

Analytic procedures

This analysis process was chosen to align to Giorgi’s process for descriptive phenomenology [43], as it was the most detailed and rigorous method identified. Further, given the method’s development within analytic psychology, this method balances the well-structured nature of STEM with the intuitive and adaptive methods inherent to qualitative research, and especially within phenomenology.

Giorgi’s method follows general protocols of phenomenology and is presented below.

A. Listen to each interview repeatedly.

B. Identify key elements or codes within the interview.

C. Only use the participant’s words to define those codes.

D. Determine the organizations of those codes, or themes for the interview.

E. Organize the themes within a hierarchy for the phenomenon

F. Repeat this process for every interview, independent of other interviews.

G. Look across all the interviews for consistent themes and hierarchical relations.

H. Determine which of those themes and relations are most important and essential to the phenomenon.

I. Develop the composite phenomenon via those essential themes and relationships. This should take the form of a hierarchy of themes.

This analysis was conducted for each participant individually, then comparing those individual phenomenon structures to develop a composite hierarchy of consistent themes for the entire population. Each individual phenomenon structure was composed from each participant's unique individual themes, giving particular emphasis to elements which were present across multiple data sources (e.g. personal definition, interview, and/or narrative). More detailed information about the method is contained in prior works by the author [blinded for review].

Findings

Findings include the views that even though the conceptual basis of engineering is important, this is treated as a given fact and not focused upon by PSF. More important to the process of learning engineering are elements such as: the development of self-assessment skills, personal metacognition, and the process of learning "what engineering actually is."

Learning engineering- a complex structure

Learning engineering was a phenomenon composed of four primary strands, answering the sentence stem'Learning Engineering is': learning the essence of engineering, developing self-assessment capabilities and metacognition, mostly done within an academic context, and through the grasping of specific conceptual topics.

Strand 1: Learning the essence of engineering

Learning engineering requires learning what engineering even is, or discovering the essence of the field. This is facilitated through learning knowledge or topics in their context, learning applications for knowledge, and both of these can be done through dialogic learning methods.

Learning engineering is not just learning a bunch of concepts, but further is learning how to apply those together like a toolset, to frame, consider or solve problems facing society. Sam describes this well, how you must have "both system and focused view." By this Sam means that you have to learn how to understand individual concepts or components, as well as the larger context or system; Sam elaborates on an example of this as both understanding what Bernoulli's equation is, as well as how or why fluid flow in a pipe is a valuable topic to learn. Sam asserts that the dual understanding of the entire pipe system as well as Bernoulli's equation, and how to do both and maneuver between them, is an important part of engineering. Sam also describes this as occurring within "meaningful memories" and how these require elements such as: "self-reflection, visualization resources, to apply topics in real life, and how [topics] relate to engineering practice."

Strand 2: Development of Self-Assessment and Metacognition

Learning engineering requires one to develop their ability to self-assess, as well as to have metacognition, or to know when and how you know things. This also requires making mistakes and learning from them, knowing how you are justifying your knowledge, and discovering your personal learning process.

The development of self-assessment and metacognition are essential to learning engineering. Given how engineering is a discipline composed of many different components from a variety of parent fields, the engineer is often the only person on the team who knows all their requisite technical components. As such, the engineer needs to know how to understand both their knowledge and the limits therein. Alexandra describes this well, how you have to "learn to solve realistic, relevant problems" through the ability to "apply a topic to really see it, and then go use it" so that you can "have reasonable, realistic confidence in [your] abilities and to be successful."

Strand 3: Academically Constrained

Many of our PSF took a stance that learning engineering must occur within or around academic settings; several even asserted that learning engineering was difficult to impossible without participating in an academic formal degree.

Learning engineering is mostly done within an academic setting, due to the rich, detailed, and intricately interrelated sequence of topics involved in engineering. Zach and Alexandra present the opposite sides of this issue; Zach strongly asserts that "I think you have to learn engineering in an academic setting" because of "the sequential structured learning" in course environments, as those courses build upon each other. Zach here is stating that learning engineering absolutely requires academics because of the sequential structured learning which is inherent to engineering degree programs. Alexandra, in contrast, makes the distinction between classroom and real-world learning. They believe that "learning happens at the edge of your understanding" but that the edges of understanding would be different in the classroom, where you are exposed to "new conceptual topics," as opposed to the industrial context where you "discover new skills." Alexandra believes that you "get experience from your ideas and practice" and that this is "the process of learning to be an engineer."

