

RAMZOR – A DIGITAL ENVIRONMENT THAT CONSTITUTES OPPORTUNITIES FOR MATHEMATICS TEACHERS COLLABORATION

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The multi-phase study described in this paper is a part of an R&D project aimed at examining the development and the implementation of a digital environment named RAMZOR for constituting opportunities for professional collaboration among mathematics teachers and supporting their efforts to plan and realize their complex daily tasks. The results of the study indicate that by providing a suitable framework for teacher collaboration and sharing of knowledge, a digital environment such as RAMZOR has the power to facilitate the development of mathematical and didactic knowledge of teachers who document their plans ahead or share their experience retrospectively, as well as of those teachers who are inspired by their colleagues' documentation and implement them. The study also indicates the potential of RAMZOR to serve as the pillar of the mathematics teachers community of practice. The examination of this potential and the conditions necessary to make RAMZOR an environment that nurtures an independent and sustainable national community of mathematics teachers is the focus of our on-going research.

Introduction

The rapidly increasing use of web media such as Wikipedia, social networks like Facebook, and databases with search engines such as Google, inspired us to consider the idea of constructing a suitable web-platform for preserving, accumulating, and continuously improving mathematics teachers' practical knowledge through applying collaborative efforts in designing lesson plans (LPs), periodic or thematic teaching programs, evaluation items and assessment tests. We took upon the challenge and gradually developed a collaboration-facilitating computer environment which we named RAMZOR. This name means "a stoplight" in Hebrew, as metaphorically, this site is supposed to serve the ordinary mathematics teacher so that s/he can do the following on a daily basis: STOP to explore and consider other colleagues' ideas; PREPARE for teaching a specific class; and then GO to the classroom, implement and possibly reflect upon the implementation of the plan, or share it with others (Movshovitz-Hadar, 2018). In what follows, we describe RAMZOR, its rationale and features, and the attentive process of its design. In addition, we provide findings from evaluation studies and formative assessment ones that accompanied the development and refinement of RAMZOR throughout its employment by mathematics teachers.

Background for the construction of RAMZOR

Barber and Mourshed (2007) phrased a most appropriate motto for our study: *"the quality of an educational system cannot exceed the quality of its teachers"* (ibid p. 11).

It has become well known that teaching is an extremely complex profession. Teachers need to possess a wide range of skills and various types of knowledge, e.g. pedagogical knowledge that relates to

teaching materials and methods, knowledge about students' learning, the capability of analyzing reflectively their actions and their impact, and much more (Shriki & Lavy, 2012). But above all, they should be able to integrate these skills and knowledge and employ them when they prepare their LPs and other teaching materials. In fact, the daily design of LPs is at the heart of teachers' professional work. However, in most cases (at least in our country) teachers prepare their LPs "in mind", and the preparation of detailed LPs is considered to be an "unnecessary burden" required only in pre-service teacher education. Even after teaching a certain lesson, LPs is not recorded and, at best, notes are written in the textbook for future reference. As a result, at the individual level, drawing conclusions is limited, and at the professional community level, there is a lack of sharing practical knowledge with colleagues (Movshovitz-Hadar, Shriki & Zohar, 2014). This stands in contrast to the recognized benefits of sharing knowledge through joint lesson planning: "*we discovered the magic of effective joint lesson planning... The expectation of teachers is not only that they should develop and employ effective practices in the classroom, but that they should share them throughout the whole system. Best practice therefore quickly becomes standard practice, adding to the pedagogy*" (Mourshed et al., 2010, p. 77).

Indeed, as evident from McKinsey report (Barber & Mourshed, 2007), one of the main factors that contribute to the success of any reform is nurturing teacher cooperation and the next generation of system leaders to ensure long-term continuity in achieving reform goals. To that end, teachers must be treated as trusted professional partners, and need to be given the tools and responsibility to lead change (OECD, 2011). Acknowledging that the "professional wisdom" lies, first and foremost, at the hands of the teachers, who actually carry out the task of teaching, we believe that they are the ones who ought to develop and improve cooperatively the teaching and learning materials. The idea underlying the design of RAMZOR as a digital platform that facilitates collaboration among teachers anytime, anywhere, was to provide teachers with a communal environment that would enable them to preserve their resources, share and discuss their practical knowledge and daily experience, develop and jointly improve materials for teaching and learning, and more. In other words, the ultimate goal of RAMZOR is to support the development of mathematics teachers' community of practice (TCoP).

