

# #HeyMathGirl! Designing an intervention to promote female students' mathematical affect

Lara Gildehaus<sup>1</sup>; Lara Siona Steiner<sup>1</sup>; Lisa-Marie Ruppert<sup>2</sup>

<sup>1</sup> University of Klagenfurt, Austria

<sup>2</sup> University of Graz, Austria

**Abstract:** Affective variables such as self-concept and sense of belonging are well-established predictors of study choice motivation and study retention, particularly in STEM disciplines. Yet, pronounced gender disparities remain: female students consistently report lower levels of mathematical self-concept and a reduced sense of belonging in mathematics. These differences are associated with the underrepresentation of women in mathematics-related fields. This paper presents the theoretical foundation, design, and preliminary findings of an intervention targeting female students' mathematical self-concept and sense of belonging. Building on positive psychology approaches, the intervention includes a modified "Three Good Things" reflection exercise as well as brief video-based role model encounters with female mathematicians. Preliminary findings for  $n=12$  preservice mathematics teachers suggest a relevant effect of the intervention. We discuss how affect-oriented interventions can contribute to greater equity in mathematics participation.

**Keywords:** gender, affect, intervention, self-concept, sense of belonging

Contact: [lara.gildehaus@aau.at](mailto:lara.gildehaus@aau.at)

## 1 Affective variables and gender in mathematics

Affective variables such as emotion, interest, motivation, and self-concept are widely recognized as key factors in mathematics education (Hannula, 2012). These variables are not only predictive of performance but also influence students' long-term academic trajectories, including study satisfaction and persistence in mathematics-related disciplines (cf. Geisler et al., 2023; Pekrun, 2024). In the context of STEM, they play a crucial role in determining whether students choose or persist in mathematics-intensive study paths (McKinney et al., 2021; Sax et al., 2015).

Crucially, affective variables exhibit consistent gender differences. For example, from adolescence onward, female students tend to report lower interest and motivation in mathematics (Leder, 2019). For instance, international assessments such as PISA or TIMSS reveal large and stable gender gaps in many countries in mathematical self-concept (the belief about one's own abilities, cf. Rach et al., 2020), which is a strong predictor of whether students consider pursuing STEM studies (Mejía-



Rodríguez et al., 2021; Sax et al., 2015). Even though different conceptualizations of self-concept are known, disparities in mathematics self-concept at least partly contribute to the persistent underrepresentation of women in STEM, despite comparable performance in many contexts.

However, affective variables would be misunderstood if taken only as an individual personal characteristic. Within the last years, it has been intensively discussed that any affective dimension does not exist in (personal) isolation but is also deeply shaped and rooted within the social (Hannula, 2012). Thus, gender disparities in affect towards mathematics are not merely individual differences; rather, they reflect systemic influences of gendered socialization, stereotypical messaging, and a cultural framing of mathematics as a masculine domain (Solomon, 2012).

Høgheim and Reber (2019) illustrate this complexity in their contribution, where they explored gender differences in interest in mathematics. Their study reveals a paradoxical pattern: While girls often rate mathematics as interesting in specific situations, they simultaneously report being less interested in it personally. Thus, girls may not be inherently less inclined toward mathematics, but rather their personal identification with the subject may be systematically lower. The authors argue that this disidentification is most likely not rooted in cognitive ability, but in the social context in which mathematics is learned.

This directly lends to another important affective variable of “sense of belonging”, describing a general perception and feeling of fitting in and being accepted in a field, and also making sense of oneself within the field (Lahdenperä, & Nieminen, 2020). Recent research has illustrated that many young women may experience mathematics as an alienating space shaped by masculine norms and stereotypes, where it is hard to participate. Such perceived misalignment can discourage engagement, diminish persistence, and reinforce a cycle of exclusion (Foyn et al., 2018; Solomon, 2012).

In the following it is thus our aim, to develop and present an intervention, that may at the one hand, promote and encourage female students affect in mathematics, specifically their self-concept as crucial for study choice motivation and retention, but on the other hand also takes the social into account and to promote female students sense-of belonging in mathematics.

## 2. Conceptual and empirical background

While such interventions around affective variables (e. g. aimed at boosting interest or reducing mathematics anxiety) are not new (cf. Gaspard et al., 2016; Maloney et al., 2013; O’Keefe et al., 2025), they often bear the risk of framing women as deficient or in need of “correction.” Followed by our focus on the social dimension of affect, we aim to present an intervention that adopts a strength-based perspective, drawing on insights from positive psychology. Positive Psychology focuses on empowering individuals by recognizing their strengths, cultivating self-reflection, and creating conditions for meaningful, affirming experiences (Carr et al., 2021). Rather than framing women as deficient or in need of “fixing,” we conceptualize their affective disadvantage as a product of socialization and structural bias, which may be constructively addressed through empowerment-focused practices and refiguring of mathematics as a domain. Thus, we are combining a focus on individual and social mechanism within the intervention.

