

Supporting STEM teachers' professional learning for competence development

Insights on the space for intervention in *Spain*

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The background

Spanish educational Laws have been changed several times during the last twenty years. Since 2013 and in process of deployment, there is a **new Educational Law** named "Organic Law for the Improvement of the Quality of Education" (LOMCE, 8/2013). Fruit of the political instability and, to a certain extent, a lack of a culture of consensus, implementation is being challenged in many levels, giving a sense of provisionality, which is reflected in the fact that regions, local authorities, and educational councils are in **continuous negotiations with the Ministry in order to modify the law**. In this situation there is certain weariness in front of the continuous legal changes and budget cut-outs.

There are important changes very much in concordance with the EU policies (European Parliament, 2006/962/EC). The Law emphasises quality and employability, encouraging selecting both the professional and the academic path at earlier ages. There is **more emphasis in STEM**, more instrumental type of disciplines, and less subjects optional. Of importance is the interest of giving the **schools more freedom in terms of adapting the national curriculum** (curriculum proposal) or **introducing new methodologies** and optional subjects (didactical programme), within

their legal competencies. The **curriculum is now organised according to a competency approach**, in which knowledge, skills and attitudes have been identified in all subjects and at all levels. Key competencies, named "basic competencies" inform the competence model. This panorama implied also **the reform of the Continuous Professional Development (CPD) programmes**, as well as access to the teacher profession, now based on Master's Degree Programmes.

Against this background, this document aims to provide insights on the space for intervention for STEM teachers' professional learning in Spain. Presented are results of work conducted in the frame of the ELITE project¹ pertaining to: the requirements for STEM teachers' competence development in the country - as evident in policy documents, teacher training curricula and students' curricula); the systemic opportunities/challenges and aligned to them recommendations for supporting STEM teachers' professional learning - as emerged through a negotiation process between policy, policy mediators and STEM teachers.

Presented results aim to serve as a basis under which educational stakeholders can reflect on and consider how best to support STEM teachers' professional learning for competence development in the country.

¹ ELITE - Enhancing Learning in Teaching via e-inquiries

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ELITE aims to support STEM teachers' professional learning for competence development via inquiry methodology.

STEM teachers' competences in Spain: Requirements & identified issues for consideration

The tables below provide an overview of Science, Technology, Engineering and Mathematic (STEM) teachers' competences that are required in the national contexts of Spain. Considered are three dimensions of competences (knowledge &

understanding, skills, dispositions & attitudes), while aspects in each dimension have been adopted by EC (2013) teacher competences' framework. Aspects in each dimension **explicitly** evident refer to evidence demonstrated in national policy documents and curricula for STEM teachers' training; aspects **implicitly** evident refer to evidence demonstrated in students' STEM curricula.

Requirements for STEM teachers' competence development in Spain



| Knowledge & Understanding required... | explicitly | implicitly |
|---|------------|------------|
| Subject matter knowledge | ✓ | |
| Pedagogical content knowledge | | ✓ |
| Pedagogical knowledge | ✓ | |
| Curricular knowledge | ✓ | |
| Educational science foundations | ✓ | |
| Contextual, institutional, organizational aspects of educational policies | ✓ | |
| Issues of inclusion and diversity | ✓ | ✓ |
| Effective use of technologies in learning | ✓ | ✓ |
| Developmental psychology | ✓ | ✓ |
| Group processes and dynamics, learning theories, motivational issues | ✓ | |
| Evaluation and assessment | ✓ | |



| Skills required ... | explicitly | implicitly |
|---|------------|------------|
| Planning, managing and coordinating teaching | ✓ | |
| Using teaching materials and technologies | ✓ | |
| Managing students and groups | ✓ | |
| Monitoring adapting and assessing teaching/learning objectives and processes | ✓ | |
| Collecting, analyzing, interpreting evidence and data for professional decisions | | ✓ |
| Using, developing and creating research knowledge to inform practices | ✓ | ✓ |
| Collaborating with colleagues, parents and social services | | |
| Reflective, metacognitive, interpersonal skills for learning individually and in professional communities | ✓ | |
| Adapting to educational contexts | ✓ | |



