CARING IN PROFESSIONAL DEVELOPMENT PROJECTS FOR MATHEMATICS TEACHERS: AN EXAMPLE OF STIMULATION AND HARMONIZING

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Hackenberg (2005) proposes that a mathematical caring relation is one in which 1) a teacher attends to the cognitive and affective needs of a student, 2) the student receives and responds to the teacher's care, and 3) this interaction occurs within the context of an effort to engender the learning of mathematics. At its heart, the mathematical caring relation construct highlights the relational nature of the teaching and learning of mathematics. I have identified four terms that are especially helpful for understanding mathematical caring relations: *stimulation, depletion, decentering,* and *harmonizing*. All four terms come directly from Hackenberg's discussions of mathematical caring relations (2005, 2010).

Stimulation and *harmonizing* are the terms most relevant to this article. Participants in the mathematics teaching and learning interaction (typically, teachers and students) experience fluctuations between feelings of stimulation, in which the participant is energized, and depletion, in which the participant is taxed. Both the teacher and student are subject to these feelings, largely in response to the actions and activity of the other, but Hackenberg holds that the teacher, as the main carer, is responsible for monitoring and appropriately responding to the experiences of stimulation and depletion of the student, the cared-for, while attempting to engender mathematical learning. This is possible when a teacher works to harmonize with a student's mathematics; that is, when a teacher takes up a student's mathematical understandings as if they were the teacher's own. This orientation, in turn, requires that the teacher *decenter* from his or her own mathematical ways of knowing. In this article, I draw especially on the concepts of harmonizing and stimulation as I attempt to make sense of my work as a mathematics teacher educator.

The idea of mathematical caring relations resonates with anyone who has struggled to find a balance between providing challenge and providing assistance, between attending to the person and to the mathematics, between posing problems that are too easy and too difficult, or between responding to cognitive needs and affective needs. Indeed, one of the strongest contributions of the idea of mathematical caring relations is its acknowledgement of the importance of an affective component, not only when one is learning, but also when one is teaching.

Another strength of the mathematical caring relation construct is its insistence, in keeping with Noddings's (1984) criteria for caring, that a student must take up and receive the care being offered for a relation to qualify as a true mathematically caring interaction. In this sense, successful teaching is not viewed as a checklist of teacher behaviors, but requires that a student engage in the relation. We cannot say with confidence that a teacher-student relation has been caring without attending to whether the student him or herself experienced the caring.

Hackenberg (2010) analyzed her own work as a mathematics teacher using the mathematical caring relation lens. She examined a teaching experiment in which she had attempted to teach and learn from four sixth-grade students. Her use of the mathematical caring relation in this way allowed her to realize, among other findings, that attending to students' cognitive constraints and energetic fluctuations can help teachers to prompt productive mathematical perturbations (von Glasersfeld, 1995) for the students. Her analysis also suggested that indications that a student is feeling depleted might serve as evidence that a teacher needs to harmonize better with the student's cognitive needs and abilities.

Sztajn (2008) extended Hackenberg's (2005) concept of mathematical caring relations beyond the interactions of teachers and students in mathematics classrooms to the interactions of teacher educators and teachers in professional development settings. By analyzing short narrative depictions of her experiences working with practicing teachers, Sztajn exemplifies her claim that Noddings's care theory can help to understand and support the work of mathematics teacher educators. Her larger argument is that we need to broaden our thinking of who should be cared-for beyond students in schools to include their teachers. In this way, Nicol, Novakowski, Ghaleb and Beairsto's study (2010) of the care experienced by students and teachers in a university mathematics methods course is similar to Sztajn's, in that they both consider the cared-for to be teachers (preservice and practicing, respectively). Both studies also expand the "mathematics" of mathematical caring relations to include "mathematics teaching."

In this article, I take up Sztajn's (2008) challenge that mathematics teacher educators regard their work with mathematics teachers as opportunities and responsibilities to care for mathematics teachers. In particular, she argues that we should attend not only to the content and format of professional development initiatives, but to the relations established within them. To that end, I seek to look anew at a professional development project in which I participated as a mathematics teacher educator, with an eye toward the caring relations that were or were not established. Like Hackenberg's (2010) study, mine is situated in a teaching experiment. But because I was working as the researcher in the project, and not as the main mathematics teacher, I am interested in casting the participating teacher as the cared-for, and in understanding my role as the one-caring. This project can be understood as one response to Hackenberg's call to further develop the mathematical caring relation construct by applying it to varied settings.

