LUMAT-B
International Journal on Math, Science and Technology Education



Conference paper

# Exploring the complex relationship between theory and methodology when studying mathematics-related motivation

Neruja Suriakumaran[1] and Markku S. Hannula[2]

[1] University of Vechta, Germany
[2] University of Helsinki, Finland

**Abstract:** A well-founded research paradigm is essential for gaining acceptable research results. To highlight the associations between ontology, epistemology, and methodology, we refer to an investigation on German and Finnish students' motivation in mathematics classroom. We identified four kinds of mathematics-learning orientations from German and Finnish 9th graders using latent class analysis. When comparing the profile outputs, discriminant analysis (quantitative approach) revealed no convincing differences. The coordination analysis method (qualitative approach) in turn reflected that different foci within German and Finnish mathematics curricula exist. The findings highlight to identify and specifically tailor the methodology according to the ontological and epistemological principles of theory.

**Keywords:** ontology, epistemology, methodology, quality of motivation

Correspondence: neruja.suriakumaran@uni-vechta.de

## 1 Introduction

The relationship between theory and methodology is complex and fundamental to produce valid empirical knowledge with regard to the scientific discourse. A substantial clarification of the adopted theory is decisive to select an adequate methodology. In turn, methodological demands and obstacles would not become visible without following the adopted theoretical principles. The main purpose of this paper is to push the discussion on the relationship between the theoretical principles and methodology. For this purpose, we examined the research framework which established the investigation on German and Finnish 9th graders' motivation in mathematics classroom.

The quality of students' motivation has several effects on their learning processes. Particularly, autonomous motivation – learner's willingness to study mathematics for its own sake – is connected to multiple positive effects while a controlled motivation is associated with internal or external stress (Ryan & Deci, 2017). Because each learner is unique and individuals bring multiple attributions for orientation into classroom (Ryan & Deci, 2017), researchers have stated that the social environment in the classroom can facilitate autonomous motivated learning processes by supporting the satisfaction of

learners' basic psychological needs of autonomy, competence, and relatedness. Scholars emphasized that mathematics learning can also become more interesting to students when they experience it as personally relevant (Bikner-Ahsbahs, 2005). Accordingly, one way to increase our understanding towards the quality of students' functioning is to understand their perspective i.e., patterns of personal relevance when studying mathematics.

Various scholars are fully aware of the significance of self-relevance or personal meaning for the internalization process and autonomous motivation (e.g., Vansteenkiste et al., 2018). However, a theoretical specification of the motivational construct "relevance" is limited (Suriakumaran, 2022). To explore the relationship between learners' motivation and their patterns of personal relevance to study mathematics, a substantial analyses of theoretical framework and adequate methodology is necessary. We applied a quantitative (discriminant function analysis) and qualitative (coordination analysis method) approach to analyse the conceptual interplay between motivation and patterns of personal relevance. Based on this practical example, we reflect on the interrelationship between theory and methodology when exploring motivation.

## 2 Research paradigm

The ontological principles (conceptualization of nature within scientific theory) and epistemological principles (systematic clarification and identification of valid knowledge with regard to the research discourse) of theory define the framework of research. Particularly, these principles specify the selection of methodology, i.e., well-founded identification of adequate research methods (Buchholtz, 2021; Slevitch, 2011). In the main, the arrangement and direction of research in mathematics education is defined by theory (Radford, 2008a). In the following, we briefly elaborate these elements of research paradigm by integrating the investigation on students' motivation as a practical example.

### 2.1 Ontological and epistemological perspectives

A theoretical lens can be viewed "as a way of producing understandings and ways of action based on" basic principles (P), methodology (M), and research questions (Q) (Radford, 2008a, p. 320). Within this tripartite view (P, M, Q) of a theoretical lens, P embraces the system of principles, M is a set of methodologies (technical procedures of data collection and interpretation) facilitating P in producing relevant data, and Q is a set of research questions. In doing so, the articulation between theoretical principles (P), questions (Q) to be explored, and methodology (M) establish the conceptualization of theories (i.e., how is understanding produced?, Radford, 2008a, 2012). At the same time, P, M, and Q mark theory's boundary (i.e., the limit of theory's principles). If limitations of principles emerge in the context of an intended investigation, "Connecting theories can (…) be accomplished at different levels (principles, methodology, research questions), with different levels of intensity" (Radford, 2008b, p. 14).