For the individual mechanism (empowerment) we integrate the “Three Good Things” technique. This is a widely used technique in positive psychology interventions, in which participants regularly reflect on three positive experiences they themselves brought about. While this intervention is mostly used in cognitive behavioral therapy, it has also been implemented in educational contexts with great effects (Carr et al., 2021). Jenßen (2024) recently adapted this “Three Good Things” intervention for the mathematics domain, asking students to document three good things about themselves in relation to mathematics, e.g., some positive moments they themselves brought about in mathematics. Within a subject-specific mathematics Master’s course for preservice primary teachers, this “Three Good Things” intervention showed great results (Gildehaus & Jenßen, 2023): Students of the course were randomly assigned to either the intervention group ( $n = 51$ ) or the control group ( $n = 48$ ). While the intervention group completed weekly reflections about three good things about themselves in mathematics (duration 10 weeks in total), as described above, the control group completed three sentences about the lecture each week (same duration). A pre-post test design was implemented before and after the end of the intervention, measuring students’ emotions and interest in mathematics. The intervention group showed significantly more reduction of unpleasant emotion (here: Shame) than the control group (Gildehaus & Jenßen, 2023). Thus, the “Three Good Things” technique so far seems to be effective for reducing Shame in mathematics, but effects on mathematical self-concept were not measured in that intervention.

However, when qualitatively analyzing what the intervention group wrote about themselves in mathematics, it became visible that they often described an increase in their ability beliefs. Throughout the intervention, they increasingly described themselves as capable, persistent, or competent in mathematics, e. g. as in the following quote:

My AHA moments [situations where you suddenly understand something – “click” moments] are piling up, and I'm understanding the content of the lectures and exercises faster and faster. At the beginning of the course, I had the feeling I wouldn't pass the exam. But now, also thanks to the homework exercises, I'm increasingly feeling like I can really successfully pass the exam.

These insights let us assume that our targeted positive psychology intervention may also enhance students' self-concept in mathematics, especially for female students. This may lay the groundwork for greater engagement, successful participation, and long-term retention in math-related studies and is thus the first pillar in our designed intervention, focusing on individual empowerment.

Yet, we are currently lacking the anticipated social perspective on affect, which also aims to promote students' sense of belonging and a refiguring of mathematics as a domain. Such a sense of belonging is usually deeply influenced by students' perceptions of who belongs in mathematics. For example, Austrian mathematical textbooks often do not include a single female mathematician, while they of course introduce mathematicians such as Pythagoras or Gauß (Alter & Köffler, 2021). Unsurprisingly, current studies still indicate that many high school students perceive mathematics as a male domain, e.g., if they are asked to draw a scientist or mathematician, they draw male persons (Dalvik, 2022; Mendick, 2006). To stress such perceptions, we aim to expose students to diverse role models who may reshape students' perceptions of mathematics as a domain, showing a community they can actually belong to and successfully participate in. This includes addressing structural bias and current gendered socialization and providing a space to refigure these. Therefore, role-models talk about their own mathematical self-concept and belonging and how it has evolved over time, what challenges they mastered and what helped them to cope. Moreover, the role-models also perform the three good things technique to provide a direct connection between the social context of mathematics and the individual empowerment.

Together, these two pillars aim to strengthen both female students' mathematical self-concept (individual empowerment with the three good things technique) and

their sense of belonging (refiguring of mathematics as a domain, social aspect with role-models). For the long term, this may increase study choice motivation for STEM as well as retention in mathematics. We further describe the concrete intervention design in the following.

### 3. The current intervention

#### 3.1. Component 1: Positive psychology intervention

To address the individual component and empower students, the first central element of the intervention will be the adaptation of the “Three Good Things” technique, as described earlier (Gildehaus & Jenßen, 2023). In our version, students get the following task: Name three good things you like about yourself in mathematics. For example, reflect on positive experiences in mathematics that you have personally brought about in the past few days. Name as many different things as possible over the time for this exercise.