Strand 4: Conceptual knowledge

PSF all asserted that part of learning engineering involved some conceptual knowledge, however all of them described this component with an attitude of 'of course you learn some topics and concepts' yet focused on the other elements as more essential or important.

The content of engineering is central to the power of an engineer, but differently from many of its STEM compatriots, engineering is always considering how to use the content. As Sora puts it, "engineering is learning to solve problems in the name of math and science" or "keeping focused on the application or usage of that concept." As Sora would describe it well, learning engineering is so that one can "connect the baseline [concept], the fundamental [principles], the foundation [underlying theory], and problem solving approaches." That is, the concept relates to some underlying and physically grounded theory, is related to a fundamental principle, but the core focus is connecting all of those with some problem solving approach(es) to leverage that concept.

Summarizing Thoughts

These findings are preliminary understandings of PSF epistemological beliefs about learning engineering; they show significantly more nuance and development when contrasted with the beliefs of undergraduate students and differences from their preservice teaching peers. Further, the beliefs visible here would be effectively facilitated through student-centered teaching methods using innovative strategies like problem-based learning as opposed to the 'sage on a stage' lecture heavy methods more commonly used in engineering classrooms.

Implications and Future Work

PSF were more focused on the higher level thinking skills [44], [45] as opposed to the procedural knowledge of learning engineering. This indicates that there is more nuanced and sophisticated epistemological beliefs for this population than their undergraduate peers [46], [47], [48]. This also aligns with the desired attitude of engineering, that lifelong learning is a process and a valued one [49], [50], [51], [52]. Further, PSF are demonstrating beliefs indicative of a view of engineering learning as more of an attitude and approach, as opposed to a set of distinct concepts. This is exciting to think about how to facilitate further epistemological development and facilitate pedagogical capabilities. Future work on this project will evaluate methods of preservice teacher training for translation to PSF contexts, compare these findings to the preparation of science education faculty, and seek to refine the model further.

References

[1] H. A. Arslantaş, “Epistemological Beliefs and Academic Achievement,” J. Educ. Train. Stud., vol. 4, no. 1, pp. 215–220, Oct. 2015, doi: 10.11114/jets.v4i1.1107.

[2] J. Brownlee, “An investigation of teacher education students’ epistemological beliefs: Developing a relational model of teaching,” Research in Education, vol. 72, pp. 1–18, 2004.

[3] J. Brownlee, “Epistemological Beliefs in Pre-service Teacher Education Students,” High. Educ. Res. Dev., vol. 20, no. 3, pp. 281–291, Nov. 2001, doi: 10.1080/07294360120108377.

[4] J. Brownlee, N. Purdie, and G. Boulton-Lewis, “Changing Epistemological Beliefs in Pre-service Teacher Education Students,” Teach. High. Educ., vol. 6, no. 2, pp. 247–268, Apr. 2001, doi: 10.1080/13562510120045221.

[5] M. M. H. Cheng, K.-W. Chan, S. Y. F. Tang, and A. Y. N. Cheng, “Pre-service teacher education students’ epistemological beliefs and their conceptions of teaching,” Teach. Teach. Educ., vol. 25, no. 2, pp. 319–327, Feb. 2009, doi: 10.1016/j.tate.2008.09.018.

[6] H. J. Green and M. Hood, “Significance of Epistemological Beliefs for Teaching and Learning Psychology: A Review,” Psychol. Learn. Teach., vol. 12, no. 2, pp. 168–178, Jun. 2013, doi: 10.2304/plat.2013.12.2.168.

[7] C. J. Faber, R. L. Kajfez, D. M. Lee, L. C. Benson, M. S. Kennedy, and E. G. Creamer, “A grounded theory model of the dynamics of undergraduate engineering students’ researcher identity and epistemic thinking,” J. Res. Sci. Teach., vol. 59, no. 4, pp. 529–560, Apr. 2022, doi: 10.1002/tea.21736.