In our practical example, we explored the interconnection between the perspectives of learners' motivation and their individually constructed patterns of personal relevance which move them to study mathematics in the classroom. For this, we examined how the ontological and epistemological foundations of two theoretical lenses connect in describing the genesis of motivation in mathematics classroom by involving both students' individual world and the external social world.

"Why" do students show a certain motivation in the mathematics classroom? The ontological principles of self-determination theory (SDT; Ryan & Deci, 2017) focuses on the learners' individual experiences. This theory's principles seek to understand how sociocultural conditions foster individuals' basic psychological needs satisfaction and focuses on the quality aspect of motivation (e.g., intrinsic, extrinsic motivation). This is a powerful lens to elaborate on basic psychological needs mechanisms which belong to individuals' biological nature. Learners' social context can support their motivation by satisfying the basic psychological needs. Although SDT's principles respect the dialectical communication between students' individual and social world, the social experiences are not likewise conceptualized.

"What" patterns of personal relevance do students construct in the mathematics classroom? Guided by Vygotsky's (1978) theoretical enterprise, the ontological principles of social constructivism provide an insight into learners' experiences of social interaction in the classroom (Ernest, 2010). This theory's principles support to understand learners' social experiences, in which they subjectively assimilate the social regulations within the classroom. This conversation, which belongs to students' social nature, between the social realm and the individual explain the production of learning and knowledge. The principles of social constructivism discuss the dialogue between social context and the individual. However, from this angle it remains unsettled which key factors affect learners' processes in private.

In terms of the interplay between learners' individual (why) and social word (what), we identified limitations of theory's principles. To produce understanding, we predicted the motivational construct personal meaning as situated at the boundary of SDT and social constructivism (Suriakumaran, 2022).

Based on learners' permanent need for meaning, the theoretical conceptualization behind this construct addresses the personal relevance learners associate with studying mathematics, which is affected by learners' personal preconditions (composed of their personal background and personal characteristics) and their mathematics learning situation (Vollstedt & Vorhölter, 2008). By adopting the perspective of the individual learner, this concept describes the construction of personal meaning in the context of the mathematics learning situation. In a nutshell, the construction of personal meaning involves an interaction between individual and social factors. Vollstedt reconstructed 17 personal meanings that students (aged 15–17) attached to mathematics learning within an educational setting (Vollstedt & Duchhardt, 2019). These varied from duty (e.g., "I mainly deal with mathematics because I have to") to purism of mathematics (e.g., "mathematics is beautiful to me as it is unique in its formalism").

By considering the connections between these two theories at the level of principles (P), we predicted that personal meaning has the potential to be considered as a so-called

boundary object (Akkerman & Bakker, 2011). That is, we see personal meaning to be located at the boundary of two theories, SDT and social constructivism, and to have multimodal ontological natures (Radford, 2014). Personal meaning encompasses conceptually a biological aspect. Within the individual level of personal meaning there seems to exist a biological regulatory mechanism that addresses learners' individual experiences of meaning construction. As such, this biological regulatory mechanism may become epistemologically observable in learners' motivation. At the same time, personal meaning includes a social aspect. Within this social level of this motivational construct there seems to exist a social regulatory mechanism. This may become epistemologically observable in learners' interpersonal experiences, i.e., production of patterns of personal relevance. Personal meaning is simultaneously an individual psychological phenomenon (viewed through the lens of SDT) and a social phenomenon (viewed through the lens of social constructivism). The specific conceptual nature of personal meaning is "flexible and robust enough" to function as a bridge between both theoretical worlds as well as to be understood from both perspectives (Suriakumaran, 2022).

## 2.2 Methodological perspective

Methodological issues, as the philosophy behind the e.g., quantitative or qualitative approaches, are not always compatible with the adopted theoretical conceptualization. Sometimes the applied methodology ignores or even contradicts with the adopted theoretical principles. Scholars usually address the theoretical and methodological issues when discussing the empirical results. However, the reflection on the interrelationship between theory and methodology is little.

