



**Book Review: Transforming mathematics education:  
from embodied experiences to an ethical commitment.**  
**Luis Radford (2021) *The theory of objectification:  
a Vygotskian perspective on knowing and becoming  
in mathematics teaching and learning***

**Brill. xvi, 259 pages. Hardcover: ISBN: 978-90-04-45965-6, €130.00.  
Paperback: ISBN: 978-90-04-45964-9, €60.00. eBook (PDF): ISBN:  
978-90-04-45966-3, €130.00**

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Accepted: 21 July 2021 / Published online: 1 September 2021  
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This book presents a unique example of a general theory that addresses the learning process at various scales. It starts from the micro-processes in a classroom, expanding to education as an ethical–political endeavour placed in a long-term historical scale. The chapters combine ethnographical analysis of classroom episodes and educational design contributions with philosophical work and detailed historical investigations of mathematical culture. Strikingly, these diverse sources speak for a coherent approach and provide consistent theoretical terminology. Radford’s theory of objectification contributes to explaining teaching–learning phenomena and to elaborating educational interventions. In particular, such comprehensive theory is appealing in the contemporary situation, in which scattered articles fill the reader’s information field and create an unbearable burden of orienting and structuring often contradictory findings within incompatible theoretical lenses. The theory of objectification offers not a simple but a systematic lens for looking at very different aspects of education. The theory of objectification addresses the learner and the teacher as individuals who are continuously developed by culture and develop culture:

The theory rests on the fundamental idea that learning is both about knowing and becoming. Behind this fundamental idea is the neo-Hegelian, dialectical, dynamic, constitutive conception of subjects and cultures: both the individual and culture are coterminous entities in perpetual flux, one continuously becoming the other and the other the one. (p. 16)

Positioning the theory of objectification in a landscape of socio-cultural theories, Radford highlights teaching–learning as a reciprocal bi-directional process of active involvement and transformations on both sides: on the side of the teacher and of the learner.

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Involvement in joint labour and establishing a joint space for action leads the learner beyond constructing or receiving knowledge and the teacher beyond transmitting or supporting knowledge construction. The theory of objectification overcomes the dichotomies of teacher- versus student-oriented teaching and traditional versus constructivist approaches. It continues the pivotal working out of cultural-historical approaches as a radical alternative to former theoretical branches (Lerman, 1996). Discussing learning as a cultural phenomenon of a particular epoch, Radford established a theory that aims not only to explain and depict education but also to transform it. The transformative stance (Stetsenko, 2020) is taken at the level of educational design interventions and also at the ethical–political macro-level. The theory calls for making ethical and political choices that have in recent times become particularly topical for researchers in mathematics education (Bakker et al., 2021).

The book is a rare combination of a complex, at times philosophical, exploration of the phenomenon of teaching-learning and of an elaborated support for the reader. The author pays much attention to making the entrance into the theory of objectification as smooth as possible: He provides an overview of the main concepts, summaries of each chapter, and comprehensible diagrams.

## 1 Framing an understanding of the theory of objectification

Despite the educational efforts of the author, this book on the theory of objectification is not an easy read. The main difficulty comes with the need to reconsider seemingly familiar notions and to become acquainted with their precise conceptual meaning within Radford's theoretical system.

The first concept that needs to be reconsidered is *knowledge*. Within the theory of objectification, knowledge does not refer to mental entities of a personal semantic network or cognitive constructs but to cultural-historical forms of thinking, action, and reflection. Knowledge exists for novices as a potentiality, in a latent form; it can be *encountered* through joint labour with an already enculturated population. Encountering—meeting with knowledge as a potential capacity of culture—happens through *knowing*, namely, through “*actualization* or *materialization* of knowledge” (p. 49). Through knowing, knowledge exposes itself in labouring within a cultural system in a concrete, sensible, material form.

The core concept of *objectification* also must be correctly understood. Unlike in other theoretical systems, objectification means neither constructing new objects in the course of reification nor creating “something objective that is universal and independent of human beings” (p. 77). Instead,

...processes of objectification are the social processes of progressively becoming aware of cultural-historical systems of thinking and doing—something we gradually notice and at the same time endow with meaning. Objectification processes are those acts of meaningfully noticing something that reveals to our consciousness through our bodily, sensory, and artefactual semiotic activity. (p. 78)

