REVIEW OF AGENTS AND PROCESSES OF CURRICULUM DESIGN, DEVELOPMENT, AND REFORMS IN SCHOOL MATHEMATICS IN COSTA RICA

Luis Hernández Solís

Universidad Estatal a Distancia – Costa Rica

Patrick Scott

New Mexico State University - USA

A synthesis of the curricular implementation processes and actions carried out since the approval in 2012 of new programs of study for primary and secondary Mathematics within the framework of mathematics reform in Costa Rica is presented. Here some of the contributing factors that have played an important role and that have sometimes generated complementary or synergistic effects are incorporated. In particular, the pragmatic perspective of a curriculum influenced by international ideas and constructions by the country's own researchers, research that has originated from the curriculum, decisive participation of multiple partners in the Reform of Mathematics Education project in Costa Rica, innovation in teacher professional development processes and the support of the private sector in this process are highlighted. Likewise, it is suggested that the strategies followed in a developing country like Costa Rica, provide lessons that can serve other countries in similar conditions.

INTRODUCTION

In the search to strengthen higher order cognitive abilities as part of the approach to the new challenges posed by a modern society, on May 21, 2012, the Higher Council of Education of Costa Rica (the constitutional body responsible for guiding and directing the different levels, cycles and modalities of the Costa Rican Educational System from a technical point of view) approved new mathematics study programs for all pre-university education in that country.

The previous curriculum had a strong behaviorist influence (programmed objectives) and was quite linear (evaluation associated with each disaggregated objective, one by one). In general, despite the language of "objectives", it was basically lists of contents, almost no interaction with the curricular foundations (their concepts and objects), absence of mathematical tasks with increasing levels of complexity, minimal problem solving and erroneously conceived, minimal participation of real contexts. There was no formal mathematical modeling and only minimal use of technologies.

The Curriculum, approved in 2012, is ordered based on mathematical contents, but the essentials are the abilities associated with the content, often in cycles of two to three years. The purpose of school mathematics program is general mathematical competence, which is interpreted as a capacity to understand and use mathematical objects in various contexts. That is why the central issue here is to promote the development of what was called transversal higher cognitive abilities: Reasoning and Argumentation, Posing and Solving Problems, Communicating, Connecting, Representing.

In terms of content, several changes were made: introduction of coordinate geometry and transformations (before there was only traditional, synthetic geometry), spatial visualization, statistics and probability in all 11 school grades, algebraic thinking beginning in the primary grades, more complete treatment of functions, including their use in analyzing algebraic relations, although trigonometric functions were eliminated (for diverse reasons). The approaches proposed are crucial: for example, in statistics, what matters is the analysis and interpretation of information, not the calculation of measures; and relations and functions are to be associated with modeling.

The curriculum proposes a model of four steps and two stages for classroom practice. The two stages are construction of learning, followed by mobilization and application of the constructed learning. The four steps for implementing the first stage are presentation of a problem, independent student work, collaborative phase for testing strategies, and the final closure. The problem is the beginning of the lesson. In the previous methodologies, instruction began with a presentation of the mathematical elements (for example, Pythagoras theorem), then examples, and later routine practice and maybe, but not most of the time, a problem was finally used. Now the flow in the classroom action has been reversed.

In summary, this Curriculum aims to bring a pragmatic perspective to mathematical knowledge and the development of higher abilities for understanding the society's realities. In addition, it formulates a new pedagogical strategy: "Problem solving with an emphasis on real contexts", which implies a substantial transformation of classroom practice. These particularities make necessary various actions that support this curricular reform.

Starting in 2013, a process of curricular implementation began. It has been characterized by changes that are deliberate and gradual. The national reality has been taken into account in light of a curriculum substantially different from those that have preceded it and with an international perspective that requires new educational scaffolding.

WHAT ARE THE PROCESSES DEPLOYED, IN THE CURRICULUM REFORM?

The Ministry of Public Education of Costa Rica (MEP) has concentrated its institutional efforts on the implementation of new Mathematics programs of study in 2012-2017. It is important to note that the Mathematics Education Reform Project in Costa Rica (of the Ministry of Public Education with the support of non-governmental entities) (PREMCR) has participated in a relevant way in the design and execution of strategies for the implementation of the curriculum. One of the first actions was the preparation of transition programs that sought a gradual introduction to the programs of study. By 2016 it can be said that the implementation process was complete up through regular high schools, but it was not until 2017 that the extra year of technical high schools was added. However, it should be pointed out that the reform requires many more stages for its definitive consolidation.