To study the double ontological nature of personal meaning, biological and social regulatory mechanisms, we firstly applied a solely quantitative approach. In the following, we provide the important information to follow this practical example's empirical work. A detailed report of these statistical analyses would go beyond the scope of this paper (for more, see Suriakumaran, 2022).

We conducted a cross-cultural study with grade nine students from Germany, N = 276 (♀: 46%), and Finland, N = 256 (♀: 48%). In Germany we considered all individuals from different schools according to their educational performance, whereas in Finland all participants attended comprehensive schools. We used a published instrument to assess the different kinds of personal meaning (Vollstedt & Duchhardt, 2019). Further, we applied an established scale to assess the quality of motivation (Thomas & Müller, 2011).

Our empirical work was explorative, with quantitative methods. We used Mplus statistical package (Muthén & Muthén, 2017) for the statistical analyses and applied the Mplus FIML algorithm to handle missing data. For the affective constructs' psychometric properties, confirmatory factor analysis (with MLR) recorded acceptable to good fit values. The gradual test of measurement invariance supported (partial) scalar invariance. This was the demanded validity of the German and Finnish models in order to conduct a fair and valid group comparison. We did a latent class analysis (LCA) with distal outcomes to identify the different kinds of German and Finnish motivational outcome and their patterns of personal relevance. Discriminant analysis is used to not only detect

those indicators which mark the differences between the groups. This analysis verified and supported but also the identified LCA.

Based on LCA we detected four profiles in Germany and Finland. Subsequently, we conducted discriminant analysis. A discriminant analysis based on the four profiles displayed three discriminant functions in German and Finnish sample. We consider specifically the eigenvalues and wilks' lambda to evaluate the quality of the model. In a nutshell, the conducted discriminant function analysis reflected in German and Finnish sample that not all four profiles significantly differ from each other. Specifically, we found no support for separating profiles 3 and 4. The canonical correlation of function 3 (preferably close to 1) of .324 in German sample and of .251 in Finnish sample indicated the model classified not correctly. What is more, wilks' lambda of test of function 3 (preferably close to 0 reflecting total discrimination) showed high values of not explained variability of 89.5 % in Germany and 93.7 % in Finland. This in turn, reflected lower discriminatory ability of the function 3 showing no significance ($p < .000$).

On the one hand, besides the LCA fit statistics, the identified class solution represented "new knowledge" with each profile and proportion of interpretability (as the most critical criterion in LCA) increased up to four-class model (Geiser, 2011). This fact was at odds with the results of discriminant function analysis. On the other hand, the quantitative research so far only studied personal meaning as an individual psychological phenomenon (through the theoretical principles of SDT). However, to explore whether personal meaning also exists as predicted in the social world, we sought for a methodological approach to interpret the personal meaning through the lens of social constructivism.