Clarifying the meaning of objectification, Radford follows the distinction between *Gegenstand* and *Objekt*. While *Objekt* is a general entity independent from the subject and not encountered, *Gegenstand* is something that appears to the subject, stands before her, objects to her, and resists the consciousness. These terms come from the German tradition of writing and can also be aligned with *predmet* and *objekt* in Russian within Activity theory. The term

objectification should be understood in the sense of encountering an independent pre-existing *Objekt* and further apprehending it as *Gegenstand*, as an object for the consciousness, in the course of intellectual and sensible activity (see pp. 76–77 for Radford’s more comprehensive explanation). In the process of learning, knowledge—cultural forms of thinking and acting—exists at first as an independent, untouched *Objekt*. These cultural forms become an aim, an objective of a joint activity—which results in revealing these new forms of thinking and acting to the learners’ consciousness, in the form of a new *Gegenstand*, that is, a new dynamic and complex object of consciousness.

While reading the book, the reader might wonder if the objects are *material* or *ideal*. This is the next pair of concepts which need to be studied anew within Radford’s theoretical framework. Unlike in empiricist or idealist approaches, the ideal should not be treated as disentangled from human senses and actions, or as mental or transcendental. Instead, in dialectical materialism, “‘ideality’ is a kind of stamp impressed on the substance of nature by social-human life-activity, a form of the functioning of the physical thing in the process of social-human life-activity” (Ilyenkov, 2012, p. 176). It is through their enactment in and through human activity that things “acquire a new ‘form of existence’”, namely their “ideal form”. Following dialectical materialism, Radford claims human activity (praxis, labour) to be at the core of producing both material cultural artefacts and the human senses that are able to perceive these artefacts in their cultural form. It is in this reciprocal process of producing culture and cultural subjects that the ideal and the material are in the unity of historical development. Radford writes that in this sense, “our thinking, feelings, deeds, and in fact all our relations to the world (hearing, perceiving, smelling, sensing, etc.), are *historical intertwines* of our body and material and ideational culture” (p. 109). The material is not out there, and the ideal is not mental, psychic, or untouchable. Together, the physicality of matter and the universal forms of historical practices shape our practices, bodies, and cultural entities. In this sense, mathematics appears “at the same time an ideal, sensible, and material” (p. 56) entity.

The last pair of concepts that I would like to highlight as having specific meaning within the theory of objectification is *reflection* and *reflexivity*. Reflection is used throughout the book—along with action—as a practice that has a cultural form. Cultural forms, or archetypes, of reflection and action constitute knowledge. Reflection in the theory of objectification is not a passive mirroring of reality. It depends on the specific situation of the reflecting organism, since reflection relies on its historically—through biological evolution and cultural development—constituted sensibilities. Based on these sensibilities formed in enactment, reflection “is a relational category between subject and object that keeps them intertwined with each other” (p. 116). It involves both an *Objekt* (an independent entity in the cultural world) and *Gegenstand*—the subjective appearance of the object to the consciousness. While *reflection* seems to be a general quality of any living organisms, but shaped culturally in the case of humans, a similar word, *reflexivity*, is used to characterize specific human attitudes. A reflexive manner of interaction with the cultural-historical context means that subjects do not only respond to the world as they are affected by it but also “react *agentically* to such context” (p. 189) in a responsible way. A subject is the locus of agency and free will, responsible for their political and ethical choices.

## 2 Main ideas and the book structure

The entire book is built following the principle of ascending from abstract to concrete, which is at the core of dialectical materialism. In dialectical materialism, concreteness is very different from the empiricist conceptualization of concrete as a surplus of sensual qualities that touches a person as an unstructured mixture and further leads to abstract ideas through generalization. Instead, concrete is constituted as an elaboration of a narrow, one-predicate abstract idea in the multiplicity of contexts (Hegel, 1966), through clarification and enrichment of the abstract by circumstances. Thus, the development of science, as well as learning, starts from the general case and progresses towards systematic clarifications of it in a variety of contexts. In a similar manner, this book progresses from a general consideration of the role of theory in mathematics education based on examples of diverse theories (Chapter 1), to introducing an overview and the main concepts of the theory of objectification (Chapter 2). The following chapters further clarify the theory's core concepts in classroom examples (Chapters 3, 4, 5, and 6). Once the main body of objectification theory is established, Radford zooms in on task design in Chapter 7, which makes the theory applicable by establishing environments in which objectification processes could proliferate. Chapters 8, 9, and 10 zoom out from the detailed analysis of micro-processes in the classroom towards much broader cultural, ethical, and political processes and concretization of the objectification theory within these broad contexts.