The setting of the professional development

Following Sztajn's (2008) approach, I first describe the format and content of the professional development project in which I was participating as a mathematics teacher educator, since these are important dimensions of any professional development effort. I then present and analyze one episode that occurred during the project, in an effort to describe the mathematical caring relations that may have been established. I finally consider the ways in which this third dimension—the quality of the relations established between providers and participants—can contribute to our understanding of our work as mathematics teacher educators.

The data for this study come from a yearlong professional development project that I have described elsewhere (McCloskey, 2008). Over the course of that year, the members of the research team worked closely with a pair of upper elementary (grades five and six, in which students are approximately 10-12 years old) schoolteachers, supporting them as they each conducted a teaching experiment—as described below—on fractions learning with some of their students. My role on the project was research assistant, and I was assigned to work with a sixth-grade teacher, Mrs. Garcia. I observed Mrs. Garcia's classroom mathematics teaching once a week, but the heart of the project was our twice-weekly teaching experiment conducted with one of her students, Julie. In that capacity, I served as the witness-researcher, supporting Mrs. Garcia as she learned to conduct a teaching experiment.

The teaching experiment methodology that we used in our project was influenced most directly from the research of Steffe (Steffe & Thompson, 2000). The goal is to "create situations that would allow the investigator to observe children at work and make inferences as to how they build up specific mathematical concepts" (von Glasersfeld, 1995, p. 17). The teacher-researcher is continually seeking to understand the reasoning behind the student's mathematical activities. To that end, she poses tasks to the student, carefully observes the student's actions, and asks her to explain her thinking. The teacher-researcher is continually forming conjectures about the student's implicit mathematics: this is the model-building process. She continually tests her model by posing follow-up tasks. As the teacher-researcher "hones in" on what the student can and cannot do and uses that to infer what the student does and does not know, she is delineating the outer boundaries of the student's mathematics. Steffe called this methodology a *teaching* experiment because the teacher-researcher is not simply trying to determine the boundaries; she is also trying to push those boundaries further by provoking learning in the student. She does this by posing tasks that are designed to be accessible yet problematic for the student's existing understanding.

Each session of our teaching experiment, called a *teaching episode,* lasted approximately thirty minutes. Julie, the sixth-grade student who worked with Mrs. Garcia and me, sat in front of a computer so that she could interact with a software program designed to provide a virtual environment in which students can exhibit their thinking about fraction concepts. The problem-posing and solving therefore occurred through a computer, which allowed her to virtually manipulate pictures of sticks and bars on the screen.

Mrs. Garcia assumed the leadership role as the teacher-researcher beginning on the very first session. She posed tasks and asked follow-up questions as she sat beside Julie at the computer. I acted as the "witness-observer," which means I sat slightly behind the two of them, operating a video recording camera. My attention was divided between ensuring the camera was capturing Julie's gestures and screen shots appropriately so that Mrs. Garcia and I could analyze them immediately after the teaching episode in our debriefing/planning session. Sometimes I suggested a follow-up question or explained some feature of the computer program, but I mostly tried to remain as unobtrusive as possible, taking field notes and marking potential moments of interest, based on either Mrs. Garcia's or Julie's actions. Following each 30-minute teaching episode, Mrs. Garcia and I met, and I audio recorded our 15- to 20-minute debriefing/planning conversation. She and I used that time to discuss what had just transpired and how that might inform our model of Julie's mathematics, and to plan accordingly for the next session.

During the teaching episodes, my initial data collection consisted of making in-the-moment decisions in my role as the witness-researcher about what to focus the camera on. I also videotaped the episodes so that Mrs. Garcia and I could more thoroughly analyze the episodes at a later time. This retrospective analysis is a hallmark of Steffe's teaching experiments (Steffe & Thompson, 2000), and the video recordings served as the major data source for Mrs. Garcia's and my model-building of Julie's mathematics. So, von Glasersfeld's (1995) radical constructivism informed not only the way the professional development project understood student learning, but teacher and researcher learning as well. We were all engaged in model-building of some sort: Julie was building mathematical models; Mrs. Garcia and I were engaged in building models of Julie's mathematics; I was attempting to build a model of Mrs. Garcia's model of Julie's mathematics; and it may even be the case that Mrs. Garcia was building a model of my model of Julie's mathematics (!).