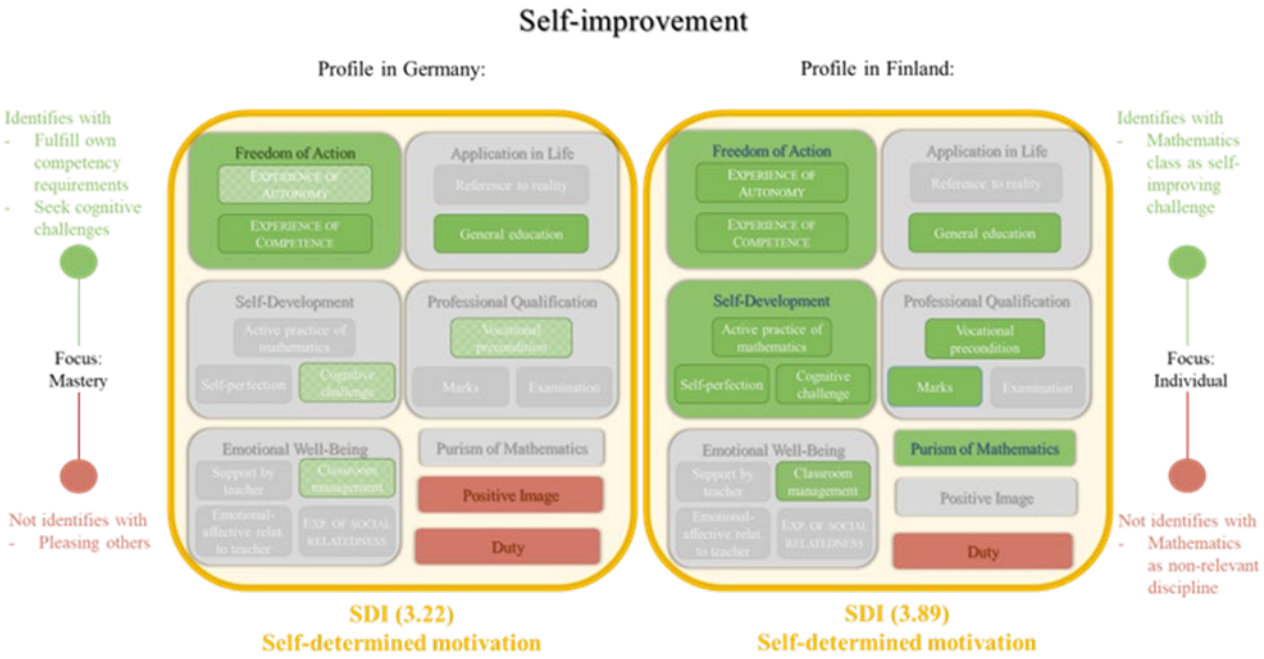
For this reason, we applied coordination analysis method. The networking strategy of coordinating which constructs a conceptual framework "by fitting together elements from different theories for making sense of an empirical phenomenon. A conceptual framework is not a new theoretical approach but a pragmatic bricolage for the purpose of understanding empirical phenomena" (Prediger & Bikner-Ahsbahs, 2014, pp. 119–120). This networking strategy brings the detected German and Finnish profiles of personal meaning (patterns of personal relevance) and their distal outcomes (quality of motivation) into a theory-driven dialogue. We followed a theory-driven interpretation procedure of the numerical data assisted by adjusted terms (originating within qualitative research paradigm, Bohnsack, 1989).

Through the conducted theory-driven interpretation, we identified four kinds of mathematics-learning orientation in view of emotional-social integration (Profile 1) – leaners' starting internalization (either balanced (GER) or autonomous (FIN) motivation); enjoyment in mathematics learning (Profile 2) – learners experience well-being and integration (autonomous motivation); external pressure (Profile 3) – learners adapt to obligatory requirements (either balanced (FIN) or less controlled (GER) motivation); self-improvement (Profile 4) – students feel freedom of action (autonomous motivation).

In the following, we report one detailed example how we systematically coordinated the two theoretical perspectives to qualify the quantitative data (Schoonenboom & Johnson, 2017). Therefore, we illustrate (see Figure 1) the results of German and Finnish profile 4 "self-improvement" where discriminant function analysis reflected in German and

Finnish sample that these profiles significantly differ not from profile 3 “external pressure”.

**Figure 1.** Results of Coordination Analysis Method. Self-Improvement – Profile 4 in German and Finnish Sample.




Note. Summarized overview of profile’s pattern of personal meaning and the corresponding motivational behaviour. Profiles in Germany and Finland is depicted through the constructed and non-constructed kinds of personal meaning embedded within the corresponding dimension of personal meaning.

The 4-point Likert scale as a whole gives clues, ranging from 0 (strongly disagree) to 3 (strongly agree). First, we examined whether each profile can be clearly interpreted by considering its mean scores with respect to the strong indicators represented by constructed ($M \geq 1.8$ = cut-off point providing orientation) and non-constructed ($M \leq 1.2$ = cut-off point providing no orientation) dimensions/kinds of personal meaning. Average values are probably made up of different components and therefore they do not provide any information when clarifying the profiles (greyed out).

The colour code (light) green is used for (a tendency towards) constructed personal meanings and (light) red is used for (a tendency towards) non-constructed personal meanings. Each dimension (of personal meaning) is coloured either green or red when all the factors of the dimension behaved in a similar manner. The colour code of the profile’s frame reflects the profile’s self-determination index (SDI), with orange for self-determined motivation.