Students are asked to perform this reflection once a week, over a period of at least 10 weeks. Specifically, high-school students (also see 3.3) will get support from their teachers for the first few times to get used to this kind of reflection. To not put any additional burden on female students and to stay in line with our strength-based approach, the intervention is performed by all students, independently of their gender. Yet, based on current studies (e.g., Jenßen, 2024) and the preliminary findings (see 3.4), we assume that the effects most likely occur among female students. Concluding, this reflection technique aims to interrupt socialized negative thinking patterns and to increase awareness of existing strengths and successes to foster students' self-concept by reinforcing ability beliefs and progress.

#### 3.2. Component 2: Role models

To address the social aspect and to promote students' sense of belonging, the second component of our intervention aims to particularly challenge stereotypes about who “belongs” in mathematics and to stress a refiguring of mathematics as a domain. As stated earlier, many students—especially girls—struggle to see themselves reflected in typical representations of mathematicians and describe a low sense of belonging. Concretely, we are creating a series of short video portraits of female mathematicians (contemporary professionals), designed in a social-media-friendly format,

targeted to high school and first-year university students (e.g., under 5 minutes long, vertical format). Each video starts with a brief introduction of the speaker and their current work. It is followed by some common “this or that” introductions, e.g., “cats or dogs?”, some of them also being related to mathematics. After this intro, where we mainly aim to create a relatable, personally meaningful relation, the speaker provides a brief insight into their way into mathematics including their own evolvment of mathematical self-concept and sense of belonging, e.g., did they like mathematics in school, how did they feel about liking mathematics, who inspired them, and how and why they decided on mathematics. We also talk about setbacks or doubts along the way and how they were overcome. Possible feelings of isolation and how they were coped with being addressed, if the speaker experienced them. Furthermore, speakers also name three good things about themselves in mathematics, following the three good things intervention, and thereby link both components of our intervention. An example of how the videos look can be found in Figure 1:

**Figure 1.** Screenshots of some of the videos. Diverse female mathematicians can be seen in front of a violet background with mathematical symbols.



Concluding, we aim to present mathematics within a social context that is diverse, relatable, and personally meaningful within these videos, based on a positive, authentic narrative of how mathematicians experience mathematics in their everyday life. Thus, the videos serve as mirrors as well as windows—mirrors in which students may recognize themselves or relate themselves to, and windows into possible futures in mathematics.

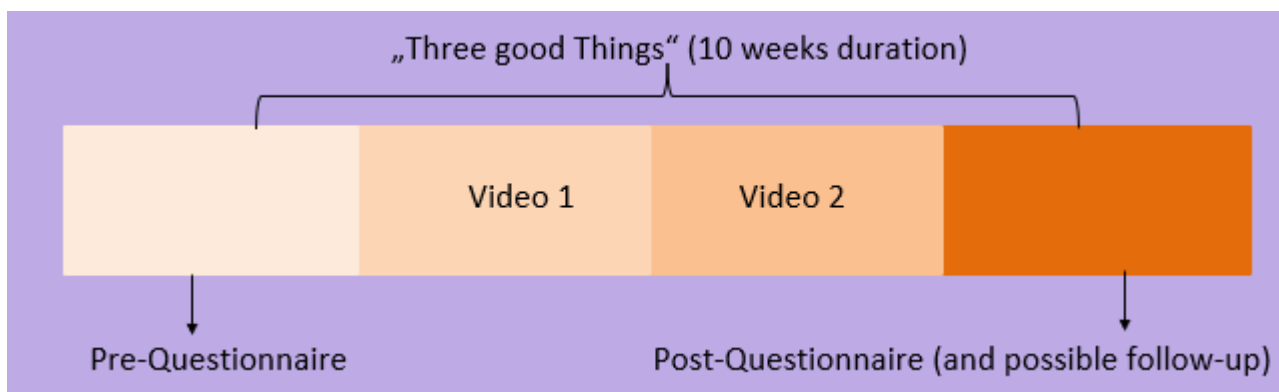
In classroom contexts, these video clips are embedded in a broader teaching unit to reinforce the message that there is no single way to “do” mathematics.

### 3.3 Design and methods

High-school students (age 14-18) as well as first-year mathematics students (age 18-28) will participate in the intervention. We will implement a quasi-controlled experimental design, which will be analyzed using mixed methods. University students will be randomly assigned to either the control or experimental group (controlled design), while high-school students, for practical reasons, will participate within their classroom structures. Thus, classes of the same year and school are assigned to either the control or experimental group (quasi-controlled design).