[8] M. Turk, “Epistemological and professional identity development in undergraduate engineering learners,” p. 2601266 Bytes, 2023, doi: 10.26174/THESIS.LBORO.14884794.V1.

[9] J. Chen and J. E. Turner, “Exploring the relationships among college students’ epistemic beliefs, epistemic emotions, and use of problem-solving strategies in engineering design contexts,” Think. Ski. Creat., vol. 53, p. 101615, Sep. 2024, doi: 10.1016/j.tsc.2024.101615.

[10] J. Cruz, N. Bruhis, N. Kellam, and S. Jayasuriya, “Students’ implicit epistemologies when working at the intersection of engineering and the arts,” Int. J. STEM Educ., vol. 8, no. 1, p. 29, Dec. 2021, doi: 10.1186/s40594-021-00289-w.

[11] L. Ding and K. Mollohan, “How College-Level Introductory Instruction Can Impact Student Epistemological Beliefs,” J. Coll. Sci. Teach., vol. 044, no. 04, 2015, doi: 10.2505/4/jcst15_044_04_19.

[12] C. Faber and L. C. Benson, “Engineering Students’ Epistemic Cognition in the Context of Problem Solving,” J. Eng. Educ., vol. 106, no. 4, pp. 677–709, Oct. 2017, doi: 10.1002/jee.20183.

[13] N. Frye, D. Montfort, S. Brown, and O. Adesope, “I’m absolutely certain that’s probably true: Exploring epistemologies of sophomore engineering students,” in 2012 Frontiers in Education Conference Proceedings, Seattle, WA, USA: IEEE, Oct. 2012, pp. 1–6. doi: 10.1109/FIE.2012.6462356.

[14] B. Faulkner and G. Herman, “Espoused Faculty Epistemologies for Engineering Mathematics: Towards Defining ‘Mathematical Maturity’ for Engineering,” in 2016 ASEE Annual Conference & Exposition Proceedings, New Orleans, Louisiana: ASEE Conferences, Jun. 2016, p. 26735. doi: 10.18260/p.26735.

[15] J. Greene A., “Collegiate faculty expectations regarding students’ epistemic and ontological cognition and the likelihood of academic success.,” Contemporary Educational Psychology, vol. 34, no. 3, pp. 230–239, 2009, doi: 10.1016/j.cedpsych.2009.05.003.

[16] A. H. Kayzouri, A. Ramezanzadeh, and M. R. Moradian, “Personal epistemologies of higher education faculty members in soft disciplines: conceptualizations, enactments, and the educational implications,” Teach. High. Educ., vol. 27, no. 1, pp. 99–113, Jan. 2022, doi: 10.1080/13562517.2019.1699527.

[17] L. M. Mataka, J. C. Saderholm, and T. Hodge, “Faculty Epistemological Beliefs and the Influence of Professional Development,” Sci. Educ. Int., vol. 30, no. 4, pp. 364–372, Dec. 2019, doi: 10.33828/sei.v30.i4.14.

[18] E. Bahçivan, “Investigating the relationships among PSTs’ teaching beliefs: are epistemological beliefs central?,” Educ. Stud., vol. 42, no. 2, pp. 221–238, Mar. 2016, doi: 10.1080/03055698.2016.1160823.

[19] M. Z. Hashweh, “Effects of science teachers’ epistemological beliefs in teaching,” J. Res. Sci. Teach., vol. 33, no. 1, pp. 47–63, 1996, doi: 10.1002/(SICI)1098-2736(199601)33:1<47::AID-TEA3>3.0.CO;2-P.

[20] M. Khalid, A. Hashmi, and Z. Javed, “Relationship between Prospective Teachers’ Epistemological Beliefs and their Conceptions about Teaching and Learning,” Elementary Education Online, vol. 20, no. 4, pp. 1681–1689, 2021.

[21] L. Maggioni and M. M. Parkinson, “The Role of Teacher Epistemic Cognition, Epistemic Beliefs, and Calibration in Instruction,” Educ. Psychol. Rev., vol. 20, no. 4, pp. 445–461, Dec. 2008, doi: 10.1007/s10648-008-9081-8.

[22] N. Soleimani, “ELT teachers’ epistemological beliefs and dominant teaching style: a mixed method research,” Asian-Pac. J. Second Foreign Lang. Educ., vol. 5, no. 1, p. 12, Dec. 2020, doi: 10.1186/s40862-020-00094-y.