| Dispositions & Attitudes required ... | explicitly | implicitly |
|--|------------|------------|
| Epistemological awareness | ✓ | |
| Teaching skills through content | ✓ | |
| Transferable skills | | |
| Dispositions to change, flexibility, ongoing learning and professional improvement, including study and research | ✓ | |
| Commitment to promoting the learning of all students | ✓ | |
| Dispositions to promote students democratic attitudes and practices as European citizens | ✓ | ✓ |
| Critical attitudes to one's own teaching | ✓ | |
| Dispositions to team working, collaboration and networking | ✓ | ✓ |

Prominent issues for consideration pertaining to the systemic educational levels identified from the review of the Spain national context through the documentary analysis are:

At policy level: Competence-based education in all level of compulsory education and baccalaureate is supported by law. Key competencies are part of the evaluation of the effectiveness of the educational system. Furthermore, STEM has more weight in the curriculum in terms of content and time. The law demands teacher education being adapted to this new situation in terms of contents and methods. In this sense, the Spanish reform recommends methods to facilitate methodological strategies that allow for classroom competencies work (ECD/65/2015).

Among the most prominent issues, we can mention:

- ***Weariness in front of the continuous legal changes and budget cut-outs***
- ***Lack of coordination among the national, regional CPD providers in terms of policies and strategic plans for STEM CPD that respond to these changes***

At policy mediation level: Universities have undergone an important challenge on creating their own Master's Degree in Secondary Education

(should to be approved by a Spanish National Agency of Evaluation), with a competence approach (knowledge, skills and attitudes) that vertebrate the study programs. However, many times University teacher trainers lack experience on the reality of the school, and are more oriented to theoretical approaches.

However, there is a great opportunity for the updating of both in-service and pre-service STEM teacher education programs (the new Law specifically mention 7 key competencies, including "mathematics competence and basic competencies in science and technology"). Then teacher education programmes should follow the same approach.

On the other hand, there is a persistence of providing teacher training on STEM according to the traditional subjects (physics, chemistry, technology and maths), which hinder the possibility to include methodologies that are becoming more and more popular in secondary education, as e.g., Project work. Many times University teacher trainers lack experience on the reality of the school, and are more oriented to theoretical approaches.

However, although training contents has been updated, there is a lack of EU policies insufficiently considered (e.g. OSR, STEM gender aspects, ICT, RRI, STE(ART)M), and methodological aspects (e.g.

IBL, project work,) are still a challenge in teacher education programs.

Among the most prominent issues, we can mention:

- ***Teacher education programmes need to get used to work according to a competence-based approach, working coordinately in all subjects with other key competencies (e.g. digital competencies)***
- ***CPD programmes need to integrate those methodologies and innovations that favour the acquisition of STEM competencies***, as e.g. IBL, PBL, OSR, ICT, Gender, etc.
- ***Need to provide STEM training paths for in-service teachers in collaboration with different types of institutions***, e.g. science centres, research centres, universities and governmental initiatives.

At practice level: There should be a high level of coherence between the competencies required by teachers and those described for students in the Law of Education and further deployments in the regions. However, in practice this does not always happen for different reasons related to the day-to-day work. On the other hand STEM competencies imply a new role for students, more active and autonomous (conscious and responsible of their own learning). Finally, the participation of parents in the day-to-day of the educational centres is important at the time of pushing for STEM-related extra-curricular activities.

