

Inputs for the incorporation of the UNESCO guidelines on ICT competency standards for teachers: the training of teachers of mathematics in Central America

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The Central American Educational and Cultural Coordination (CECC) and the Spanish International Cooperation Agency (AECI) reported that one of the major challenges that face the region is that the countries have uneven development training in ICT (Information and Communication Technologies). Comprehension of this context, challenges and goals are critical because, as it discussed in this paper, the impact on the quality of the system not only depends on resource acquisition and training, or the application of international tests *per se*, but, we must know the dynamics and impact of initial training and, in particular, initial training focused on competencies, skills and abilities with the use of technological tools. For the foregoing reasons, the aim of this paper is provide to the community a range of perspectives on certain standards regarding to the quality of teacher training in mathematics and, specifically, how incorporate international standards defined by the UNESCO (United Nations Educational, Scientific and Cultural Organization) based on teacher training with ICT skills.

Keywords: Technological competencies, mathematics, curriculum, teacher training.

Claves para la incorporación de las directrices de la UNESCO sobre competencias TIC para docentes: la formación del profesorado de matemáticas en América Central. La Coordinación Educativa y Cultural Centroamericana (CECC) y la Agencia Española de Cooperación Internacional (AECI) señalan que uno de los grandes retos con lo que cuenta la región es que, por países, existe un desarrollo desigual de formación en TIC (Tecnologías de la Información y Comunicación). La comprensión de este contexto, sus retos y metas es fundamental pues, como se analiza en este trabajo, el impactar sobre la calidad del sistema no sólo dependerá de adquisición de recursos y capacitación, ni de la aplicación de pruebas internacionales *per se*, sino que, se deberá conocer e impactar en la dinámica de la formación inicial y, en particular, la formación inicial enfocada sobre las competencias, destrezas y habilidades con el uso de las herramientas tecnológicas. Por las razones expuestas, el objetivo de este artículo es ofrecer a la comunidad una serie de perspectivas sobre ciertos estándares relativos a la calidad de la formación de docentes en Matemática y, específicamente, la forma en que se puede incorporar los estándares internacionales definidos por la UNESCO (Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura) en la formación docente basada en competencias TIC.

Palabras clave: Competencias tecnológicas, matemática, currículo, formación de docentes.

Educational systems worldwide are being more influenced by the so-called *knowledge society*. To a greater or lesser extent, countries as Costa Rica see the need to in-

corporate issues of Science and Technology in its national agendas. These initiatives involve not only training in the Sciences as such but, involve among other elements, an oriented lifestyle management and utilization of technology resources.

In Central America, on issues related to incorporating technology in education, Costa Rica is an excellent starting point for un-

understanding what happens in many countries of this region. This country is one that has the largest *per capita* investment in education in the region, but even so, has similar figures for desertion and failure to countries that invest less in its education system. In contrast, Costa Rica is a country that has been able to sustain growth in access and coverage of basic and diversified education (see e.g., Rodríguez-Clare, 2005).

This growth, although uneven, has opened the door for new challenges on issues such as inclusion, time of graduation, dropout, and mainly, it relates to the quality of the system. This quality is influenced by many factors, such as the number of students per classroom, the resources for teachers, the effectiveness and impact of training for in-service teachers, and initial formation of prospective educators.

Several reports indicate that in terms of educational quality, the country is in an incipient state. For example, the Second Report of the State of Education in Costa Rica (2008), says that “in relation to quality, academic performance indicators show that, far from improving, grew worse academic performance” (p. 25)¹.

These reports also point out some weaknesses in the system; also highlight some of the goals to follow. The report of the Planning Office of Higher Education (2006) suggests that, to promote the achievement of the factors that influence the quality of the entire system it must:

1. Strengthen the teaching of mathematics, science and technology.
2. Ensure that every person who graduated from high school to master two languages and have the technological flexibility.
3. Achieve the professionalization and certification of teachers.

Also, the Central American Educational and Cultural Coordination (CECC) and the Spanish International Cooperation Agency

(AECI) reported that one of the major challenges that the region faces, is that for countries, there is uneven development training in ICT (Retana and Esquivel, 2006).