Costa Rica, as is the case in other developing countries, has major weaknesses that may hinder or slow down a curriculum implementation process: budgetary limitations, instability in the continuity of educational policies and reform processes, weak teacher preparation, lack of well-focused professional development processes, absence of monitoring mechanisms, among others. Taking into account all these weaknesses in the education system, the curriculum had to go beyond being a guiding document. It had to anticipate conditions and face resistance on multiple flanks.

This new curriculum is more than a content adjustment (readjustment, increase or decrease). It implies a different paradigm, and therefore its implementation has been a complex process that has required multiple tasks with different lines of attention. For example, the classroom implementation process brought challenges to the work of teachers. One of the challenges has been lesson planning, as indicated in the Fifth State of Education Report (2015):

> The preparation of the classroom action acquires a more relevant place with this curriculum than with the previous ones. A greater preparation in the various pedagogical and cognitive aspects present in the lesson is demanded of teachers: mastery of the curriculum and not just the mathematics content of the curriculum, mathematical preparation in the new topics and also in the corresponding approach to each one of them (p.156).

Traditionally, teacher planning revolved around mathematical content and meeting objectives. However, Ruiz (2015) points out that the vision of problem solving that is introduced in this curriculum is a strategy for organizing lessons. This puts an emphasis on a particular style of pedagogical mediation where teacher planning is a transcendental element; as well as being more demanding and involving more intellectual effort.

Being a substantial transformation, the role of the teacher in the implementation of this methodology is transcendental. However, one of the challenges in the realization of this curriculum is precisely the initial and ongoing professional development of in-service teachers (Gaete and Jiménez, 2011).

Trying to solve these deficiencies, a column of "Specific Suggestions" has been added to the Program of Studies document. This is a novel way of offering not only brief methodological suggestions associated with concepts and skills, but to specify what is desired for implementation in each case, visualizing the meaning of the proposed skills.

Although this column of suggestions can guide lessons in some ways, it was considered that this was not enough to fill so many training gaps. This is why, given the depth of the differences between this curriculum and those that preceded it, PREMCR designed a large number of curricular support documents and made the decision to unleash a large-scale teacher professional development process through different strategies and modalities.

From 2011 to 2017, blended courses (face-to-face sessions and online independent work) were carried out for primary and secondary school teachers separately. It is a novel strategy that involves two types of sessions: one to work with teacher leaders and another to train large populations of teachers. Local officials and teacher leaders with the administrative support of the central offices of the Ministry, were responsible for offering in the different educational regions the same course they received in the first phase. The documentation, the self-assessment practices, the exams and all the resources were essentially the same in the two phases. This process helped to guarantee significant academic quality in each course in both phases. The details of this project and its actions can be seen in Ruiz (2013), however it is important to note that through this strategy it was possible to serve almost all teachers of secondary mathematics (2500), and 50 to 60% of primary teachers (20,000).

The needs of the mathematical reform implied a need to serve the educational community in an even broader way. There was a desire to reach populations that had not received the blended courses, to serve those who had not successfully completed those blended courses, as well as those who wanted

to complement their preparation. Here the blended strategy was no longer enough. During 2014 and 2015, completely virtual courses were offered as MOOCs (Massive Open Online Courses).

In 2016, also using MOOCs, support was provided to high school students who had to take exit tests that are also used for entrance to higher education. This was the first time that the new curriculum had been used as a reference for the design of the tests even though the students taking the tests had just begun to use the new curriculum three years earlier and most of those years it had been through transition programs.

The experience of the years 2014 to 2016 led to a new innovation: the Mini MOOC. These are courses with the same virtues as MOOCs, but are focused on specific, compact, short and self-sufficient topics. Mini MOOCs can be completed in less than 15 hours. The Mini MOOCs are grouped into collections. The perspective that has been taken is to create spaces that respond more to individual (personalized) needs. Between 2017 and 2018, more than 50 of these mini courses have been designed and executed. This modality has been applied for both teachers and high school students.

This strategy is innovative for the country. Ruiz (2013, 2017) points out that MOOCs and Mini MOOCs drastically modified what had been usual in the professional development processes that were taking place in Costa Rica and opened up new horizons that use communication technologies intelligently. At the same time, in an intrinsic way, the experience in the use of this type of platform not only brings teachers closer to the use of Information and Communication Technologies (ICT) but also modifies their professional profiles, promoting a modern vision of the educator.

A relevant aspect is that this experience of curricular implementation has served as a model for other educational reforms that are being carried out in the country. That is why it is considered that in the context of a developing country like Costa Rica, the actions and strategies followed in this process of consolidating a curriculum, which still has not concluded, provide lessons that can be useful to other countries with similar conditions.