Chapter 1, *Theories in mathematics education*, deals with the most general question of what is a theory in mathematics education and how does it contribute to educational research and practice. The author shows that the triplet of theoretical principles, methodology, and research questions frames the focus of a theory and allows researchers to deal with particular problems while restricting access to the other aspects of the educational process. Analyzing the prominent examples of constructivism and the theory of didactical situations, Radford shows that—despite different attitudes towards the role of social interaction in teaching and learning—both theories emphasize the importance of the learner's autonomy. Importantly, the empirical sources do not provide evidence towards one theory or another, as an observation in a natural science would. Instead, it is through the different theoretical lenses that we see different aspects within the same scene. Thus, the choice of a theory depends not on its explanatory power regarding an empirical evidence but on a broader choice of an educational project, including philosophical origins and political and ethical stances. In particular, the theory of objectification considers "... Mathematics Education as a political, societal, historical, and cultural endeavour ..." (p. 15).

Chapter 2, *An overview of the theory of objectification*, uncovers the position of the theory within other socio-cultural theories in mathematics education. This chapter is critical to understanding the entire book, as it clarifies the rather specific terminology of the theory in relation to other socio-cultural theories, thus preventing the reader from making simplified interpretations along the familiar paths. Surprisingly to readers who are used to thinking about Vygotsky's approaches as instrumental and based on artefact and language mediation, semiotic or cultural mediation does not lie at the core of objectification theory. On the contrary, Radford goes along with late Vygotsky in criticizing the prominent role of artefacts and language as mediators in communication and learning. Instead, he claims, artefacts are an integral part of the ongoing social process that is referenced as *activity* or *joint labour*. Joint labour (*deyatel'nost'* (Russian) and *Tätigkeit* (German)) should be understood as the dynamic unity of collaborative enactment towards producing common work. In joint labour, students and teachers produce knowledge and also co-produce

themselves as reflexive and responsible subjects. The chapter ends with a synoptic panorama of the theory of objectification, which might be used as a terminological guide while reading the book.

As already mentioned, the theory of objectification has an unusual take on the notion of knowledge, which is discussed intensively in Chapter 3, *Knowledge and Knowing*. Knowledge—taken as a latent potentiality within a community capable of a particular *ideal form* of actions—is fluid; it continuously develops in the cultural-historical process, along with the development of symbolism and practices. The development of knowledge always passes through *knowing*, namely a concrete singular materialization of knowledge. Concrete is understood here as a manifestation and a materialization of general and abstract ideas as a node in respect to a particular context. In this way, knowing in the theory of objectification is always happening within the particular practice (or joint labour), thus manifesting knowledge. Yet, the joint labour is transformative, and knowledge is transformed towards a more concrete understanding of phenomena once it passes through the process of materialization or actualization in knowing. Thus, ascending from the abstract to the concrete is achieved. In this sense, writes Radford, mathematics is not limited to symbolic systems which only hold a potentiality for mathematical practice to unfold. Instead, mathematics is at the same time ideal, sensible, and material. A small classroom example helps the reader digest these theoretical developments and supports the theory of objectification as a particular lens for consideration of classroom events.

Having accomplished setting up the theoretical and philosophical frame in the first three chapters, in Chapters 4, 5, and 6, Radford presents the core of the objectification theory for mathematics teaching and learning. The chapters were partially published previously in 2010–2013; however, in the book, they are reframed as they are coordinated with the enriched context of the theory. The central notions of the theory are repeated again and again within different chapters, thus helping to embed them. Each chapter presents a theoretically informed reading of classroom episodes that showcase how students learn to grasp mathematical patterns. Chapter 4, *Learning*, presents learning as becoming aware of cultural forms of acting and reflecting which are at the core of the objectification process. Importantly, awareness should not be understood as an internalized representation of the external world in the solitary internal plane of rational subjective experience. Instead, consciousness is concrete, alive, affective, and social. Objectification does not lead to a replica of culture. Radford pays a lot of attention to separate his understanding of objectification from the common understanding of internalization, often treated as Vygotskian. While *objectification* reveals the world of cultural knowledge to the subjects, the dialectically opposed process of *subjectification* transforms students on their way to becoming active and creative members of a cultural practice. As students struggle and become emotionally involved in classroom activities, they actively incorporate themselves into the culture and their consciousness is transformed—not filled in, as some traditional approaches suggest.