The goals and challenges indicate that, although improving education is considered as a shared responsibility, one of the major routes around this quality is regarding to the initial teacher training in universities. If this is compounded by the steady increase in coverage, then it can infer that some of the responsibility for the quality of prospective teachers is related on the same quality standards that the country is committed to fulfill. Added to this, some universities are affected because, these invest more resources in improving the quality of their graduates, a greater number of credits, graduation time and accreditations with national and international agencies; this regards, Second Report of the State of Education in Costa Rica (2008) notes that

The characteristics presented by this growth in academic offerings, risk education system, for helping to incorporate people who do not have the conditions for quality education. These limitations are the poor controls adopted by some universities in selecting students for careers in education and for teacher training. In this situation, we add the weaknesses of the recruitment process by the MEP (Ministry of Public Education) and the lack of incentives to attract and retain good staff. (p. 34) (*Idem* footnote 1).

Challenges and goals are critical, as we discussed in this paper, the impact on system quality refers not only, to the acquisition of material resources or training or the application of international tests *per se*. But, we need to direct some efforts in understanding the dynamic of initial training in Mathematics and, in particular, initial training focused on competencies, skills and abilities with the use of technological tools.

For these reasons, the aim of this paper is to offer to the community a variety of perspectives on certain standards regarding

¹ Translate by author.

to the quality of teacher training in mathematics and, specifically, how incorporate international standards defined by UNESCO (United Nations Educational, Scientific and Cultural Organization) based on teacher training in ICT skills.

In first instance, it analyzes the main features of competency-based curricula and why this model offers certain advantages for the incorporation of these standards. Secondly, it performs a scan to the UNESCO's documentation and lastly, it tries to find ways to incorporate this knowledge in a proposal, previously developed by Morales (2010).

Technology Skills for Mathematics Education

About competency model and its relevance

The growth of the concept of competencies was imminently economic. As early as the 90's, The European countries wanted to move in groups. For this, it was necessary to consolidate a way to include the most significant sectors of the countries.

European countries experienced a lot change to its laws, but perhaps a significant event for the rest of the international community was the creation of a single currency. As the Euro strengthened gradually, econo-

mic systems transcended the first experience on the new market and when its stabilization was achieved, this sector was able to concentrate on new challenges.

In the middle of 90's already it was known some efforts to create a model of education in accordance with new era. Even so, it needed a way to align and compare different curriculums (or programs), and specifically, how to ensure quality.

With different professionals, Euro zone urged a system in which, they could ensure, for example, that an engineer trained in Germany had the "similar" knowledge and skills that other trained in England.

After several attempts, was in Bologna (July, 1999) when a meeting is held between ministers of education in Europe and generated a pact (with the Sorbonne declaration on higher education one year before). In summary, the Bologna Treaty was agreed to adopt a system of readable and comparable degrees, including degrees and postgraduate courses, with credit-based system and to promote mobility and quality.

Other declarations and statements preceded the Bologna Declaration (Prague, 2001; Berlin, 2003; Bergen, 2005; London, 2007 and Leuven, 2009); The Glasgow Declaration (2005) described the need for Euro zone; on its front page highlights the slogan:



Figure 1. *Glasgow Declaration (2005): Strong Universities for a Strong Europe.*

Strong Universities for a Strong Europe (see Figure 1). The Glasgow Declaration logo expresses the intension to reform educational systems in order to encourage professionals in the Euro zone with the rest of the world.

These facts in European community gave us a lesson in how a series of needs could be translated in quality for Primary, Secondary and Higher Education.

By creating a system that is comparable, not only it created the opportunity to contrast the positive and negative outcomes of educational programs, but, even more important it was having this model based on competencies that professionals must acquire during their training.

This set of competencies reflects the need of knowledge, but at the same time, it introduces a model in which the abilities and skills are as important as the theory.

As a result, it was important to redefine the meaning of competence; certainly the competencies involve the object of knowledge (theory) and how that knowledge will be useful (practice).

Other definition was proposal in The Tuning Project for Latin America:

The concept of competence in education sits within a broad conceptual map of the comprehensive education of the citizen, including new approaches, such as significant learning in different areas: cognitive (knowing), psychomotor (know-how, skills), emotional (savoir-être), attitudes and values. In this regard, competence cannot be reduced to simple professional performance, nor to the mere apprehension of knowledge to know how to do, but instead encompasses a whole set of capacities, which are developed through processes that lead a responsible person to be capable of performing multiple actions (social, cognitive, cultural, sentimental, professional, productive), through which they project and display their capacity to resolve a given problem, within a specific and changing context. (Beneitone, Esquetini, González, Marty, Siufi and Wagenaar, 2007, p. 32).

As stated above, competency-based model allows transforming the curriculum; in consequence, the university, students, professionals and employers from each country, can determine, by consensus, the skills that are necessary to their students.

Therefore, the concept of relevance in each curriculum will be defined through dialogue, making it context sensitive and, in most cases, sensitive to change.