Professional learning communities (PLC) and community of practice (CoP)

The two notions, PLC and CoP, share similarities as well as differences in the context of the models they are based on (Blankenship & Ruona, 2007; Vangrieken, Meredith, Packer, & Kyndt, 2017). This is true in particular with respect to issues related to membership, leadership, organizational culture, and knowledge sharing. While the PLC models draw from learning organization theory, CoP draws from situated cognition, social learning theory, or knowledge management theory. Thus, whereas PLC models address team or group learning focusing mainly on students' needs and increasing students' achievement, CoP models address the need for alignment to the organization strategy and they are focused mainly on the improvement of practice. In addition, PLC models highlight the role of an external leader while the CoP models favor leadership from within the community. Nonetheless, both models provide a theoretical framework for a study towards better understanding of ways to facilitate teachers' learning and collaboration processes as well as their specific effect on teachers' practice and students' learning.

According to Wenger (1998), in order for a community to be recognized as a CoP, three conditions must be met: (i) The domain: A CoP is identified by a common domain of interest; (ii) The community: A CoP consists of members who are engaged in joint activities and discussions, assist

each other, share information, and nurture relationships that enable them to learn from one another. However, they do not necessarily work together regularly; (iii) The practice: Members of a CoP are practitioners. They develop a shared repository of resources and ways of addressing frequent problems, thereby engaged in the process of mutual learning. In general, national communities of mathematics teachers, conform to Wegner's first two characteristics: they share an interest in mathematics, its teaching, and learning, many of them meet in professional conferences, read professional journals, and share a professional language enabling them to learn from one another. However, the third characteristic, to a large extent, is still missing in many national communities of mathematics teachers, and the one in Israel in particular. Although a vast majority of them teach mathematics on a regular basis, only a small number of mathematics teachers develop their own repertoire of resources and fewer share them with the entire community (Shriki & Movshovitz-Hadar, 2011). While conceiving RAMZOR, our intention was to develop a dedicated "home address" for the entire professional community of mathematics teachers in Israel, viewing the nurturing of TCoP as promoting the share of knowledge thus supporting the improvement of teachers' practice.

Features of RAMZOR digital environment

RAMZOR digital environment for teachers (<http://RAMZOR.sni.technion.ac.il>) was developed by "Omnisol Information Systems LTD". It was originated as a "structured Wiki" platform – a Wiki that manages structured objects. Some of its capabilities are similar to "MediaWiki" which include a dedicated text editor, discussion page, versions control, personal user pages alerts and more, while its "structured" capabilities include advanced search competencies, monitoring and permissions management. RAMZOR allows collaborative development and improvement of teaching and learning materials of various types and encourages professional interaction among teachers.

Writing the details is done on a pre-determined Word file templates (for LP, Thematic or periodic program, assessment items or evaluation tests) which are preceded by several descriptive details. For instance, the preceding details for a LP are: the title of the lesson, prior knowledge required, students' grade and study level, behavioral objectives of the lesson, anticipated difficulties and how to manage them, and more; The LP template includes a detailed reference to each part of the lesson, the time allotted to them, the flow of the lesson in a form of teacher-students dialogue, and more. In addition, auxiliary materials can be attached, such as student worksheets, assignments for homework and links to relevant applets. RAMZOR also enables users' comments to each entry, feedback and elaboration on it. Each teacher has his/her personal area and can, for the purpose of respecting privacy, choose who to share the materials with, from keeping a draft for personal viewing to the sharing with the entire community.

RAMZOR: three preliminary design studies

In designing RAMZOR, we implemented a multi-phase study process that included three preliminary studies aimed at examining the contribution of collaborative writing of teaching materials to the professional development of mathematics teachers as well as evaluating the suitability of RAMZOR's features to teachers' needs (Segal, Shriki, Movshovitz-Hadar, 2016).