In summary, the format of this particular professional development project was a yearlong experience of conducting two concurrent teaching experiments, each conducted by a small group composed of a mathematics teacher educator, a classroom teacher, and her students, which met regularly in small groups of various configurations. The content of the professional development was children's development of fraction concepts and how to build models of student understanding. Next I discuss how care theory can be used to analyze some of the relational dimensions of the professional development.

Looking for care: stimulation and harmonizing

One possible approach to this study would be to analyze the format and content of the professional development project, as described above, using care theory and its constructs. For example, I might consider our choice of fractions as the mathematical content for the project and whether or not that decision reflected a caring orientation toward the mathematics teachers. How was this topic chosen? Was it chosen by the professional development providers, by school administrators, or by the teachers themselves? How was it presented to the participating teachers? Was it presented as if it were up for negotiation or as if it were "set in stone?" Was a rationale provided for its selection? Did the teachers agree to participate because they were interested in the topic of fractions? Answers to these questions would shed light on whether the teachers were cared-for during those important initial decisions about the design of the professional development. I save that analysis for another time. Here I use concepts from Hackenberg's (2005, 2010) discussions of mathematical caring relations, especially her notions of stimulation and harmonizing, to analyze a vignette from the professional development. I begin with an example in which Mrs. Garcia, the classroom teacher with whom I worked, showed signs of stimulation.

The exchange below occurred approximately four months into the professional development project. At the preceding debriefing/planning session, Mrs. Garcia and I chose to pose this task to Julie in order to test our model of Julie's fraction understanding:

> This is my stick. My stick is 4 times as long as your stick. Draw your stick.

In previous episodes, Julie had been able to correctly solve these related tasks: "Make a stick that is 4 times as long as this stick" and "Make a stick that is ¼ as long as this stick." (I discuss more about the mathematical relationship between these three tasks later.) We were confident that she would solve this task easily and quickly, but we were curious about how she would approach it. However, she experienced significant perturbation with the task, and this caused us to reconsider our model for Julie's mathematics.

Mrs. Garcia began by using the computer software to make a virtual stick and then told Julie that her (Mrs. Garcia's) stick was four times as long as Julie's stick. She then asked Julie to construct her stick using that information. Julie did eventually solve the task, although that moment is not depicted here. A few minutes after the exchange transcribed below, she realized that she needed to divide Mrs. Garcia's stick into four equal-sized pieces, and pull out one of those pieces. She said, "That's all I had to do the whole time?" as if, upon arriving at the correct answer, she was surprised at how long she had struggled. So, Julie does successfully solve the task. Just as important is what Mrs. Garcia and I learned about the limits of Julie's understanding of fractions as sizes relative to the whole.

1. [Mrs. Garcia has made a stick and a copy of the stick]
2. *Mrs. Garcia:* Okay this is my stick so you can't touch it [laughs], and my stick is 4 times as long as your stick, so you have to make your stick … mine is 4 times as long.
3. *Julie:* Okay. So…can I copy your stick?
4. *Mrs. Garcia:* Yes, you just can't touch my stick. [laughs]
5. [Julie copies the stick, and takes a while to decide how many equal-sized pieces to divide it into. She begins by dividing it into eight pieces and examines the resulting stick. She removes the hash marks, and then tries again to decide how many equal-sized pieces to divide it into. She works silently for over one minute. Mrs. Garcia leans in for a better view of the screen.]
6. *Julie:* This is hard.
7. *Mrs. Garcia:* Yes (agreeing). So…here's my stick, it's four times as long as yours.
8. *Julie:* Okay
9. [Julie decides to divide it into 5ths. She looks at the resulting bar. She removes the hash marks. Continues to consider how many equal-sized pieces to divide it into. Another 65 seconds of silent problem solving goes by.]
10. *Mrs. Garcia:* Do you have any questions Andrea, or suggestions? That can kind of move her in the right direction?
11. *Andrea:* What are you thinking Julie, is there any way you can explain…what's making this hard when you said it was hard?
12. *Julie:* I guess I don't really get it.
13. *Andrea:* At this point it looks like you're trying to decide what number. You know you want to divide it into pieces, but you don't know how many times?
14. *Julie:* Yeah.
15. *Andrea:* So, so far you've tried 8 and 5 and why did you not go with…stick with either one of those?
16. *Julie:* Because I didn't think they'd work.
17. *Andrea:* Okay.
18. *Mrs. Garcia:* I can give her a concrete example, but that might give away the answer. I can think of something in the classroom that I can tell you with different numbers. [laughs]

19. *Andrea:* Well are you going to make a stick that's bigger or smaller than…?