We focused on the ones (green) that provided orientation within those profiles. Some personal meanings (light green) showed a tendency towards orientation. For German learners, studying mathematics for self-improvement means satisfying their own competence requirements (focus on mastery), but for Finnish students it means strengthening their personal development (focus on the individual). Across countries, these profiles

reflected the highest degree of self-determination. In addition, some personal meanings were explicitly referring to a scope that provides no orientation for the learner and these are the red ones. Whereas in Germany they did not identify with "I try my best in learning mathematics to please others" in Finland they did not identify with the statement that mathematics was a non-relevant discipline. The profiles' poles (in the left- and rightmost positions) were reconstructed from the individuals' self-reports about which scopes were accepted and which were rejected for their own relevance system (patterns of personal meaning) as a means of providing orientation. Based on the foci, namely mastery and individual, we named these profiles self-improvement (Suriakumaran, 2022).

The examination of the German and Finnish mathematics curricula revealed that both countries aim to support learners' mathematics performance but adopt different focus. Historically, Finland has a very strong emphasis on education from the perspective of the German concept of "Bildung" (Autio, 2021). Based on the German influence, the Finnish system is equally concerned with learners' mathematical skills and with their individual development. On the contrary, the German system essentially accentuated students' performance. This analytical work helped also to understand why similar orientations (e.g., emotional-social integration) have different quality of motivation.

## 3 What's the push?

This paper explores in detail the structural arrangement of research paradigm when studying mathematics-related motivation. As an initial step, we applied discriminant analysis to contrast the German and Finnish profile outputs. Due to methodological limitations, we adjusted our research process by integrating the coordination analysis method in order to understand the interplay between biological regulatory mechanisms (quality of motivation) and social regulatory mechanism (patterns of personal relevance). Regarding the major goal of this paper, we initially discuss the different empirical evidence when applying discriminant analysis and coordination analysis method. Furthermore, we highlight the conceptual relationship between the specific theoretical principles and the two different methodological paradigms. To this effect, we reflect on the following question "How do the theoretical principles and both methodologies, mono-methodological quantitative research approach and coordination analysis method, interrelate in view of the interplay between motivation and patterns of personal relevance?"

### 3.1 Main findings

We applied two different methodological approaches to examine this theoretical interplay.

The discriminant function analysis could not statistically discriminate the identified German and Finnish profiles 3 "external pressure" and 4 "self-improvement" from one another. One reason might be that the empirical data was not prepared appropriately to

conduct discriminant analysis. That is, the level of (partial) scalar invariance and the relatively small sample size might clarify why the data was too sensitive for discriminant analysis. However, the mono-methodological quantitative statistical approach supported to assess the students' motivational outcome and patterns of personal relevance.

The coordination analysis method, in turn, supported a theory-driven interpretation of quantitative data, in terms of systematically coordinating the two theoretical perspectives, and qualified the quantitative data (Schoonenboom & Johnson, 2017). On the one hand, this method considers the double ontological nature of personal meaning through the principles of SDT and social constructivism. On the other hand, it helped not only to verify the empirical evidence but also to contrast and refine the interplay between motivation and patterns of personal relevance. We identified four kinds of mathematics-learning orientations. Theorizing the results of the coordination emphasized that each country's profiles have cultural tags that refer to their respective cultural setting or focus in the curriculum. In a nutshell, coordination analysis intercommunicated with the adopted theoretical principles, while the mono-methodological quantitative research approach did not fully achieve this.

## 3.2 Reflecting on the interrelationship between theory and methodology

Measurement theories and analysis procedures respect theoretical principles at different levels. As a result, feedback on the adopted theoretical principles is correspondingly different. In our case, the mono-methodological quantitative approach picked up the nature of personal meaning as a individual psychological phenomenon. Subsequently, the thus-generated empirical profiles had to take up and clarify the other, i.e., personal meaning as a social phenomenon. Within the quantitative research approach, there is no research activity which helps to link theories. A sequential-dependent methodology (Schoonenboom & Johnson, 2017) was necessary which to consider the double ontological natures of personal meaning. This specific methodological approach (M) helped by systematically considering both theories' principles (P) and study's research questions (Q) to model the interplay (R as the fourth element; Radford, 2012) between motivation and patterns of personal relevance (for more see Suriakumaran, 2022).