In Chapter 5, *Processes of objectification*, Radford analyses the objectification process in detail as embedded into teaching–learning activity. Reshaping Leontiev’s traditional schemata of action as achieving a goal, and activity as fulfilling an object/motive, Radford talks about the Object, Goal, and Task of an activity. He separates the objective of the entire teaching–learning activity as shaping students’ thinking from the subordinate goal of solving mathematical problems of a particular type and further subordinate mathematical tasks. Semiotic means—words, gestures, speech prosody, and others—are the way of expressing the concrete process of knowing in the course of joint labour: for example, a student comes to distinguish mathematical relations by explicitly discussing them and pointing at corresponding models. While knowing is accomplished through expressive

semiotic means available within the joint labour space, later, the semiotic means undergo a *contraction*. Semiotic means become briefer and disappear from the shared space, as students come to distinguish mathematical meaning without explicitly expressing their structuring activity.

This leads to Chapter 6, *Embodiment*, that highlights a specific understanding of embodiment within the theory of objectification. The critical point here is that culture reshapes human sensory organs. A vivid example comes from a classroom activity where a teacher helps students in noticing regularities in a pattern recognition task. A regularity—that seems obvious to an enculturated eye—slides away from the students' attention. It is through gestures and rhythms that the teacher shapes students' perception, thus revealing new structures in the world. This chapter is critical for an understanding of the anti-empiricist turn that the theory of objectification takes. It is not that students come to possess some knowledge about the outside world. Instead, the world is shaped differently through the new forms of sensibilities acquired in the direct enactment with the world together with an enculturated adult within culturally relevant intentionality. New forms of perceiving and acting are co-produced in teaching and learning, and the world is reshaped in the processes of objectification.

Chapter 7, *Task design or configuring teaching–learning activities*, vividly exhibits the principle of ascending from the abstract to the concrete, as it applies theoretical vision to designing particular activities for the learning of mathematics. The general approach promotes the processes of objectification of mathematical forms of action and thinking through problem solving in small groups supported by a teacher. Radford provides specifications for mathematical problems suitable for such activity and the organization of collaboration in the classroom. Also, capitalization of previous knowledge and the intensive involvement of the artefacts is essential for objectification success, as students pass through the designed problem. The first key principle in designing specific problems is *conceptual and contextual unity*: the problems need to be embedded into a meaningful narrative that makes sense for the students. At the same time, the story should allow for exposing the complexity of various mathematical objects under investigation so that their interrelation could be grasped while working on the problems. The second key principle is *increasing conceptual complexity*, introduced to “make the students progressively aware of mathematical objects at increasingly sophisticated and profound levels of generality” (p. 146). The students ground their conceptualizations in concrete sensory experiences with manipulatives and technological devices, develop theoretical reflections, and establish mathematical practices of manipulating with mathematical symbols. Importantly, those levels of conceptualization emerge in an overlapping manner, altogether contributing to a rich understanding of mathematics. Joint labour with peers and teacher lies at the core of this approach. Through collaboration students develop critical reflections, and the teacher's questions promote reaching “deep levels of mathematical consciousness” (p. 146).

Starting from Chapter 8, the theory of objectification (TO) zooms out to position mathematics education—taken from the TO perspective—in contemporary society with its historical, political, and ethical dimensions. We see the theory growing and becoming more powerful in recent years, as these chapters are either new or bring forth very recent materials. In Chapter 8, *The cultural nature of mathematical thinking*, instead of exemplifying theoretical statements with an empirical example, Radford dives into the history of Greek mathematics and shows how mathematics—frequently understood as the universal “strong” science—developed as a cultural practice in response to multiple factors, including economics, politics, the structure of society, and aesthetics, triggered by the symbols and artefacts in use. Radford shows how theorematic and pragmatic branches of mathematics in

ancient Greek society develop as thesis and antithesis to each other. This chapter is important as an illustration of the cultural-historical analysis, but also it is fascinating reading. The *overdetermination* of mathematics' development in society by economic, symbolic, ideological, historical, ethical, and other factors acting all together serves as a ground for an understanding of the following chapters which address educational theory as an ethical project. Chapter 9, *Processes of subjectification*, describes a subject—both a teacher and a student—as a dynamic, responsible project of self-transformation in the process of becoming. The personal and the cultural jointly contribute to overdetermination, and subjectification is seen as a social process of ingrowing (in Vygotsky's terms) of culture into a subject and—at the same time—a responsible and reflective self-constitution in becoming. This becoming is understood as the process of co-producing learners and teachers as never-finished dynamic projects.