20. *Julie:* Smaller.

21. *Andrea:* Okay.

22. *Mrs. Garcia:* But first what you're trying to decide is how many to split that into.

There are several ways Mrs. Garcia can be thought to be exhibiting stimulation in this excerpt. Firstly, although the debriefing/planning session which had occurred several days before this exchange is not transcribed here, it should be noted that at that time, Mrs. Garcia and I worked together to articulate our model of Julie's fraction reasoning, and that was what led to Mrs. Garcia posing this question to Julie to start the session. So, the mathematical question that Mrs. Garcia posed here was developed as a result of conversation and curiosity that Mrs. Garcia and I shared.

Secondly, it is not insignificant that Julie worked silently for about one minute (in lines 5 and 9) twice in this exchange. During the four months prior to this episode, Mrs. Garcia had struggled with allowing Julie to work for long periods without intervening and without attempting to provide some form of assistance. This was especially challenging for her when it was not obvious that Julie had a clear problem-solving plan. Mrs. Garcia came from a teaching background in special education, and the teaching approach she had practiced for much of her career consisted of breaking up problems into smaller problems, and providing assistance to students as needed for every step along the way to solving them. So, by her admission, it was difficult for Mrs. Garcia to watch a student struggle without intervening. I interpret her willingness to do so in this episode to be an indication of Mrs. Garcia's genuine and growing curiosity in Julie's ability and method for solving this problem in particular, and in the broader agenda of the teaching experiment in general.

Lastly, I take the question asked in line 10, in which Mrs. Garcia asks me for my opinion, as further evidence that she was interested in honoring our goals for the teaching experiment by not telling Julie the answer, as she may have wanted. Instead, Mrs. Garcia decided to ask me to help her think about how best to access and support Julie's thinking, and together, Mrs. Garcia and I muddled through as we sought to honor the sometimes conflicting-feeling goals of teaching and research.

Mrs. Garcia seemed curious and motivated (*i.e.,* stimulated) throughout this entire episode, and I entered into "problem-solving" mode with her. Both she and I were surprised that Julie struggled so much on this task, and our shared model of Julie's mathematics was challenged and perturbed. In that sense, I am harmonizing with Mrs. Garcia, in that my goals for the session become the same as Mrs. Garcia's. Our regular meetings (approximately twice weekly) had been occurring for about four months at this point, and our goals for the teaching experiment itself (as a subset of the goals of the larger professional development project) were becoming more and more of a shared experience. This harmonizing may be an indication of a caring relationship being established between me (here acting as a mathematics teacher educator) and Mrs. Garcia (the "cared-for" mathematics teacher).

This example also serves as an example of why this particular professional development project was difficult for me. As a mathematics teacher educator, it was sometimes difficult for me to know how best to respond when Mrs. Garcia asked me for help, as she did in line 10. I struggled because I was attempting to fill two roles that often seemed to be conflicting: professional development provider and witness-researcher in the teaching experiment. I sometimes struggled to decide whether I should allow Mrs. Garcia to continue with a line of questioning so that she could maintain ownership as the teacher-researcher of the teaching experiment. Or should I intervene when I thought a different trajectory of tasks might be more productive? The dual roles I was filling were challenging for me to navigate and sometimes led to my own feelings of stimulation, in which I followed my "best hunch" about how to proceed, and of depletion, in which I felt stuck and unproductive.