Each methodological approach has its strengths and limitations, similar to theory and its principles (Radford, 2012). These meta-methodological insights show that a substantial clarification of the adopted theory, or in our case, theoretically specifying the concept of a motivational construct is essential to select an adequate methodology. The feedback towards theoretical principles and the empirical evidence which come to the fore are biographically connected to the individual measurement theory. Accordingly, methodical demands and obstacles would not become visible without following the adopted theoretical principles.

Theoretically, we consider motivation as an affective construct which is not separable from cognitive activities. This monist perspective, conceptualizing mathematics thinking as an interdependence of embodied, psychological, and social phenomenon is also necessary when we frame our research. That is, the interrelation between theory, questions, methodology, and results frame the research process. Accordingly, these elements

should be considered through a monist perspective within the research framework by exploring their complex understanding among one another depending on study's individual major goal. A substantial exploration helps to identify ontological, epistemological, and methodological demands and investigates their harmony with one another in terms building a well-founded research paradigm.

## 4 Conclusions

As a "take home message", we suggest to examine and reflect on research with regard to the adopted theoretical lens:

- Which theoretical perspective did you adopt and why?
- Which ontological and epistemological principles of the theory did you adopt (which did you leave out and why)?

And the adopted methodology:

- Which methodological approach did you adopt and why?
- To what extent do the methodological principles respect the ontological and epistemological principles of the theory?

This substantial exploration of theory and methodology may help to identify the strengths and limitations towards the interrelation between theory and methodology.

## Research ethics

### Author contributions

S.N.: conceptualization, investigation, methodology, project administration, validation, visualization, writing—original draft preparation, writing—review and editing
H.M.S.: formal analysis, writing—review and editing

All authors have read and agreed to the published version of the manuscript.

### Informed consent statement

Informed consent was obtained from all research participants.

### Data availability statement

Data is unavailable due ethical restrictions. For more information please contact the contributors.

## Acknowledgements

Thank you to Jessica F. A. Salminen-Saari for offering to translate the questionnaire. Dr Eeva Haataja, thank you for translating the questionnaire, supporting the data collection, and conducting the cognitive lab.

## Conflicts of Interest

The authors declare no conflicts of interest.

## References

Akkerman, S. F., & Bakker, A. (2011). Boundary crossing and boundary objects. *Review of Educational Research*, *81*(2), 132–169. https://doi.org/10.3102/0034654311404435

Autio, T. (2021). From and bildung toward competences and skills in Finnish curriculum policy?: Some theoretical, historical, and current observations related to Finland. In W. Zhao & D. Tröhler (Eds.*), Euro-Asian Encounters on 21st-Century Competency-Based Curriculum Reforms* (pp. 41–56). Springer. https://doi.org/10.1007/978-981-16-3009-5

Bikner-Ahsbahs, A. (2005). *Mathematikinteresse zwischen Subjekt und Situation: Theorie interessendichter Situationen - Baustein für eine mathematikdidaktische Interessentheorie*. Zugl.: Flensburg, Univ., Habil.-Schr., 2003. *Texte zur mathematischen Forschung und Lehre: Vol. 43*. Franzbecker.

Bohnsack, R. (1989). *Generation, Milieu und Geschlecht: Ergebnisse aus Gruppendiskussionen mit Jugendlichen*. Zugl.: Erlangen-Nürnberg, Univ., Habil.-Schr. *Biographie und Gesellschaft: Vol. 8*. Leske + Budrich.

Buchholtz, N. (2021). Voraussetzungen und Qualitätskriterien von Mixed-Methods-Studien in der mathematikdidaktischen Forschung. *Journal für Mathematik-Didaktik*, *42*(1), 219–242. https://doi.org/10.1007/s13138-020-00173-0

Ernest, P. (2010). Reflections on theories of learning. In B. Sriraman & L. English (Eds.), *Theories of mathematics education* (pp. 39–47). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-00742-2_4

Geiser, C. (2011). *Datenanalyse mit Mplus: eine anwendungsorientierte Einführung* (2nd ed.). VS Verlag für Sozialwissenschaften. https://doi.org/10.1007/978-3-531-92042-9

Muthén, L. K., & Muthén, B. O. (2017). *Mplus user's guide: Statistical analysis with latent variables* (8th ed.). Muthén.