Data are collected at a minimum of two and up to three time points (pre, post, and possible follow-up). Students (and for minors, their legal guardians) give their written consent to participate in the intervention and data collection. The collection includes a questionnaire on quantitative measures of affective variables related to mathematics (self-concept and sense of belonging as main variables, see Table 1). Study choice motivation for STEM (for high-school students) and study retention and satisfaction (for university students) will be included as outcome variables. An overview of the design and time plan can be found in Figure 2:

**Figure 2.** Timeline of the intervention design.



Qualitative data collection will include the reflections from the “Three good things” activity, as well as feedback on the perceived impact of the videos and talks. We will further conduct group discussions about gender and mathematics after the intervention to gain insights into students' thoughts and deeper insights about their sense of belonging (processes) during the intervention.

Quantitative data analysis will mainly use ANOVAs to identify if effects in the experimental group are higher than in the control group. Qualitative data analysis will use structured content analysis (Kuckartz, 2019) for the reflection from the intervention and reflexive thematic analysis for the group discussion (Braun & Clarke, 2019).

Triangulation of both data strands will, for example, include relations between identified themes in the written reflections and effects in pre-post testing.

**Table 1.** Used scales and example items

Construct	Example item
Self-concept (Rach et al., 2021)	When it comes to mathematics, I'm pretty good.
Sense of belonging (Good et al., 2012)	I feel like I am part of the math community.

### 3.4. Preliminary findings

To ensure our anticipated effect of the three good things intervention on (female) students' self-concept, we have conducted a first preliminary study this summer term, focusing on the first component of our overall intervention. In total, 21 pre-service mathematics teachers in their fourth semester from a medium-sized Austrian university participated in our preliminary study. However, given that this participation was voluntary, only 12 students (10 female) completed the intervention until the end of the semester (duration 10 weeks). We measured students' mathematical self-concept and their sense of belonging one week before and after the intervention. A t-test for paired samples showed an increase in mathematical self-concept ( $T(11) = -1.64, p = .06$ ) with medium effect size (Cohen's  $d = -0.47$ ) but no changes in students' sense of belonging ( $T(11) = 0.573, p = .29$ ). This is in line with our theoretical assumption, that component 1 of our intervention (section 3.1.) can increase students' self-concept, but component 2 (section 3.2.) will be needed to also foster students' sense of belonging.

For component 2, the first videos have been produced and evaluated with mathematics education experts as well as students. They were revised accordingly, but have not yet been tested in the field.

## 4. Discussion

Affective variables are known to play an important role when it comes to mathematics learning (Hannula, 2012). Yet, they may exhibit consistent gender differences, with direct impact on study choice motivation and study retention in STEM and mathematics (cf. Sax et al., 2015).

We therefore presented an intervention that offers a dual approach: enhancing individuals' self-concept (individual empowerment via positive self-reflection) and

sense of belonging (social aspect, refiguring mathematics as a domain based on diverse role models). Within the preliminary findings, we tested the first part of the intervention with satisfactory outcomes for students' self-concept. Yet, it seems relevant for the main study to have possible dropout from the intervention in mind. Limitations are clearly the small sample of the preliminary study, but also a certain dependence of our intervention on the specific Austrian (Western European) context. Taking the social context of gender into account implies that we are context-dependent, limiting the applicability of our intervention for other cultural contexts.

## Acknowledgements

This project is funded by the Austrian Fund for the Empowerment and Promotion of Women and Girls, by the State of Austria (Project Number 96).

## References

- Alter, G., & Köffler, N. (2021). Let boys explain the world to girls who do not know-visual representations of gender and diversity in Austrian primary textbooks and implications for diversity-sensitive education. *Journal of Visual Literacy*, 40(3-4), 149–169. <https://doi.org/10.1080/1051144X.2021.1974770>
- Braun, V., & Clarke, V. (2019). Reflecting on reflexive thematic analysis. *Qualitative research in sport, exercise and health*, 11(4), 589–597. <https://doi.org/10.1080/2159676X.2019.1628806>
- Carr, A., Cullen, K., Keeney, C., Canning, C., Mooney, O., Chinseallaigh, E., & O'Dowd, A. (2021). Effectiveness of positive psychology interventions: A systematic review and meta-analysis. *The Journal of Positive Psychology*, 16(6), 749–769. <https://doi.org/10.1080/17439760.2020.1818807>
- Dalvik, J. S. (2022). *Stereotypes and mathematics: A quantitative approach to the Draw a mathematician test* (Master's thesis, UiT Norges arktiske universitet).
- Gaspard, H., Dicke, A.-L., Flunger, B., Häfner, I., Brisson, B. M., Trautwein, U., & Nagengast, B. (2016). Side effects of motivational interventions? Effects of an intervention in math classrooms on motivation in verbal domains. *AERA Open*, 2(2), 233285841664916. <https://doi.org/10.1177/2332858416649168>
- Gildehaus, L., & Jenßen, L. (2023). Replication of a positive psychology intervention to reduce mathematics related shame. In M. Ayalon, B. Koichu, R. Leikin, L. Rubel, & M. Tabach (Eds.), *Proceedings of the 46th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 2). PME.
- Good, C., Rattan, A., & Dweck, C. S. (2012). Why do women opt out? Sense of belonging and women's representation in mathematics. *Journal of personality and social psychology*, 102(4), 700. <https://doi.org/10.1037/a0026659>
- Hannula, M. S. (2012). Exploring new dimensions of mathematics-related affect: Embodied and social theories. *Research in Mathematics Education*, 14(2), 137–161. <https://doi.org/10.1080/14794802.2012.694281>