The next section it will point out two proposals related to this model.

International Programs

It is necessary to create benchmarks to measure the way that some actions can impact to the system (Primary, Secondary and Higher Education).

In one hand, for secondary education, The Program for International Student Assessment (PISA) is one of the most distinguished programs. It was launched in 1997 under the auspices of the Organization for Economic Cooperation and Development (OECD) and its main objective is to provide an evaluation framework for the knowledge of students in the various participating countries and, at the same time, provide valuable information to governments to make decisions. This Program is characterized by building and implementing its assessments, and takes into account the educational system and society.

Many publications of this project have become a point of reference for determining the needs for countries. In Table 1, it shows some of these publications useful for Central American countries.

It is not the aim of this paper to describe the PISA project in depth, but there are some reasons in which this program may be of interest in the Central American context:

- PISA (OECD) is working on the evaluation of students with ages very close to 15 years; in many countries, this is the age at which obligatory education ends; this coincides with the Costa Rican educational program.
- PISA (OECD) is accepted as an international assessment of education.

Table 1. *Some of the publications that are recognized as benchmarks for international assessment of educational quality.*

Year	Publication
1999	Measuring Student Knowledge and Skills: A New Framework for Assessment.
2000	Measuring Student Knowledge and Skills: The PISA 2000 Assessment of Reading, Mathematical and Scientific Literacy
2001	Knowledge and Skills for Life. First Results from PISA 2000
2002	Reading for Change – Performance and Engagement across countries
2003	The PISA 2003 Assessment Framework. Mathematics, Reading, Science and Problem Solving Knowledge and Skills
2003	Definition and Selection of Competencies: Theoretical and Conceptual Foundations (DeSeCo), Summary of the final report «Key Competencies for a Successful Life and a Well-Functioning Society»,
2004	Learning for Tomorrow's World. First Results from PISA 2003
2005	Are Students Ready for a Technology-Rich World? What PISA Studies Tell Us

PISA Program, OCDE.

nal quality. In 2009 was implemented in 67 countries; 30 countries were OECD members and 37 countries were invited.

- PISA (OECD) is not focused only on cognitive aspects or areas, but, it assesses the skills and abilities of students for adulthood.

In other hand, for the higher education level, it does not suggest a specific program, but each career assesses the relevance of changes in its curricula in terms of competencies; hence, each career approves a specific methodology to improve quality.

One of the most recognized methods is offered by the Tuning Project, which is directed mainly to create knowledge about educational systems. To be precise, the Project helps to compare degrees and curriculum.

This project started in Europe and was product of the reform of the Bologna Declaration. *Tuning*, as a methodology, has been applied in over 175 universities in Europe, and it was replicated in Latin America between 2004 and 2007 in 19 countries.

Tuning promotes assessments, but focuses on providing participants a systematic strategy in which is able to determine the nature of a degree (or Career) and thus to adapt the curriculum to the needs expressed by all participants. The main feature of *Tu-*

ning is that uses the notion of competency to understand and compare the programs.

The teaching model involved in competence-based education seeks to overcome the barriers between the place of formal learning and everyday family life, work and the community, establishing a thread running between everyday knowledge, academic knowledge and scientific knowledge.... Breaking down the borders between formally and non-formally acquired knowledge enables the recognition the value of multiple sources of knowledge, such as personal experience, prior learning in different areas of each person's life, imagination, art and creativity. (Mockus, cited by Beneitone, Esquetini, González, Marty, Siufi and Wagenaar, 2007, p. 31)

These two programs mentioned are examples of potential sources of support from the international community, with perspectives in the modification of specific sectors of the educational system. This does not mean that these are the solutions to problems and system demands. As noted by De Faria (2010), "it is not importing theories from other latitudes. We need to assume a reflective attitude and discuss the proposals of individual projects and take the best for us and our region" (p. 35) (*Idem* footnote 1).

In the next section, there will be a brief detail on the proposal of UNESCO with regard to standards of competency sets for teachers in initial training. Subsequently, it is considered a component for the analysis of these standards applied to a previous proposal (Morales, 2010) and how it is redefined through indication on the arguments and perspectives of UNESCO.

Standards of UNESCO on ICT competences for teachers

In January 2008, UNESCO published a document which provides assistance and guidelines to create (or reform) programs of training teacher with ICT; this in order to fulfill the task of offering real training for students (prospective teachers). These guidelines are divided into three different frameworks: the framework of educational policies (UNESCO, 2008a), standards of competence modules (UNESCO, 2008b) and framework guidelines for its implementation (UNESCO, 2008c).