Among the most prominent issues, we can mention:

- ***For teachers, there is a surplus of subjects and contents, obsession for finishing the programs, as well as a tendency to use summative evaluation.***

- ***For students, there is a lack of interest on contents because students do not find their connections with reality.***
- ***Parents need more information on the importance of implementing STEM innovations in the schools, so they can be involved on the decision-making on their particular centres.***

As a result of the documentary analysis, we identify proposed issues for further exploration and discussion:

- ***At policy level:*** Opportunities and challenges in building STEM teacher competences by the teacher trainings
- ***At policy mediation level:*** Opportunities and challenges for STEM teachers' competence development in schools management of strategy, curricula and teaching approaches
- ***At practice level:*** Teacher competences are needed to design IBL activities in the class. Teachers need a support for IBL day-to-day application. Content should be provided to spread widely the approach

Emergent systemic opportunities and challenges for supporting STEM teachers' professional learning for competence development

The results of the documentary analysis were communicated and negotiated with policy makers, policy mediators (responsible for STEM teacher training), teachers and broader society members in the course of the ELITE's project Spanish multiplier event². The goal of the event was to discuss topics above in constructive way leading to insights how to organize more effective STEM teachers' professional competence development.

² The ELITE project multiplier event E4 took place on the 28th of September 2017 in Barcelona with the participation of 47 national educational stakeholders. The event was conducted

under the EASW workshop methodology, which allows for interaction between stakeholders and aim for consensus building rather than instructional approach.

Outcomes of the negotiation process related to the new National regulatory framework, are synthesized in a Strengths, Weaknesses,

Opportunities and Threats (SWOT) analysis presented here below.

SWOT analysis of the National regulatory framework in accordance with teachers' competence development

| | |
|---|-------------------|
| <ul style="list-style-type: none"> ○ Freedom to develop your own lesson plans according to the regular education framework, and curriculum regulations. The current laws allow it. ○ The education policies in line with the development of cross-competence approaches. ○ Education policies could be nourishing by results and tools that applied educational research provide. ○ Freedom for teachers to use inquiry-based methodologies. ○ Teachers' personal motivation to improve their competences based on CPD. ○ STEM teachers can teach a diversity of STEM subjects. | <p>Strengths</p> |
| <ul style="list-style-type: none"> ○ In practice, STEM research results do not make a significant impact on educational policies. ○ Results of research don't flow to teachers and their practice. There is not a good communication between university researchers and school teachers. ○ An important part of teachers do not perceive the necessity of changing STEM teaching paradigms, because they do not trust on new methodologies and tools. ○ Teachers work separately by departments, not knowing well the contents of the different school disciplines. This prevents a integrated curriculum approach or working holistically in competences development, for example in projects. ○ CPD programs sometimes do not provide courses that incorporate innovative pedagogical approaches to new STEM topics, since they consider only the new knowledge as the most important. ○ The cross-competence approaches sometimes do not match the organisation of the curriculum, which is usually organized by subjects, splitting the contents on the different STEM components. ○ Different motivational levels on teachers, which hinder the possibility of introduce STEM innovations. ○ Lack of communication among teachers at the school. ○ Teachers lack skills on issues as gender and STEM, conflict resolution, and emotional education not only to teachers, but to parents | <p>Weaknesses</p> |

| | |
|-----------------------|--|
| O pportunities | <ul style="list-style-type: none"> ○ Flexible educational organization based on the autonomy of schools. This allows for certain freedom for curriculum organisation, e.g. defining learning objectives by educational cycle, and not by course. This allows for achieving the objectives in a longer term, so STEM contents can be organized differently by course. ○ Educational centers can proposal interdisciplinary programmes, and then they receive support by the administration in terms of teachers training and resources. ○ Families can influence the introduction of STEM innovations (robotics, etc.), which can be included not only as extracurricular activities but within the curricula. ○ There are resource centers, as well as resource banks....but it would be necessary to offer more training support. ○ Pre-service education allows for the integration of contents coming from different STEM subjects. ○ In both secondary and upper secondary education, there are targeted subjects (Project research work, Synthesis project) that imply a more comprehensive approach to STEM and inquiry-based education. |
| T hreats | <ul style="list-style-type: none"> ○ The rotation of school teachers (given to the low labor stability) works against the continuation of collaborative projects and innovations at schools. Then the motivation for initiating innovative STEM projects is reduced. ○ The administration promotes CPD programmes, however it is not compulsory for teachers to enroll. ○ The educational institutions are reluctant to change their functioning and organization. ○ Families lack of participation in the school life, probably because adolescence is the time for students to be independent. ○ Lack of leadership of the school management in promoting innovation. ○ Lack of time for enrolling in CPD in the school calendar, and sometimes the training is mostly based on single subjects. ○ Teachers lack confidence in implementing STEM innovations, including the parents' pressure to get fast results. |