[23] O. Yilmaz‐Tuzun and M. S. Topcu, “Relationships among Preservice Science Teachers’ Epistemological Beliefs, Epistemological World Views, and Self‐efficacy Beliefs,” Int. J. Sci. Educ., vol. 30, no. 1, pp. 65–85, Jan. 2008, doi: 10.1080/09500690601185113.

[24] C. Allendoerfer, D. Wilson, M. J. Kim, and E. Burpee, “Mapping beliefs about teaching to patterns of instruction within science, technology, engineering, and mathematics,” Teach. High. Educ., vol. 19, no. 7, pp. 758–771, Oct. 2014, doi: 10.1080/13562517.2014.901962.

[25] L. A. Bryan, “Nestedness of beliefs: Examining a prospective elementary teacher’s belief system about science teaching and learning,” J. Res. Sci. Teach., vol. 40, no. 9, pp. 835–868, Nov. 2003, doi: 10.1002/tea.10113.

[26] I. S. Caleon, Y. S. M. Tan, and Y. H. Cho, “Does Teaching Experience Matter? The Beliefs and Practices of Beginning and Experienced Physics Teachers,” Res. Sci. Educ., vol. 48, no. 1, pp. 117–149, Feb. 2018, doi: 10.1007/s11165-016-9562-6.

[27] K. L. Dandy and K. Bendersky, “Student and Faculty Beliefs About Learning in Higher Education: Implications for Teaching,” p. 23, 2014.

[28] R. Goertzen M., R. Scherr E., and A. Elby, “A New Perspective on teaching assistants as tutorial instructors: Respecting TA’s beliefs and experiences,” Physics Review Special Topics- Physics Education Research, vol. 6, no. 2, pp. 020125-1-020125–11, 2010.

[29] R. M. Goertzen, R. E. Scherr, and A. Elby, “Tutorial teaching assistants in the classroom: Similar teaching behaviors are supported by varied beliefs about teaching and learning,” Phys. Rev. Spec. Top. - Phys. Educ. Res., vol. 6, no. 1, p. 010105, Apr. 2010, doi: 10.1103/PhysRevSTPER.6.010105.

[30] R. M. Goertzen, R. E. Scherr, and A. Elby, “Respecting tutorial instructors’ beliefs and experiences: A case study of a physics teaching assistant,” Phys. Rev. Spec. Top. - Phys. Educ. Res., vol. 6, no. 2, p. 020125, Dec. 2010, doi: 10.1103/PhysRevSTPER.6.020125.

[31] B. R. Lowell and K. L. McNeill, “Changes in teachers’ beliefs: A longitudinal study of science teachers engaging in storyline curriculum‐based professional development,” J. Res. Sci. Teach., p. tea.21839, Dec. 2022, doi: 10.1002/tea.21839.

[32] M. Popova, L. Shi, J. Harshman, A. Kraft, and M. Stains, “Untangling a complex relationship: teaching beliefs and instructional practices of assistant chemistry faculty at research-intensive institutions,” Chem. Educ. Res. Pract., vol. 21, no. 2, pp. 513–527, 2020, doi: 10.1039/C9RP00217K.

[33] J. Raths, “Teachers’ Beliefs and Teaching Beliefs.,” Early Childhood research and progress, vol. 3, no. 1, p. 11, 2001.

[34] B. T. Spike, N. D. Finkelstein, C. Singh, M. Sabella, and S. Rebello, “Examining the Beliefs and Practice of Teaching Assistants: Two Case Studies,” presented at the 2010 PHYSICS EDUCATION RESEARCH CONFERENCE, Portland, (Oregon), 2010, pp. 309–312. doi: 10.1063/1.3515231.

[35] J. H. Van Driel, A. M. W. Bulte, and N. Verloop, “The relationships between teachers’ general beliefs about teaching and learning and their domain specific curricular beliefs,” Learn. Instr., vol. 17, no. 2, pp. 156–171, Apr. 2007, doi: 10.1016/j.learninstruc.2007.01.010.