Preliminary study 1 - My favorite math LP. This study focused on teachers' willingness to share their LPs with colleagues. Via an e-mail, we approached about 400 middle and high school mathematics teachers, asking them to send their favorite LP, written according to specific guidelines

provided in advance. They were asked to approve uploading their LPs into a designated open web site. The teachers were told that among the senders there would be a lottery with monetary prizes. Four rounds of raffles took place in 6 months intervals. Only 10-15 LPs were sent to each round. This first step left us not only disappointed but with many open questions related to teachers' responsiveness and motivation to share their LPs with their colleagues.

Preliminary study 2 - Joint lesson planning on MediaWiki system. Eleven graduate students, experienced high school mathematics teachers, participated in a semester-long activity in which they collaboratively designed LPs on a MediaWiki system. At the time this experiment was carried out, MediaWiki seemed to us as the best available platform for facilitating collaborative group work aimed at developing a dynamic repository of LPs and discussing educational ideas. Results of a study that followed the teachers' experience (Shriki & Movshovitz-Hadar, 2011) indicated that the process of joint lesson planning supported the development of the participants as a small TCoP that interact on a daily basis, discuss ideas, and share LPs and other professional resources. The results also pointed at many concerns of the participants, categorized as social and technical ones.

These results led us to recognize the need for teachers to arrive at agreed-upon social norms for managing a shared repository of learning and teaching resources as a preliminary necessary condition for nurturing teacher cooperation. We also realized that the technical concerns related to MediaWiki make it an inappropriate platform for accumulating, preserving, and improving mathematical LPs. To develop a more appropriate environment, we approached Omnisol Information Systems Company and started the development of RAMZOR digital environment mentioned above.

Preliminary study 3 - A 3-day summer school for joint lesson planning. With the insight gained from study 2, we organized a 3-day summer school for two consecutive years in which two groups of selected teachers designed LPs (individually or in pairs/small groups), provided feedback to peers' LPs (orally or in writing), improved their own LPs subsequent to receiving feedback, and reflected upon the entire process. Data was gained through questionnaires, interviews, transcripts of small groups discussion and whole group ones, and content analysis of the LPs and feedbacks (Movshovitz-Hadar et al., 2014). Our findings indicated that ongoing processes of collaboration and sharing are rare in schools. According to the teachers, this situation is a result of several causes, among them: (1) Heavy workload that leaves no time for interaction; (2) Mathematics teachers' tendency not to consult their colleagues for fear of being perceived as having insufficient mathematical knowledge; (3) In small schools there is often only one mathematics teacher for certain grades/levels of teaching, and therefore has no colleague to consult with; (4) A lack of awareness to the benefits of cooperating and sharing knowledge. The LPs were written using the early version of RAMZOR digital environment. This enabled participants to relate to the LPs and enabled us to witness shortcomings of the digital environment, thus, to extend our R&D efforts towards improving the suitability of RAMZOR as a tool for managing professional knowledge. The teachers' reflections indicated that they had developed an awareness of their personal gains from writing LPs and receiving peers' feedback. The teachers also pointed out that writing LPs and sharing knowledge strengthened their self-efficacy and contributed to empowering them as members of the TCoP, and in particular, as expressed by one of the participants "*the fact that academia finally understands that teachers are the ones who possess the professional knowledge, and the ones who can be trusted to chart the way, has increased our professional stature*".

In summary, two main observations were reached through the three preliminary studies, on the basis of which we kept developing the digital environment: (i) Although teachers recognize the benefit of being exposed to other teachers' materials, they do not rush into the opportunity to share their own LPs, unless they are put in a framework that makes them do it; (ii) Once provided with a digital environment that enables lesson planning, teachers become aware of the major role of planning their lessons in details, in terms of the effectiveness of teaching, improvement of the teaching quality, and deepening of learning.

As typical to R&D projects, we put less emphasis on developing, testing and advancing theory (OECD, 2004). Rather, our focal points are concerned with the design of a long-term effort, situated in the real-life school settings, which involves a larger sample of mathematics teachers using RAMZOR for planning their work and sharing their experiences.

RAMZOR in practice: The main study

Following the aforementioned preliminary studies, during 2014-2017 we conducted a three-year intervention, in 20 high schools. In the background, there was a sharp decline between the years 2006-2014 in the number of students taking matriculation exams in mathematics at the highest possible level (called in Israel - 5 units), which resulted, among other things, from a severe shortage of teachers willing to teach mathematics at this high level. There was a need to support the development of a professional and independent CoP of mathematics teachers who teach 5 units.