Overall, the insights gained by the negotiation process allows to support the argument that ***the new policy documents provide much more flexibility and autonomy in decisions in front of all stakeholders' groups.*** At the moment not only the universities and the regional governments, but also the science institutions, publishing houses and non-government organizations are eligible to offer teachers training courses, which raise the level of concurrency in terms of thematic of offered courses and quality of their design and implementation. ***Teachers, themselves, are encouraged by the policy framework and career paths to upgrade their professional qualifications*** requiring gaining of credit each year. Active

participation in experience exchange activities – workshop, seminars, open lessons, conferences- is recognised. In addition, ***schools might receive a dedicated financial support for teachers' professional development if they present training plans.*** However, the ***training is mostly out of the school time, which limits the impact of the offer.***

As an outcome of the negotiation process, identified are the following ***critical factors that affect STEM teachers' professional learning for competence development*** in the country, related to the content, the methodology, the form and the assessment of professional learning provisions:

- **Teachers lack training on STEM-related methodologies, and examples of good practice.** For STEM teachers to improve their teaching methodologies, the use of open science resources, or the inclusion of topics related to the socio-scientific issues that attract students' attention. They claim also practical courses related to the use of STEM digital resources, and looking for interdisciplinarity so they can collaborate with other colleagues in developing a more integrated view of STEM, and as a consequence, on developing STEM competencies of their students.
- All the stakeholders groups agreed on the **need of application of active teaching and learning methods in the classroom.** Special attention is, again, dedicated to the inquiry-based and project based learning methods, which are emerging in the Spanish schools, and are required to develop STEM competences in an integrated way. For STEM learning disciplines there is a special need teacher to be trained on how to design, deliver and conduct attractive STEM resources.
- **Inclusive education is still a challenge in front of Spanish teachers.** Aspect related to the STEM and the fighting gender stereotypes in STEM, were discussed and an agreement upon including this area for teacher training was reached
- **Work with parents and with other actors.** The role of parents associations in the school is very important. They organize extracurricular activities, many of them related to STEM areas, as e.g. robotics, science days, etc. Furthermore the role of parents is also key in order to break stereotypes about science among their sons, and more importantly among girls. They also are sensible to introducing learning innovations and projects (many

times with science centres) since this means prestige for the school and better outcomes.

- According to the modalities of teacher' training, the common opinion is that there a **need of development of communities of practice between STEM teachers**, something that can be done both face-to-face and online, especially given the limitations of teachers in terms of schedule and geographical distribution.
- Discussing the **training methodology**, all the participants share their believes that **the teachers' training should be based on the same innovative learning methods which are expected teachers to apply in the classroom**, as opposite to the popular lecture-based teaching, which is less and less popular in Spain.
- With respect to the assessment system, participants focused on the need to **adopt project work as the assessment methodology**.

Policy Recommendations towards supporting STEM teachers' professional learning for competence development

The critical issues on STEM teachers' professional learning for competence development in Spain were further discussed in the course of the EASW event, with the view to suggest proposals for enhancing STEM teacher' professional learning provisions. The understandings gained from this process facilitated the formulation of the ELITE's project recommendations on how to support Spanish STEM teachers' learning for competence development.

The formulated recommendations are structured around two axes: the one pertaining to the emergent critical issues on STEM teachers'

professional learning for competence development in the country, and the other pertaining to the systemic educational levels.