The *last chapter* of the book addresses *Ethics*. On the one hand, the topic might seem unrelated to other parts of the book; on the other hand, through adopting an ethical stance the theory of objectification positions itself as a transformative, active attitude to education, as a “rearrangement of the empirical world” (in Marx and Engels' words, quoted on p. 218). Maintaining the custom of this book to adopt deep historical and philosophical lenses, Radford moves aside ethical projects by Kant and Hobbes and delves into an ethical project of Lévinas, showing that absorption into contact with the other is critical for Lévinas as it is for the theory of objectification. Further, in line with dialectical materialism TO puts forth *communitarian ethics*. It is love, cooperation, and solidarity that are at the core of TO's ethical commitment. Based in these values, student–teacher interaction is seen as reciprocally affirming each other's responsibility and agency in co-producing knowledge and themselves. A teacher does not take a powerful position but invites students into a collaborative space as she makes herself vulnerable and takes the risks associated with this open position.

### 3 Potential directions for future development

Finally, I would like to suggest two issues that are in my opinion essential for a cultural-historical perspective on education and that are not yet in the theory of objectification. One issue comes from a micro-scale analysis of embodied interaction, and the other is triggered by the macro-scale methodology of ethical and political transformations. My two concerns are by no means intended to limit the contribution of the objectification theory but to trigger further theoretical conversation.

In the theory of objectification, “Learning consists of noticing ... cultural-historical systems of thinking and action” (p. 79). In the course of objectification, learners gradually become aware of cultural forms of perceiving and acting and “try to grasp something that lies before [them]” (p. 79) as they learn. So learning requires a reflective awareness of thinking and acting. However, it seems, we—as cultural subjects—are not always aware of how culture is infused in our actions and thinking. For example, we are not aware of the distance between partners in everyday conversations until we encounter cultural differences. Action constitution is a complex dynamic process, which is far beyond the reach of our conscious reflection. Moreover, a full awareness might destroy practice: the well-known effect of choking under pressure in sport most probably emerges due to the player's focus on procedural performance and self-monitoring (Beilock & Carr, 2001). To appreciate this phenomenon, imagine learning to ride a bike and consciously estimating an angle

of leaning to the right or left when turning. Such a deliberate focus barely would help find an appropriate movement. These examples demonstrate that learning is not limited to noticing and growing awareness; moreover, reflective awareness does not always contribute positively to learning.

When extending embodied mechanisms of physical interaction to mathematics learning (Abrahamson & Sánchez-García, 2016), research shows that the students exhibit various sensorimotor routines (Duijzer et al., 2017). Only later do those sensorimotor patterns converge into intersubjective mathematical objects through cultural referencing. In the context of a cultural-historical approach, it might mean focusing students' deliberate attention on the *goals* of actions, rather than on the *form* and “a general or archetype of doing things” (p. 44), as Radford suggests.

Critically, designers of educational environments create material culture that largely constrains students' movements and perception without being noticed. Embodied approaches to designing technological environments (e.g., Abrahamson & Sánchez-García, 2016; Nemirovsky et al., 2013) create spaces in which students learn to perform cultural forms of embodied routines pre-reflectively. Later, those routines provide a source for semiosis and reflective awareness. It would be interesting to see how such environments are theorized within the objectification theory and investigate the degree to which awareness of those routines is productive for understanding mathematics.

My second concern addresses the transformative stance of the objectification theory at the level of ethics. The theory of objectification suggests an ethical commitment that calls for “reflexive and critical constitution of ... will, love, cooperation, and solidarity—i.e., capacities that affirm the social, cultural, and historical nature of individuals and where our relations to others as sentient beings becomes the ontological condition of our existence” (p. 222). Radford submits that through joint labour, committing to truly social co-production, and affirming themselves and others as expressive and valuable, teachers and students might overcome alienation and develop genuine education.

However, in a twenty-first century that follows a sequence of collapsed modernist projects of the twentieth century, and after the “end of history” announced by postmodernists, I call for caution in placing one ethical system in a prominent position. Taking this question to an extreme, I would like to think, along with the author, how the transformation driven by communitarian ethics differs from the former modernist projects, particularly from the communist transformations that dialectical materialism has (destructively) supervised in the Soviet Union. How can a theory support transformations without falling into utopian traps? An attempt to elaborate a utopian methodology of creating communitarian sub-communities calls for attention to local historical contexts and, more importantly, to an inevitable failure of the project (Brown & Cole, 2001). To ensure that transformations—driven by the objectification theory according to the ethical values—avoid imposing changes in a top-down manner, thus making educational system more totalitarian, we might need to anticipate the failure of the project and to keep the ethical system open and flexible.