It may be helpful to look to the "Mathematics" in mathematical caring relations for further insight to this vignette. What role did mathematics play in this vignette? What was mathematical about the care that I did, or did not, help to establish between Mrs. Garcia and me? In one sense, the radical constructivist orientation (von Glasersfeld, 1995) that undergirded the entire teaching experiment is premised on a form of mathematical caring. Both Mrs. Garcia and I entered the teaching experiment assuming that Julie had a mathematics that was her own and was a legitimate and valid form of mathematics. This respect for Julie's mathematics was what Mrs. Garcia and I drew upon as we watched Julie struggle to decide how many pieces she should partition the stick into and we refrained from intervening. We assumed, in other words, that Julie's mathematics might very well suggest to her that eighths and fifths were reasonable paths for constructing fourths, and so we allowed her to pursue those options and to encounter the perturbations for herself.

More specifically, we considered the task we posed to be an opportunity to assess Julie's splitting operation (McCloskey & Norton, 2009) because although the operation suggested by the action verbs of the statement ("4 times as long as") is the language of iteration, the actual operation required for successful resolution is partitioning (that is, dividing into four equal-sized pieces). Julie had successfully solved iterating tasks ("Make a stick that is 4 times as long as this stick") and partitioning tasks ("Make a stick that is ¼ as long as this stick") in previous episodes, but we see in the exchange above that a splitting task, which required Julie to recognize the compositional nature between the partitioning and iterating operations, was indeed more challenging for her. Although Mrs. Garcia and I were tempted to conclude that Julie did realize the need to partition and that her difficulty was simply deciding *how many* pieces she should partition the stick into (this is what I was probing for when I tried to get Julie to articulate that the final stick would be smaller than the original, in line 19), our later analysis led us to interpret that Julie was not even confident in the appropriateness of partitioning, and so we inferred that Julie had not yet constructed the splitting operation.

Our radical constructivist orientation, furthermore, precluded Mrs. Garcia and I from ever being certain about Julie's mathematical understandings, as we assumed that no one ever has direct access to another person's mathematics. Our models were always tentative, always subject to testing and revision, and always only our best guesses based on inferences; in this way we were always attempting to harmonize with Julie's unknowable, but still present, mathematics. On the other hand, our position as teachers necessarily required us to act *as if* we knew what Julie understood because we wanted her to learn something about fractions and to come to understand more than she already did. In this case, we wanted her to construct the splitting operation. So, rather than allowing ourselves to remain complacent, we pushed ourselves to act as if our models were accurate representations. This is also a form of caring because we sought to stimulate Julie to construct ever more powerful ways of operating. Both Mrs. Garcia and I were constrained by our own mathematical understandings, but we made an effort to remain open to learning new things—mathematical things—from one another and from Julie. Our caring, in other words, was rooted in mathematics: our care for Julie's present mathematics and her potential mathematics, which may or may not be similar to our own.

Discussion

Many mathematics teacher educators have a natural inclination to care about mathematics teachers. Indeed, for many of us who work in mathematics teacher education, the opportunity to work with our colleagues, who are doing the important work of teaching mathematics in schools, is what drew us into the field to begin with. Many of us have a natural stance of affection and respect for mathematics teachers, and in many cases this is because we began our careers doing that same work, and we know how difficult it can be. But, as Hackenberg (2005) and Noddings (1984) have written, just because there is a natural inclination to "care," does not guarantee that the cared-for receives and experiences that care. In the case of mathematics teacher education, this means that professional development providers do not necessarily provide successful and effective experiences for teacher learning, although they may care deeply about teachers. An intentional effort should be made to follow the principles of caring in mathematics teaching. Furthermore, we must provide opportunities for teachers themselves to communicate with us about whether and how they experience our efforts as "care," and we must be appropriately responsive. Such conscious efforts on our part can be understood as a manifestation of the caring instinct many of us bring to our participation in professional development. Having a framework and tools to implement the principles of caring makes conscious and visible what may be instinctive already.

Philipp, Thanheiser and Clement (2002) report on the success of their efforts to design and implement mathematics courses and scaffolded teaching experiences for preservice elementary school teachers based on an expanding model of "circles of caring." They hypothesized that if mathematics methods courses and mathematics content courses were designed to "tap into" preservice teachers' natural inclination to care for children, the preservice teachers' circles of caring could eventually expand (through well-designed university and field-based experiences) to include care for children's mathematical thinking, and then eventually to include care for the discipline of mathematics more broadly. I think that there may be a parallel to this model for mathematics teacher educators, who may initially become involved with professional development efforts motivated by a general "caring" for mathematics teachers. However, given proper opportunity and support, these mathematics teacher educators may come to seek out and be informed by an increasing amount of research and informed conversation about principles of good professional development. Such principles should include attention not only to form and content, but also to the relations established therein, so that mathematics teacher educators build on their natural care for teachers as a population and mathematics as a discipline to the field of professional development more broadly (including work that develops constructs such as the mathematical caring relation).