The intervention was based upon three central pillars: **(i) Mentoring.** An experienced mathematics teacher ("the mentor") was responsible for one or two teachers from the same school ("the mentee"). Altogether there were 20 mentors and 24 mentees from 20 high schools. The mentoring included: mutual observations in classes, preparation of teaching programs (periodic or thematic), and designing LPs and evaluation items. The research literature provides an extensive discussion of the advantages of the mentoring model, in particular of school mentoring (e.g. Kadji-Beilran, Zachariou, Liarakou & Flogaitis, 2014); **(ii) Utilizing RAMZOR.** The mentors and mentees were engaged in collaborative writing of LPs, teaching programs and assessment items for various topic included in the curriculum. Teachers implemented the LPs in their classes as well as those written by their peers, provided feedback, and wrote "parallel" versions adapted to their classes; **(iii) Professional development workshops** for mentors and mentees. During each of the three years of the project, there were periodic online and face-to-face meetings with the project staff. The online sessions were held separately for the mentors and the mentees, while the face-to-face meetings were for both the mentors and mentees.

Research questions. The study that followed the 3-year intervention project addressed several research questions. In this paper, we focus on two of them: What is the contribution of collaborative writing of teaching materials using RAMZOR: (i) To the personal professional development of the participant (mentors and mentees)? (ii) To the development of the participants as members of a mathematics-TCoP?

Research instruments. Four main research instruments were used to gather information: (i) A monthly formative assessment questionnaire; (ii) Recording of the online and face-to-face meetings; (iii) An examination of the LPs, teaching programs and evaluation materials written in the RAMZOR; (iv) Semi-structured interviews.

Data analysis. A qualitative research paradigm was employed. First, the data were analyzed through a process of open and axial coding to identify the main categories and sub-categories (Corbin &

Strauss, 2008). At the second stage, a triangulation process was implemented, comparing the categories obtained from each research tool (Miles & Huberman, 1994). The third phase of the analysis consisted of reviewing the findings obtained at the first and second stages while focusing on data related to the participants' professional development and the development of mathematics-TCoP. **Results.** Due to space limitations, we focus on partial findings that relate to the contribution of using RAMZOR to the teachers' mathematical and didactic knowledge, as indicators of professional development, as well as to their sense of belonging to TCoP. In the questionnaires distributed at the end of each year, the participants were asked to express their consent with the statements: "Reviewing and employing other teachers' LPs contributed to my mathematical knowledge" and "Reviewing and employing other teachers' LPs contributed to my didactic knowledge". Table 1 presents the distribution of the degree of teachers' agreement with the statements on a five-level Likert-type scale, both for mentors and mentees, at the end of the third year of the project.

Table 1: Distribution of mentors' and mentee's degree of agreement with the statements: Reviewing and employing other teachers' LPs contributed to my: mathematical knowledge (Stat. A); didactic knowledge (Stat. B), in percentage

Teachers	Degree of Agreement									
	A very large extent		A large extent		A medium extent		A little extent		Not at all	
	Stat. A	Stat. B	Stat. A	Stat. B	Stat. A	Stat. B	Stat. A	Stat. B	Stat. A	Stat. B
Mentees (N=24)	22	22	64	71	14	7				
Mentors (N=20)		25	54	44	46	31				

Table 1 indicates that both the mentors and the mentees perceive the reviewing and employment of other teachers' LPs as contributing to their mathematical/didactic knowledge at least to a medium extent. In addition, the mentees perceive this contribution as more meaningful than the mentors. It should be remembered that for the mentees it was the first experience in teaching high-level mathematics. Therefore, one could expect that reviewing and practicing the detailed LPs in RAMZOR that were written collaboratively by mentors and mentees will be more beneficial to the mentees, in terms of mathematical and didactic knowledge, than for the mentors. The following are several typical quotations from the participants' entries (translated from Hebrew). As for **mathematical aspects**, participants wrote: "There were LPs that exposed me to new ways of proving statements that involve geometry locus. For example, I learned that homothetic transformation enables the preservation of the loci features" (a mentee); "In one of the LPs, there was a clear visual explanation for the meaning of the integral formula. It opened my eyes, and I realized that understood (and taught) it technically" (a mentee); "The very fact that I had to write a LP about conic sections made me delve into the little details I was not sure about in the case of the hyperbola. When you teach, you can sometimes "smooth things out", but not when you know your colleagues will read and use it" (a mentor). As for **didactic aspects**, participants wrote: "I applied the LP on similar triangles with the problem-posing approach, and students' problems actually help me to understand how students understand the topic and process information" (a mentee); "I tried the LP on presenting the solution of distance word problems graphically, and I realized that it helped many students