In addition to *inviting* rather than *enforcing* the power of culture, we might want to appropriate the ideas of feminist and critical theory scholars on a return to *authorship* (e.g., Walker, 1990) and the calls of human rights activists for *self-advocacy* (e.g., Test et al., 2005). These approaches draw attention to unique experiences and stigmas that need to be treated with special care while aiming for inclusivity. Students might not only become actively involved in historically and socially constituted joint labour but also rebel against its structure as being oppressive. Accepting *emancipation as a collective project*—as Radford suggests—educators might want to re-establish instructional designs and lesson plans in collaboration with students. For example, the students with autistic spectrum



disorder might suffer from elevated classroom noise when working in small groups and might call for the alternative forms of collaboration. As an ethical–political endeavour, education might unfold as a fractal of local historically constituted values and social practices, and require probing and re-establishing ethical commitments.

## 4 Conclusion

While Radford’s book provides a systematic unifying theory, it is also a journey with the author through years of exploration and thinking. Just as learners and teachers shape their knowing in an ultimately developing, never-ending process, we can see the theory of objectification as evolving and developing. It began as an exploration of the role of semiotic resources in mathematics teaching and learning, and continued by expanding on ethical and political issues: It travelled from a descriptive to transformative methodology (Stetsenko, 2020) and to taking a responsible position on developing future society. The book is highly recommended for those interested in the Theory of Objectification and, more broadly, in socio-cultural research; it will also inspire those who aim to transform mathematics teaching towards nurturing critical and reflexive cultural subjects. The book brings a great example of a theory that might contribute to the development of mathematics education as a historical, cultural, and political endeavour.

## References

- Abrahamson, D., & Sánchez-García, R. (2016). Learning is moving in new ways: The ecological dynamics of mathematics education. *The Journal of the Learning Sciences*, 25, 203–239. <https://doi.org/10.1017/CBO9781107415324.004>
- Bakker, A., Cai, J., & Zenger, L. (2021). Future themes of mathematics education research: An international survey before and during the pandemic. *Educational Studies in Mathematics*, 107(1), 1–24. <https://doi.org/10.1007/s10649-021-10049-w>
- Beilock, S. L., & Carr, T. H. (2001). On the fragility of skilled performance: What governs choking under pressure? *Journal of Experimental Psychology: General*, 130(4), 701–725. <https://doi.org/10.1037/0096-3445.130.4.701>
- Brown, K., & Cole, M. (2001). A utopian methodology as a tool for cultural and critical psychologies: Toward a positive critical theory. In M. J. Packer & M. B. Tappan (Eds.), *Cultural and critical perspectives on human development* (pp. 41–65). State University of New York Press.
- Duijzer, C., Shayan, S., Bakker, A., Van der Schaaf, M. F., & Abrahamson, D. (2017). Touchscreen tablets: Coordinating action and perception for mathematical cognition. *Frontiers in Psychology*, 8, 144. <https://doi.org/10.3389/fpsyg.2017.00144>
- Hegel, G. W. F. (1966). Who thinks abstractly? In W. Kaufmann (Ed.), *Hegel: Texts and commentary* (pp. 114–118). Anchor Books.
- Ilyenkov, E. (2012). Dialectics of the ideal (2009). *Historical Materialism*, 20(2), 149–193. <https://doi.org/10.1163/1569206X-12341248>
- Lerman, S. (1996). Intersubjectivity in mathematics learning: A challenge to the radical constructivist paradigm? *Journal for Research in Mathematics Education*, 27(2), 133–150.
- Nemirovsky, R., Kelton, M. L., & Rhodehamel, B. (2013). Playing mathematical instruments: Emerging perceptuomotor integration with an interactive mathematics exhibit. *Journal for Research in Mathematics Education*, 44(2), 372–415. <https://doi.org/10.5951/jresmetheduc.44.2.0372>
- Stetsenko, A. (2020). Research and activist projects of resistance: The ethical-political foundations for a transformative ethico-onto-epistemology. *Learning, Culture and Social Interaction*, 26, 100222. <https://doi.org/10.1016/j.lcsi.2018.04.002>

- Test, D. W., Fowler, C. H., Wood, W. M., Brewer, D. M., & Eddy, S. (2005). A conceptual framework of self-advocacy for students with disabilities. *Remedial and Special Education, 26*(1), 43–54. <https://doi.org/10.1177/07419325050260010601>
- Walker, C. (1990). Feminist literary criticism and the author. *Critical Inquiry, 16*(3), 551–571. <https://doi.org/10.1086/448546>

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