Prediger, S., & Bikner-Ahsbahs, A. (2014). Introduction to networking: Networking strategies and their background. In A. Bikner-Ahsbahs & S. Prediger (Eds.), *Networking of theories as a research practice in mathematics education* (pp. 117–125). Springer International Publishing.

Radford, L. (2008a). Connecting theories in mathematics education: Challenges and possibilities. *ZDM*, *40*(2), 317–327. https://doi.org/10.1007/s11858-008-0090-3

Radford, L. (2008b). Theories in mathematics education: A brief inquiry into their conceptual differences. *Working paper. Prepared for the ICMI Survey Team 7. The notion and role of theory in mathematics education research*, 1-17.

Radford, L. (2012). *On the growth and transformation of mathematics education: Paper presented at the International Colloquium The Didactics of Mathematics:* Approaches and Issues. A Homage to Michèle Artigue. Université de Paris VII. May 31 to June 1, 2012. Working Paper. Retrieved May 17, 2021, from https://www.researchgate.net/publication/319089825_On_the_growth_and_transformation_of_mathematics_education_theories

Radford, L. (2014). Towards an embodied, cultural, and material conception of mathematics cognition. *ZDM*, *46*(3), 349–361. https://doi.org/10.1007/s11858-014-0591-1

Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. Guilford Press.

Schoonenboom, J., & Johnson, R. B. (2017). How to construct a mixed methods research design. *Kölner Zeitschrift Fur Soziologie Und Sozialpsychologie*, *69*(Suppl 2), 107–131. https://doi.org/10.1007/s11577-017-0454-1

Slevitch, L. (2011). Qualitative and quantitative methodologies compared: Ontological and epistemological perspectives. *Journal of Quality Assurance in Hospitality & Tourism*, *12*(1), 73–81. https://doi.org/10.1080/1528008X.2011.541810

Suriakumaran, N. (2022). *Understanding the conceptual interplay between learners' motivation and patterns of personal meaning in the mathematics classroom: Results from Germany and Finland* (Doctoral dissertation, Universität Bremen). Staats- u. Universitätsbibliothek. DOI: 10.26092/elib/1631

Thomas, A. E., & Müller, F. H. (2011). *Skalen zur motivationalen Regulation beim Lernen von Schülerinnen und Schülern. Skalen zur akademischen Selbstregulation von Schüler/innen SRQ-A: Wissenschaftliche Beiträge aus dem Institut für Unterrichts- und Schulentwicklung Nr. 5.* Institut für Unterrichts- und Schulentwicklung.

Vansteenkiste, M., Aelterman, N., Muynck, G.-J. de, Haerens, L., Patall, E., & Reeve, J. (2018). Fostering personal meaning and self-relevance: A self-determination theory perspective on internalization. *The Journal of Experimental Education*, *86*(1), 30–49. https://doi.org/10.1080/00220973.2017.1381067

Vollstedt, M., & Vorhölter, K. (2008). Zum Konzept der Sinnkonstruktion am Beispiel von Mathematiklernen. In H.-C. Koller (Ed.), *Sinnkonstruktion und Bildungsgang. Zur Bedeutung individueller Sinnzuschreibungen im Kontext schulischer Lehr-Lern-Prozesse*. (pp. 25–46). Verlag Barbara Budrich.

Vollstedt, M., & Duchhardt, C. (2019). Assessment and structure of secondary students' personal meaning related to mathematics. In M. S. Hannula, G. C. Leder, F. Morselli, M. Vollstedt & Q. Zhang (Eds.), *ICME-13 Monographs. Affect and Mathematics Education* (pp. 137–164). Springer International Publishing. https://doi.org/10.1007/978-3-030-13761-8_7

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. M. Cole, V. John-Steiner, S. Scribner, & E. Souberman (Eds.), Harvard University Press.