In summary, it should be emphasized that historically these actions have not been usual in Costa Rica when there has been a change in curricula. This reform has been possible thanks to the active and transcendent participation of PREMCR in leading various implementation strategies.

ROLES OF TEACHERS, TEACHER EDUCATORS, RESEARCHERS AND MATHEMATICIANS IN THE CURRICULUM REFORM?

Costa Rica's Mathematics Curriculum (MEP, 2012) was written by a team of university researchers and independent experts external to the MEP. Angel Ruiz, with the Minister's support, formed the writing committee for the new curriculum with five researchers in mathematics education from public universities with whom he had worked in some cases for more than 20 years. Although the initial education of the committee members was in mathematics, over time they had specialized in such areas as history and philosophy of mathematics, use of technology, statistics and mathematics education. This group was joined by six primary and secondary teachers, four were released from their school assignments by the MEP to work comprehensively in the preparation of the curriculum.

Not including MEP officials on the writing team did generate friction and, in some cases, they provided little support to the reform process. However, despite all these negative reactions, there has been continuity during two government administrations. This situation is documented in Ruiz (2013).

One aspect that was decisive in the reform was that the same team that wrote the curriculum also assumed a decisive role in the implementation of the reform. This was possible through PREMCR. Both in the design and in the implementation, in addition to the researchers from the public universities, the project included in-service teachers primary and secondary teachers and specialists in communication technologies (Ruiz, 2013, 2015, 2017). Teachers have been provided by the MEP, and specialists and researchers have been hired with private financial support.

Given that this mathematics reform touches several components of the national education system, the team that has guided the reform can be considered the factor that has made this process more visible than would the implementation of a textbook series. One dimension of this group is its important connections in the international mathematical education community (ICMI, CIAEM, NCTM, among others).

Another transcendental aspect was that it was based on the premise that a reform requires a network of leaders willing to promote it throughout the country and serve as a reference in their educational institutions. This strategy not only brings forth outstanding teachers who underpin the implementation of the curriculum in different educational regions of the country, but in this process an important new actor has emerged: the Regional Mathematics Advisor.

Poveda and Morales (2015) point out that the reform in Mathematics Education has brought changes in the role of the Regional Mathematics Advisor. Ruiz (2015) suggests that the Regional Advisers have become true leaders and reference points in their regions. They have become decisive in the implementation of the reform.

As mentioned above, one of the weaknesses for the curricular implementation process is the initial training of teachers, and the absence, until recently, of continuous professional development processes (Alfaro, Alpízar, Morales, Ramírez & Salas, 2013).

In recent years, the public universities in one way or another have made changes to articulate their teacher preparation programs with the reform curriculum and the work of classroom teachers. It would be expected that in the following years these institutions will provide teachers with appropriate skills that will be prepared to consolidate the curricular implementation. Ruiz (2015) points out that universities have a great responsibility with respect to the success of the curricular implementation; as they will nurture teachers who must be prepared to face the challenges posed by this reform.

PUBLIC ENGAGEMENT AND THE MEDIA IN THE CURRICULUM REFORM?

The processes of curricular implementation in a developing country are complicated because the social, political and educational contexts impose conditions and limitations. A condition in Costa Rica is that the Minister of Education is appointed by the incoming government every four years, and this often affects the continuity of projects and reform actions. Much of the success of these processes depend on historical and political conjunctures. This is how the second administration of Minister Leonardo Garnier Rímolo (2010-2014) established a commitment, not only to the design of the Mathematics curriculum, but also to its implementation.

In the process of implementing this reform, a strategic alliance between the public and private sectors emerged. PREMCR was born as a joint project between the Ministry of Public Education (MEP) and the Costa Rica United States Foundation for Cooperation (CRUSA). Between 2012 and 2013 the

Project had the commitment and support of both entities. Even so, the reform has always had obstacles and threats. This is because the new curriculum and its implementation processes have meant a significant change in tasks and a much greater preparation demand, not only for teachers, but also for MEP officials in general. The challenges have been perceived differently by the various actors.

Uncertainty has been present at different times. In the last six months of the Garnier administration much of the support and resources that the MEP had provided, and that were needed by PREMCR, were weakened. Another moment was in 2014, because Costa Rica had a change of government and a new political party emerged in power. This was perceived as a new threat to the curricular reform. However, the new Minister, Sonia Marta Mora (2014-2018), assumed the reform as a priority of her administration, and therefore the chances of success increased considerably.