This program assumes that with the use of ICT, students may be competent (to use); it can improve research capabilities, and discrimination of the information; it can assist students in problem solving and decision making; it can stimulate creativity and productivity, to be communicators, collaborators and producers, as well as responsible and informed citizens.

From educational policy framework, it suggests three approaches:

- Technology Literacy.
- Knowledge Deepening.
- Knowledge Creation.

The first approach translates into technological understanding; the second is based on the management of problem solving, as a strategy, and the third, is based on the production of new knowledge. In addition to these approaches, UNESCO suggests a link between the skills of five components of the education system: pedagogy, practice and training of teachers, Curriculum and assessment, educational administration and organization and, finally, use of ICT.

Under the standards, the proposal offers 15 competencies, one competence for each component and related to the three approaches. As regards the framework of the implementation guidelines, offers examples of the methods to achieve the guidelines.

In the following sections it examines the competences for teachers of Mathematics offered by Morales (2010) in the different approaches of UNESCO.

About the previous proposal and the strategy for UNESCO standards compliance: the case of Teachers of Mathematics

In the above scheme, it was offered an initiative formulated through analysis of the competencies considered from the academic perspective and these were compared against a range of possible activities to foster such competencies.

Furthermore, seven groups were defined, where it must develop these skills (Morales, 2010): basic technological competencies, diversity-related technological competencies and computer ethics, technological competencies related to the administration of the educational process, technological competencies related to pedagogical administration of the educational process, methodologies related technological competencies in the educational process, technological competencies related to virtual communities and *Blended Learning*, and competencies related to specific software.

Below is the proposal (Table 2) that has been suggested on some of the competencies embedded within the components of the initiative designed by UNESCO and related Technology Literacy Framework. In this paper, it has been defined and redefined certain competencies of the 27 originals (Morales, 2010) and included 8 new under the suggested strategy in Verdejo (2008). These are the competencies that, in consideration of the author, should be analyzed in the context of mathematics teacher training in Central America.

The following table shows the relationship determined for the Knowledge Deepening Framework of UNESCO concerning the above proposal (Table 3).

Table 2. *Technology Literacy Framework in the proposed competencies for prospective teachers in mathematics education.*

UNESCO Component	Concrete competence
CURRICULUM AND ASSESSMENT	The teacher is able to use word processors as a tool for presenting information related to their tasks (tests, reports, plans). The teacher knows the role of technology in the national curriculum.
PEDAGOGY	The teacher manages information related to databases and spreadsheets used in teaching. The teacher recognizes the relevance of using ICT in activities and presentations made in the classroom.
ICT	The teacher explains the key concepts associated with ICT and in particular to the computer. The teacher manipulates the computer functions properly. The teacher knows file-management functions in an operating system.
ORGANIZATION and ADMINISTRATION	The teacher is able to use spreadsheets as tools for managing information about their work.
TEACHER PROFESSIONAL DEVELOPMENT	The teacher is able to use spreadsheets to maintain and analyze information from their students. The teacher knows the basics of incorporating technology in various types of activities (group or individual) The teacher builds documents for communication of past ideas in word processors, spreadsheets and WYSIWYG, On and Offline versions. The teacher can differentiate between proprietary and free software. The teacher can use the CAS as tools to simplify calculations.

Based on Morales (2010)

Table 3. *Knowledge Deepening Framework in the proposed competencies for prospective teachers in mathematics education.*

UNESCO Component	Concrete competence
CURRICULUM AND ASSESSMENT	The teacher recognizes the importance of using material and technological resources copyright (ethical approach). The teacher is able to offer proposals on the use of educational software.
PEDAGOGY	The teacher discusses the incorporation of technology in models based on solving problems. The teacher can encourage collaborative work online.
ICT	The teacher knows the concept of communication networks as the Internet. The teacher knows the concepts of e - Learning and Blended – learning. The teacher knows the hierarchy of identities in the creation of virtuality.
ORGANIZATION and ADMINISTRATION	The teacher is able to offer (or to design) different learning environments.
TEACHER PROFESSIONAL DEVELOPMENT	The teacher can create structures at Dynamic Geometry Software (DGS) and problematize the visualizations. The teacher is able to flow charts outlining routines based on numerical methods. The teacher is able to understand pre-built routines for data analysis and approaches to solutions to issues of matrices, equations, numerical differentiation and integration).