understand the verbal formulation and identify the connections between the givens" (a mentee); "I understood how a thoughtful integration of technology can respond to students' difficulties. I applied the LP where there was an applet demonstrating the relationship between the tangent slope and the derivative of a given function, and since then I look for LPs in RAMZOR that integrate technology" (a mentor); "My mentee found a LP in trigonometry with 3D applications. Together we analyzed this LP and thought it might help many students to see spatial information. We tried it in class, and for many students it was kind of a breakthrough. They were finally managed to see things" (a mentor).

The participants were also asked to express their consent with the statement: "Sharing my lesson plans with other teachers contributed to my sense of belonging to the teacher community of practice". Table 2 presents the distribution of the degree of teachers' agreement with the statement, both for mentors and mentees, at the end of the third year.

Table 2: Distribution of mentors' and mentee's degree of agreement with the statement: Sharing my lesson plans with other teachers contributed to my sense of belonging to teacher community of practice, in percentage

Teachers	Degree of Agreement				Not at all
	A very large extent	A large extent	A medium extent	A little extent	
Mentees (N=24)	29	43	28		
Mentors (N=20)	31	38	23	8	

As evident from Table 2, most of the mentors and the mentees reported that sharing LPs with their peers contributed to their sense of belonging to TCoP at least to a medium extent. The following are typical quotations from the participants' entries (translated from Hebrew): "*When I write a lesson plan in RAMZOR, I get constructive feedback from colleagues. It is really important because we don't have opportunities to share our ideas and products and get feedback on what we do. For me, this is the meaning of a community*" (a mentee); "*When I share my lesson plans, I feel that I am contributing not only to my mentee but to the entire community. It is like remaining your legacy. Otherwise, it would disappear. It really makes me happy and proud*" (a mentor).

Discussion and conclusions

The multi-phase study described in this paper indicates that spontaneous processes of sharing practical knowledge among teachers are not common. Lacking feedback on their work, many teachers feel a sense of isolation. Therefore, it seems that RAMZOR digital environment address a real need of teachers, as it provides a suitable environment for teacher collaboration. The results of the main study indicate that RAMZOR became a set-up for teacher collaboration and for sharing of knowledge. The fact that the repository includes detailed LPs and not merely anecdotal information facilitated the development of mathematical and didactic knowledge both of mentors and of mentees, as composers as well as consumers of LPs. In addition, the study points out the potential of mathematics teachers' collaborative work with RAMZOR to support the development of mathematics-TCoP. According to the definition of Wenger (1998), the teachers in this study had interest in a common domain: improving their math teaching in 5 units level, they were engaged in joint activities and discussions, assisted each other, shared practical knowledge and learned from one another. All these were made possible due to the collaborative nature of RAMZOR environment. However, it should be

noted that the work of the mentors and mentees was carried out as part of a project in which we, as the managers of the project, were involved in direct connection with the participants. Therefore, in order to examine the feasibility of TCoP development without our direct involvement, while maintaining RAMZOR as the pillars of teachers' collaborative work, in September 2017 we started a new 3-year R&D project. Thirteen high schools in one of the largest cities in our country are taking part in this project. Two teachers from each school are working with the project team staff on a regular basis, while at the same time they work with their entire math teachers school staff aiming at the establishment of a local school as well as an overall municipal independent and sustainable mathematics-TCoP. Obviously, our ultimate goal is to nurture such a national mathematics-TCoP, turning RAMZOR digital environment into an accessible fruitful repository for the benefit of all teachers. Further research is needed to examine the conditions necessary to achieve this goal.

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