Here we must highlight that this educational reform has received the support of non-governmental organizations. In the 2012-2015 period, the reform project received decisive financial support from CRUSA that was executed through the Omar Dengo Foundation. In the period 2016-2017, the Business Association for Development (AED) supported the reform, and CRUSA has maintained its contribution. Many of the resources that have been developed, and a large number of the actions carried out, were possible thanks to this national support. This expresses that the mathematical reform has been seen until now as a country-wide project where public and private sectors have converged.

Although Costa Rica is a small country geographically, it presents a great diversity of conditions and particularities. The progress in implementation of the reform has differed in the various regional education directorates (Costa Rica is organized into 27 educational regions). In some regions there has been greater intensity than in others, and there are differences at the school and classroom levels as well. While the reform continues to advance in the national consciousness, full implementation will be a complex and long-term process that invokes multiple dimensions of national life (including some outside of education). New actions should use and enhance the high-quality resources that were already generated in the 2012-2017 period, as well as improve them with what has been learned. Providing continuity to the efforts is undoubtedly the first priority.

The year 2018 brought another change of government and uncertainty regarding the direction of educational reform arose again. Past political support has facilitated the very solid steps that have been taken. However, it is not possible to assure, a priori, that new governments will provide the necessary continuity. Nor is it certain that the progress already made is sufficient to assure that the country will not regress in the absence of political support.

RESEARCH INFORMING THE CURRICULUM DESIGN AND DEVELOPMENT?

Costa Rica has been able to count on researchers from the public universities who for many years have identified findings in national and international Mathematics Education, and who have contributed their work in this project of change and curricular implementation. In particular, there is a vision of Mathematics as an historical and cultural construction with a strong influence from the empirical, physical and social worlds, which support the design of this curriculum. This is a perspective based on the works of A. Ruiz (1987, 1990a, 1990b, 1992, 1995a, 1995b, 1995c, 2000, 2001, 2003).

This theoretical influence directly impacted the curriculum of Mathematics of Costa Rica and inscribes it within the latest trends in mathematics education: those that use competencies or skills as

an essential factor for teaching and learning. However, although the program of studies emphasizes the strengthening of superior cognitive abilities, here a pragmatic vision of mathematical competence is presented from an original perspective: The curriculum is not organized by means of competences, but rather they are proposed as objectives to develop during pedagogical mediation. (MEP, 2012).

The curriculum integrates, in its foundations, theoretical elements of the international community, especially the NCTM and PISA, adjusted to the national reality under the influence of ideas contributed by Costa Rican researchers. Likewise, in the organization of the lessons, concepts or ideas raised in the theoretical frameworks of the French Mathematics Didactics and classroom action models of Japan are incorporated.

Here it should be noted that an intellectual construction of its own has been made, advancing in ideas about curricular design and its implementation, which can serve as a contribution to international research and experience. It must be emphasized that a model external to the country has not been adopted. There is in the foundation, in the programs of studies and in the curriculum in general, an autochthonous and functional use of the elements that are identified in the research and experience of International Mathematics Education adjusted to the conditions of a peripheral, developing country.

This richness from theory and this international perspective on the curriculum have encourages a great amount of research in recent years, including multiple undergraduate and postgraduate works on various subjects of mathematical education.

In addition, the mathematical reform in Costa Rica has been widely documented with several publications: Ruiz (2013, 2015), Ruiz and Barrantes (2016). New intellectual constructions have also been developed in the light of the curriculum (Ruiz, 2017).

The pragmatic nature of the curriculum has motivated in-service teachers to make public their successful classroom experiences. This also prompted some regional pedagogical consultancies in Mathematics to generate teaching materials. In conclusion, this curriculum has served as a pivot to promote educational research and development in Costa Rica and beyond.

References

Alfaro, A.L., Alpízar, M., Morales, Y., Ramírez O., & Salas, O. (2013). La formación inicial y continua de docentes de Matemáticas en Costa Rica. *Cuadernos de Investigación y Formación en Educación Matemática.* Número especial, Noviembre. Costa Rica. Retrieved from http://revistas.ucr.ac.cr/index.php/cifem/article/view/12225

Gaete, M. & Jiménez, W. (2011). Carencias en la formación inicial y continua de los docentes y bajo rendimiento escolar en Matemática en Costa Rica. *Cuadernos de Investigación y Formación en Educación Matemática*, 9, pp. 93-117.