[36] A. Barlow and S. Brown, “Discovering Upper-Division Students’ Cognitive Engagement Across Engineering Courses—An Interpretive Phenomenological Analysis Approach,” Stud. Eng. Educ., vol. 1, no. 1, p. 58, Nov. 2020, doi: 10.21061/see.5.

[37] S. Chance, G. Duffy, and B. Bowe, “Comparing grounded theory and phenomenology as methods to understand lived experience of engineering educators implementing problem-based learning,” Eur. J. Eng. Educ., vol. 45, no. 3, pp. 405–442, May 2020, doi: 10.1080/03043797.2019.1607826.

[38] N. Greening, “Phenomenological Research Methodology,” Sci. Res. J., vol. VII, no. V, May 2019, doi: 10.31364/SCIRJ/v7.i5.2019.P0519656.

[39] T. Groenewald, “A Phenomenological Research Design Illustrated,” Int. J. Qual. Methods, vol. 3, no. 1, pp. 42–55, Mar. 2004, doi: 10.1177/160940690400300104.

[40] M. D. Vagle, “Gathering Phenomenological Material,” in Crafting Phenomenological Research, 2nd ed., Second Edition. | New York : Routledge, 2018.: Routledge, 2018, pp. 85–107. doi: 10.4324/9781315173474-10.

[41] M. D. Vagle, “Possible Methodological Approaches,” in Crafting Phenomenological Research, 2nd ed., Second Edition. | New York : Routledge, 2018.: Routledge, 2018, pp. 54–70. doi: 10.4324/9781315173474-8.

[42] R. H. Hycner, “Some guidelines for the phenomenological analysis of interview data,” Hum. Stud., vol. 8, no. 3, pp. 279–303, 1985, doi: 10.1007/BF00142995.

[43] A. Giorgi, “The Descriptive Phenomenological Psychological Method,” J. Phenomenol. Psychol., vol. 43, no. 1, pp. 3–12, 2012.

[44] J. A. Middleton et al., “A Social Network Analysis of Engineering Faculty Connections: Their Impact on Faculty Student-Centered Attitudes and Practices,” Educ. Sci., vol. 12, no. 2, p. 108, Feb. 2022, doi: 10.3390/educsci12020108.

[45] S. A. Finkenstaedt-Quinn et al., “Postsecondary Faculty Attitudes and Beliefs about Writing-Based Pedagogies in the STEM Classroom,” CBE—Life Sci. Educ., vol. 21, no. 3, p. ar54, Sep. 2022, doi: 10.1187/cbe.21-09-0285.

[46] S. Brown, D. Montfort, and N. Frye, “What is Engineering Knowledge: A Longitudinal Study of Conceptual Change and Epistemology of Engineering Students and Practitioners,” in 2013 ASEE Annual Conference & Exposition Proceedings, Atlanta, Georgia: ASEE Conferences, Jun. 2013, p. 23.1365.1-23.1365.20. doi: 10.18260/1-2--22750.

[47] N. Frye, D. Montfort, and S. Brown, “Personal Epistemology and Sophomore Civil Engineering Students,” in 2013 ASEE Annual Conference & Exposition Proceedings, Atlanta, Georgia: ASEE Conferences, Jun. 2013, p. 23.963.1-23.963.11. doi: 10.18260/1-2--22348.

[48] D. Montfort, S. Brown, and D. Shinew, “The Personal Epistemologies of Civil Engineering Faculty,” J. Eng. Educ., vol. 103, no. 3, pp. 388–416, Jul. 2014, doi: 10.1002/jee.20050.

[49] B. Bakioğlu, "Teacher candidates' teaching-learning conceptions and self-efficacy in organizing out-of-school trips: The mediating role of lifelong learning," Res. Pedagogy, vol. 11, no. 2, pp. 483–500, 2021, doi: 10.5937/IstrPed2102483B.

[50] M. Gunawardena and K. Wilson, "Scaffolding students' critical thinking: A process not an end game," Think. Ski. Creat., vol. 41, p. 100848, Sep. 2021, doi: 10.1016/j.tsc.2021.100848.

[51] D. Kember, "Beliefs about Knowledge and the Process of Teaching and Learning as a Factor in Adjusting to Study in Higher Education".

[52] L. S. Vygotsky and M. Cole, Mind in society: Development of higher psychological processes. Harvard university press, 1978.