These are presented here below:

Recommendations pertaining to the emergent critical issues

1 | Promotion of active teacher strategies in STEM teachers' training offers: inquiry-based learning & problem based learning

This is a key point for any professional development course as well as pre-service training. Many times teachers have modern materials and resources at the school; however, they don't take all the advantages of them because of not using the adequate teaching methodologies, as inquiry-based learning. Project-based learning is also a must, since this methodology is becoming very popular, and an integrated view of STEM competencies call for the use of this approach.

2 | Inclusive education / dealing with diversity in education as a priority for teachers training provisions

Dealing with diversity in education is considered a key point, which in the case of gender has been already identified by the regional authorities. It seems then that supporting training on this issue match this current national and regional priority. There is also an interest on using personalization strategies for approaching differences in terms of learning.

3 | Focus on topics related to socio-scientific issues for STEM learning

This has been identified by experts as a good strategy for attracting students to science.

The use of, for instance science in the news, scientific controversies, etc. proves to fight the lack of interest in STEM introducing very up-to-date themes to be further developed from the content point of view at the classroom.

4 | Enhancement of teachers' capacities to work with digital resources

Open Science resources have been identified as a good help for teacher designing STEM activities. The use of ready-made resources is a good entry level for this type of digital resources, since many teachers ask for easy ways of introducing innovative practices. For those more active the adaptation or the design of resource based on these examples are also seen important for improving the interest of students, so their competencies. Teachers would need examples of good practices in this respect.

5 | Consider the school as a learning community and open-up STEM school learning

In some schools teachers and parents work together in many aspects related to STEM, from extracurricular activities to the organization of science fairs and other events. However, many of the teachers lack skills for working with parents associations in preparing strategies and examples of good practice of STEM activities at schools.

Approaching STEM in collaboration with scientific centres, and science museums and other local institutions have been identified of importance to supporting STEM in the schools, and in the CPD courses for teachers.

6 | Modernization of training methodology and assessment approaches in professional learning provisions

Teachers' training should be based on the same innovative learning methods which are expected teachers to apply in the classroom, as opposite to the popular lecture-based teaching, which is less and less popular in Spain. Consider project work as a training assessment method.

Recommendations pertaining to the systemic educational levels

Policy level

- ☑ The administration should work together with other institutions for providing realistic STEM teachers training paths, including online delivery.
- ☑ Researchers in the area of STEM should participate in the institutional plans, providing advice on contents and methodology, as well as on impact evaluation of the STEM programmes
- ☑ As with respect to plans for introducing STEM innovation the educational policymakers, need to coordinate with all key players, as e.g. universities (as providers of both pre-service and in-service), science centres, publishing houses, other local training institutions, practitioners, etc.

Policy mediation level

- ☑ The teachers' timetable should be organized taking account the time and the space necessary in order for those of different disciplines (but with the same students) being able to work together in organising IBL activities.

- ☑ It would be very important that school managers support the introduction of the IBL methodology in the study program, adjusting and/or adapting the learning objectives to the stages needed to implement STEM this way (considering the flexibility of the local curricula).
- ☑ School authorities should promote the communication between teachers and parents on the potential and the benefits of the IBL methodologies for STEM education.
- ☑ Teachers need more opportunities for in-service training. Give the timetable limitations, online teacher training (or a combination of online and face-to-face) is a good approach in many cases.



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Practice level

- ☑ Teacher's need more support to design and implement IBL activities in the class.
- ☑ Teachers need to master IBL methodology, so they can feel confident to implement IBL activities in their class.
- ☑ For beginner teachers, a database of best resources and learning units can facilitate the STEM take up, and the design and the implementation of IBL activities. These resource should be innovative, combining traditional content and STEM current themes been able to raise the interest of students.
- ☑ Teachers require seeing STEM in a more integrated way, then going beyond the traditional subjects and combining contents through project-based learning. This requires many time the understanding of parents, reducing their anxiety in front of innovation learning results.

The above recommendations aim to provide a basis for the establishment of a dialogic process between policy, policy mediation and practice, towards a renewed approach and curriculum for STEM professional learning.