Ministerio de Educación Pública de Costa Rica (2012). *Programas de Estudio Matemáticas. Educación General Básica y Ciclo Diversificado*. Costa Rica: autor. Retrieved from http://www.mep.go.cr/sites/default/files/programadeestudio/programas/matematica.pdf

Ministerio de Educación Pública de Costa Rica (2015). *Educar para una nueva ciudadanía: Fundamentación de la transformación curricular costarricense*. Costa Rica: autor. Retrieved from http://www.idp.mep.go.cr/sites/all/files/idp_mep_go_cr/publicaciones/7-2016_educar_para_una_nueva_ciudadaniafinal.pdf

Poveda, R. & Morales, Y. (2015). Desafíos del Asesor Regional de Matemáticas ante la Reforma en Educación Matemática. *Cuadernos de Investigación y Formación en Educación Matemática, 13*. Costa Rica. Retrieved from https://revistas.ucr.ac.cr/index.php/cifem/article/view/19145

Programa Estado de la Nación. (2015). Quinto Informe Estado de la Educación. San José, Programa Estado de la Nación.

Ruiz, A. (1987). Fundamentos para una nueva actitud en la enseñanza moderna de las Matemáticas Elementales. *Boletín de la Sociedade paranaense de matemática.* Vol. VIII (1), Junio, Curitiba, Brasil.

Ruiz, A. (1990a). *Matemáticas y filosofía. Estudios logicistas.* San José: Editorial de la Universidad de Costa Rica.

Ruiz, A. (1990b). Matemáticas: una reconstrucción histórico-filosófica para una nueva enseñanza. Publicado en UNESCO. *Educación Matemática en las Américas VII (Actas de la VII Conferencia Interamericana de Educación Matemática*, celebrada en República Dominicana, 12-16 julio 1987). Republicado en *Cuadernos de Investigación y Formación en Educación Matemática*. N. 7. Julio 2011. Costa Rica.

Ruiz, A. (1992). Las Matemáticas modernas en las Américas, Filosofía de una Reforma, *Educación matemática* (*Revista Iberoamericana de Educación Matemática*): Vol. 4, No. 1, Vol. 4, No. 1, abril 1992, México.

Ruiz, A. (1995a). (Editor). *Historia de las Matemáticas en Costa Rica. Una introducción.* San José, Costa Rica: Edit. UCR, UNA.

Ruiz, A. (1995b). Fundamentos teóricos e históricos de la reforma de los programas de Matemáticas en la primaria y secundaria costarricenses en 1995. En *Memoria* Novena Reunión Centroamericana y del Caribe sobre formación de profesores e investigadores en Matemática Educativa. La Habana, Cuba: agosto de 1995.

Ruiz, A. (1995c). Constructivismo empírico y filosofía de las matemáticas comentario sobre ideas de Kitcher y Ernest. En *Memoria* Novena Reunión Centroamericana y del Caribe sobre formación de profesores e investigadores en Matemática Educativa. La Habana, Cuba: agosto.

Ruiz, A. (2000). *El desafío de las Matemáticas*. Heredia, Costa Rica: EUNA. Versión digital descargada de http://angelruizz.com.

Ruiz, A. (2001). Asuntos de método en la Educación Matemática. Revista Virtual *Matemática, Educación e Internet*, Volumen 2, Número 1, Abril, Instituto Tecnológico de Costa Rica (2001). Cartago, Costa Rica. Retrieved from: http://www.itcr.ac.cr/revistamate

Ruiz, A. (2003). *Historia y filosofía de las Matemáticas*, San José, Costa Rica: EUNED.

Ruiz, A. (2013). Reforma de la Educación Matemática en Costa Rica. Perspectiva de la praxis. *Cuadernos de Investigación y Formación en Educación Matemática*, Número especial, Costa Rica. Retrieved from http://revistas.ucr.ac.cr/index.php/cifem/issue/view/1186.

Ruiz, A. (2015). Balance y perspectivas de la Reforma de la Educación Matemática en Costa Rica. *Cuadernos de Investigación y Formación en Educación Matemática, 13*. Costa Rica. Retrieved from http://revistas.ucr.ac.cr/index.php/cifem/issue/view/1866

Ruiz, A. (2017). Evaluación y Pruebas Nacionales para un Currículo de Matemáticas que enfatiza capacidades superiores. *Cuadernos de Investigación y Formación en Educación Matemática*. Año 12, Número especial. Costa Rica. Retrieved from https://revistas.ucr.ac.cr/index.php/cifem/issue/view/2552

Ruiz, A. & Barrantes, H. (2016). Desafíos para la formación inicial de docentes ante los programas oficiales de matemáticas en Costa Rica. *Cuadernos de Investigación y Formación en Educación Matemática*, *14*. Costa Rica. Retrieved from http://revistas.ucr.ac.cr/index.php/cifem/issue/view/2093