

## Advancing the materiality of gender equitable STEM learning

Anna Keune, Technical University of Munich, [anna.keune@tum.de](mailto:anna.keune@tum.de)

**Abstract:** My research investigates the tools and materials used for learning with the aim to contribute to the understanding of gendered materiality of STEM learning and to design of educational design technologies that support all learners.

### Research goals and theoretical framework

My research stands at the intersection of learning sciences and design scholarship with an aim toward equitable STEM and digital skills education. My objective is to advance our understanding of the role materials play in STEM learning, to contribute to understanding of how they can widen STEM identities and participation, and to integrate these understandings toward the design of educational design technologies for inclusive STEM learning.

I am motivated by the potential of technologies to transform what counts as STEM participation as well as widening who participates and I investigate how creative materials can inform technology design and learning for diversified STEM education. My theoretical commitments are predominantly constructionist. Constructionism assumes that learning happens best when people manipulate digital or physical materials toward the design of personally meaningful and shareable projects and in this process internalize domain related concepts. In my work, I focus on how design experiences result in “objects-to-think-with” that are simultaneously material objects and internalized mental structures (Papert, 1993). In particular, I am interested in the multiple epistemological approaches (Turkle & Papert, 1990) made possible through a diversity of materials that are often related to traditional crafts, art, and design practices and connected to socio-historical practices associated with women.

The special interest in materials that I take on also involves studying how the materials that we use for STEM learning actively foster or hinder equitable STEM education. Thus, I fuse constructionist perspectives with a posthumanist stance (e.g., Barad, 2003; Kuby et al., 2018), which makes it possible for me to investigate the active role digital and physical materials play in human learning. These perspectives de-center the human, and guide my analysis of how STEM concepts unfold and change over time in the real world through relational repetitions and variations that leave traces in the world (e.g., Kuby et al., 2018). These perspectives are increasingly emerging for the study of learning, a movement my research actively contributes to (e.g., Pepler et al., 2020). My theory of design is based on participatory design of educational technologies (e.g., Leinonen et al., 2016; Bratteteig & Wagner, 2014). In this, I am particularly guided by encompassing the participatory role of digital and physical materials and how these typically non-agentive participants contribute to shaping the design processes and design results for STEM learning.

My prior work in analyzed the longer-term co-development of a 3D printer station and youth’s vocational opportunities showed how digital, physical, and spatial designs co-develop with opportunities for youth and how the design toward this co-development can contribute to STEM learning (e.g., Keune & Pepler, 2019). These are promising early findings that support the idea that materials—whether digital or physical—play an active and non-neutral role in learning. Their non-neutrality needs to be considered to support sustainable and equitable STEM learning. The early studies led me to further inquiring the gendered materiality of STEM learning.

### Methods of three strands of research

I pursue a research trajectory toward better understanding the gendered materiality of STEM learning through three strands of predominantly qualitative research: (1) Materiality of STEM learning, (2) gender equity in STEM, and (3) technology design for inclusive STEM learning.

The research strand on “materiality of STEM learning” focuses on research that analyzes and fosters STEM domain conceptual understanding for all students. The active role of materials in STEM education has been a central question in my research. An example of work that falls under this umbrella is my qualitative research on how non-technologically augmented fiber crafts can become contexts for computational learning and what the performance of computational concepts in these contexts means for capturing learning (Keune, 2021). My research showed that digital and physical computational crafting materials can be used for performing STEM domain concepts through feelable and embodied engagement. Computational crafting also makes it possible to shift deficit approaches to focus on digital skills, including creative design and risk taking. Additionally, the work advanced new methodological threads toward domain specific artifact analysis by comparing pseudocode translations of craft projects over time.

The research strand on “gender equity in STEM” focuses on research that advances understanding of the role materials play in widening STEM identities and participation. The non-neutral role of materials in STEM education has been a central question in my research for the past number of years. An example of work that falls under this umbrella is an empirical quantitative study that found that feminine materials reduce gender differences in mental rotation ability (Keune et al., 2021). Female students performed significantly higher on mental rotation tasks with objects that are perceived as feminine, matching scores of male peers while stereotypical gender differences were seen only on objects perceived as gender neutral. Particularly, this work focuses on gender equity in STEM domains by investigating how creative materials can present contexts that can make STEM education better for everyone. My research showed that materials are non-neutral players that teach aspects of STEM that are beyond domain concepts and that affect who performs well. Work to extend this line of research is planned toward fostering belonging of women in STEM and computing.

The research strand on technology design for inclusive STEM learning focuses on designing and leveraging novel technologies to advance knowledge about strategies that diversify STEM. This strand leverages the advances of the other two strands toward the design of educational design technologies, including space design and educational construction kits, that are aimed toward inclusive STEM learning.

### **Future plans and contributions to the learning sciences**

To advance the three research strands, I plan a series of related research studies. This series will include mixed-methods research on assessment possibilities for domain learning that emerge when tuning into material relational aspects of domain learning. Additionally, I plan material participatory design research to leverage understanding about the gendered materiality of learning toward the implementation of a space for educational design technologies and computational crafting at the Technical University of Munich.

By fusing constructionist with posthumanist theoretical approaches toward the study of learning, my work promises to advance theoretical understanding of the gendered materiality of STEM learning. The dual theoretical focus further promises methodological contributions for studying learning that are aligned with approaches to make it possible to recognize materialized relational patterns that are beneficial for learning. The work also promises practical contributions by producing learning materials and programs that can be used in future work on the gendered materiality of STEM learning.

### **References**

- Barad, K. (2003). Posthumanist performativity: Toward an understanding of how matter comes to matter. *Signs: Journal of Women in Culture and Society*, 28(3), 801-831.
- Kuby, C. R., Spector, K., & Thiel, J. J. (Eds.). (2018). *Posthumanism and literacy education: Knowing/becoming/doing literacies*. Routledge.
- Leinonen, T., Keune, A., Veermans, M., & Toikkanen, T. (2016). Mobile apps for reflection in learning: A design research in K-12 education. *British Journal of Educational Technology*, 47(1), 184-202. doi:10.1111/bjet.12224
- Papert, S. (1993). *The children's machine: Rethinking school in the age of the computer*. Basic Books.
- Bratteteig, T., & Wagner, I. (2014). *Disentangling participation: power and decision-making in participatory design*. Springer.
- Turkle, S., & Papert, S. (1990). Epistemological pluralism: Styles and voices within the computer culture. *Signs: Journal of women in culture and society*, 16(1), 128-157.
- Peppler, K., Rowsell, J., & Keune, A. (2020). Editorial: Advancing posthumanist perspectives on technology-rich learning. *British Journal of Educational Technology*, 51(4), 1240-1245. doi: 10.1111/bjet.12979
- Keune, A., (2021) Fabric-based computing: (Re)examining the materiality of computer science learning through fiber crafts. *Künstliche Intelligenz*, 0(0), 0-0. Doi: 10.1007/s13218-021-00747-1
- Keune, A. & Peppler, K. (2019). Materials-to-develop-with: The making of a makerspace. *The British Journal of Educational Technology*, 50(1), 280-293. doi: 10.1111/bjet.12702
- Keune, A., Zambrano-Gutiérrez, J., Phonethibsavads, A., & Peppler, K. (2021). The unexamined influence: An object's perceived gender on spatial reasoning skills in girls. In N. Rummel & U. Hoppe (Eds.), *Reflecting the past and embracing the future: International Society of the Learning Sciences (ISLS) Annual Meeting 2021* (pp. 629-632). Bochum, Germany: International Society of the Learning Sciences.