It may be the case that the mathematical caring relations established between mathematics teacher educators and mathematics teachers—typically in professional development contexts—are even more complex than those established between mathematics teachers and their students, which usually occur in school classroom contexts. On the one hand is the obvious difference that in professional development experiences, additional personnel are involved because we are considering not only mathematics teacher educators and the mathematics teachers with whom they are working, but their students as well, whether directly or indirectly. On the other hand, the complexity is heightened by more than just the additional role, but also by additional mathematics. For example, not only did Mrs. Garcia, Julie, and I each bring our own mathematics to bear during the experiment, but Mrs. Garcia and I were also engaged in building a model of Julie's mathematics, and I, as the mathematics teacher educator, was building a model of Mrs. Garcia's model of Julie's mathematics. I was explicitly attempting to both understand and support Mrs. Garcia's understanding of her student's mathematics. And so, not only is more mathematics at play in professional development contexts, but there are more models of mathematics, and some of these are second-order models (models of models), which are further removed from their origin. We can apply lessons learned from successful professional development projects, in which mathematics teaching improved when teachers were supported to use research findings to help assess and support student thinking. Analogously, mathematics teacher educators should make an effort to use research constructs about mathematics *teacher* thinking so that we can build better-informed models. In this way we can be better prepared to care for the mathematics teachers with whom we work.

The consistency between findings from an analysis using mathematical caring relations and other research-based principles of good professional development (such as those summarized in Clarke, 1994) does not render a construct like the mathematical caring relation redundant, but rather shores up its validity. That is to say, when the use of a new construct lends us new insights, including new terms for thinking and talking about mathematics teaching and mathematics teacher education, this can help us as we incorporate the construct into our collection of analysis tools, even if the immediate implications for practice seem to confirm what we already knew. It is important to provide fresh examples and even non-examples in ever new contexts.

The professional development project described in this article did not incorporate the notion of care into its design, nor did we consider care in our immediate evaluation of the project's effectiveness. I have used care here to retroactively analyze the care that I did and did not experience; but the window of time for capturing Mrs. Garcia's reflections on the care she experienced, including the ways that she served as a carer for me as well as for Julie, for example by wondering: "Is Andrea getting what she needs for her research?" has passed. An additional benefit of considering the ways that a mathematics teacher may be caring for the mathematics teacher educator is that the traditional power relationship can be inverted. Recognizing that the mathematics teacher has expertise (for example, Mrs. Garcia's knowledge about Julie as a person, not just as a mathematics learner) over and above the mathematics teacher educator, is one way to foster reciprocality and partnership between the mathematics teacher educator and the mathematics teacher (see Jaworski, 2008). What I am advocating here is that care be taken up not only for analyzing past events, but incorporated as a consideration before and during interactions with mathematics teachers. The caring construct is powerful because, although Hackenberg (2010) conceives of it as a constructivist construct, mathematical caring relations broaden my conception of the teaching/ learning interaction to one that is relational, in keeping with recent calls for more sociocultural perspectives on conceptualising "learning to teach" (Goos, 2008). Caring should be a characteristic not only of our mathematics teaching, but also of our support of mathematics teachers and the research we do around this work. Mathematical caring relations in general, and harmonizing and stimulation in particular, may be helpful constructs for us as we seek to do this.

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Consider a normal day in the street. You are walking down the sidewalk thinking about what you need to say in an upcoming meeting and you hear the noise of an accident. You immediately see if you can help. You are in your office. The conversation is lively and a topic comes up that embarrasses your secretary. You immediately perceive that embarrassment and turn the conversation away from the topic with a humorous remark. Actions such as these do not spring from judgment and reasoning, but from an *immediate coping* with what is confronting us. We can only say we do such things because the situation brought forth the actions from us. And yet these are true ethical actions; in fact, in our daily, normal life they represent the most common kind of ethical behaviour.

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