Based on Morales (2010)

Table 4. *Knowledge Creation Framework in the proposed competencies for prospective teachers in mathematics education.*

UNESCO Component	Concrete competence
CURRICULUM AND ASSESSMENT	The teacher can assess the impact of other proposals. The teacher recognizes the strengths and weaknesses of students when using methods supported by ICT. The teacher knows incorporate methodologies such as WebQuest.
PEDAGOGY	The teacher dominates the concept of WEB 1.0, 2.0 and 3.0, and its related tools (Blogs, wikis, chats, IP - Communications, etc.). The teacher is able to propose strategies for the effective incorporation of technology as a pedagogical mediation.
ICT	The teacher manages specialized search engines on these networks. The teacher can pose strategies based on Computer Algebraic Systems (CAS), DGS, statistical software and software-oriented modeling of phenomena.
ORGANIZATION and ADMINISTRATION	The teacher is able to make proposals for innovation at the institutional level through the use of technologies.
TEACHER PROFESSIONAL DEVELOPMENT	The teacher knows how to use technology as a support for qualitative research and qualitative. The teacher is able to raise their own training strategies. The teacher knows how to share their experiences.

Based on Morales (2010)

Table 4 shows the relationship determined for the Knowledge Creation Framework.

Framework guidelines for implementation

As it was indicated in the introduction, the major weaknesses that have many countries in the region are the few policies in the development of their university systems. There are countries such as Costa Rica, which have the advantage that the university system is based on academic credits, which has been important to avoid large gaps between the universities. However, Fidalgo and Garcia (2007) illustrate that the above condition is not sufficient for the development of the system.

The Tuning Latin America Project (2004-2007) is an excellent reference to understand where to direct the efforts. Among the main considerations arising from this project are: Build educational programs sensitive to the comparison (by competencies), develop knowledge about teaching methodology for competency-based curricula, and the academic credits and quality of programs.

In one way or another, these international trajectories show to the countries in the region, that careers need to be “backed” by organizations for quality and accreditation to ensure its excellence. Obviously, the fact that two career have the same amount of credit is not enough to say that retain similar characteristics. For example, in Costa Rica, there are differences in similar degrees in Mathematics Education with one year or more (see, Ruiz, Barrantes and Gamboa, 2009).

All the items above are relevant in developing countries in the region, but in our case, one of the greatest barriers is that the government does not have a teacher recruitment policy to ensure the employment of skilled personnel.

Another factor that is considered essential in developing policies is that the region has few specific researches on the use of ICT. This causes that the definition of policies specific to the region is a task often theoretical, and without basis in research experiences in our context.

Therefore, we consider necessary a research agenda in mathematics education designed to:

1. Research on the use of ICT and its impact on achievement.
2. Research on the use of ICT and environmental characteristics (age, gender, race, socioeconomic status, among others).
3. Research on the use of ICT and software specializes in all areas (geometry, functions, calculus, among others) and strategies of learning.
4. Research on the use of ICT and design of educational activities with the computer.

Definitely, the policies needed for development in this discipline must be the result of the confrontation of current needs with the experience in the classroom. We will know this experience through research.

Conclusions

The education of the region has variables that could allow a development or progress in the quality of life of individuals through the improvement of education systems (and lifelong learning). Many of the challenges that face these countries are to analyze and implement programs aimed at improving its systems.

For this reason, the implementation of international programs will depend on reflection and research, generated primarily from the same universities and research in institutions of education.

In the case of the UNESCO's proposal, it considers putting a set of guidelines and policies needed, but the task is to translate

these strategies into practice. In this sense, this paper may provide a framework for discussion on possible competencies for prospective teachers in mathematics. Of course, such initiatives must be accompanied by incentives and commitments of all stakeholders in the educational work.

In addition, it is required a great effort from the same governments to improve standards and quality regarding the hiring of professionals; it may, amongst other things, improve employment opportunities and salaries. In the case of Costa Rica, it has been shown that although all sectors should be given incentives; science-based sectors and technology are fundamental to the development of knowledge in the country, and evidently in the region. So, it will be necessary to teach highly skilled professionals that meet current needs in mathematics education and, at the same time, with skills that respond to a variety of challenges. Central America should focus on recent researches as Pérez, Losada and González (2009) in Europe, which showed trends towards improvement of education through the training of teachers with high abilities.

To reach this goal, proposals are required, involving not only the improvement of curriculum and educational programs in these nations, but to involve the teachers in new practices in the classroom. In short, we cannot think about improving the system without increasing the capacities of in-service and pre-service teachers, and simultaneously, establish a curriculum "susceptible" to the incorporation of didactic tools in line with our context.

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