- Høgheim, S., & Reber, R. (2019). Interesting, but less interested: Gender differences and similarities in mathematics interest. *Scandinavian Journal of Educational Research*, 63(2), 285–299. <https://doi.org/10.1080/00313831.2017.1336482>
- Jenßen, L. (2024). „Name three good things about yourself in mathematics”. An intervention to reduce pre-service teachers’ shame in mathematics. *International Journal of Applied Positive Psychology* 9, 189–208. <https://doi.org/10.1007/s41042-023-00120-7>
- Kuckartz, U. (2019). Qualitative text analysis: A systematic approach. In G. Kaiser & N. Presmeg (Eds.), *Compendium for Early Career Researchers in Mathematics Education* (pp. 181–197). Springer International Publishing. [https://doi.org/10.1007/978-3-030-15636-7\\_8](https://doi.org/10.1007/978-3-030-15636-7_8)
- Lahdenperä, J., & Nieminen, J. H. (2020). How does a mathematician fit in? A mixed-methods analysis of university students’ sense of belonging in mathematics. *International Journal of Research in Undergraduate Mathematics Education*, 6(3), 475–494. <https://doi.org/10.1007/s40753-020-00118-5>
- Leder, G. C. (2019). Gender and mathematics education: An overview. In G. Kaiser & N. Presmeg (Eds.), *Compendium for Early Career Researchers in Mathematics Education* (pp. 289–308). Springer.
- Maloney, E. A., Schaeffer, M. W., & Beilock, S. L. (2013). Mathematics anxiety and stereotype threat: Shared mechanisms, negative consequences and promising interventions. *Research in Mathematics Education*, 15(2), 115–128. <https://doi.org/10.1080/14794802.2013.797744>
- McKinney, J., Chang, M.-L., & Glassmeyer, D. (2021). Why females choose STEM Majors: Understanding the relationships between major, personality, interests, self-efficacy, and anxiety. *Journal for STEM Education Research*, 4(3), 278–300. <https://doi.org/10.1007/s41979-021-00050-6>
- Mejía-Rodríguez, A. M., Luyten, H., & Meelissen, M. R. (2021). Gender differences in mathematics self-concept across the world: An exploration of student and parent data of TIMSS 2015. *International Journal of Science and Mathematics Education*, 19(6), 1229–1250.
- Mendick, H. (2006). *Masculinities in Mathematics*. McGraw-Hill Education.
- O’Keefe, P. A., Ramya, S. M., & Horberg, E. J. (2025). A growth-theory-of-interest intervention helps align science students with a new multidisciplinary curriculum. *Contemporary Educational Psychology*, 102371. <https://doi.org/10.1016/j.cedpsych.2025.102371>
- Pekrun, R. (2024). Control-value theory: From achievement emotion to a general theory of human emotions. *Educational Psychology Review*, 36(3), 83. <https://doi.org/10.1007/s10648-024-09909-7>
- Rach, S., Ufer, S., & Kosiol, T. (2021). The role of mathematical self concept for studying mathematics: How prepared do university mathematics students feel? *Zeitschrift Für Erziehungswissenschaft*, 24(6), 1549–1571. <https://doi.org/10.1007/s11618-021-01058-9>
- Sax, L. J., Kanny, M. A., Riggers-Piehl, T. A., Whang, H., & Paulson, L. N. (2015). “But I’m not good at math”: The changing salience of mathematical self-concept in shaping women’s and men’s STEM aspirations. *Research in Higher Education*, 56(8), 813–842. <https://doi.org/10.1007/s11162-015-9375-x>
- Solomon, Y. (2012). Finding a voice? Narrating the female self in mathematics. *Educational Studies in Mathematics*, 80(1-2), 171–183. <https://doi.org/10.1007/s10649-012-9384-z>