International Journal of Engineering Education Vol. 34, No. 5, pp. 1626–1633, 2018
Printed in Great Britain

0949-149X/91 $3.00+0.00

Proposal for a Postgraduate Programme for STEM Education*

LUCIANO ANDREATTA CARVALHO DA COSTA
State University of Rio Grande do Sul, Porto Alegre Campus, Av. Bento Gonçalves, 8855, 91540-000, City of Porto Alegre, State of Rio Grande do Sul, Brazil. E-mail: andreatta.luciano@gmail.com

TÂNIA CRISTINA BAPTISTA CABRAL
State University of Rio Grande do Sul, Guaíba Campus, Address: Rua Santa Maria, 2300, Bairro Bom Fim Velho, 92500-000, City of Guaíba, State of Rio Grande do Sul, Brazil. E-mail: cabral.taniacb@gmail.com
Pontifical Catholic University of Rio Grande do Sul, Avenida Ipiranga 6681, Prédio 30, Bloco C, Sala 104, 90619-900, City of Porto Alegre, State of Rio Grande do Sul, Brazil.

FABRÍCIA DAMANDO SANTOS
State University of Rio Grande do Sul, Guaíba Campus, Address: Rua Santa Maria, 2300, Bairro Bom Fim Velho, 92500-000, City of Guaíba, State of Rio Grande do Sul, Brazil. E-mail: fabriciadamando@gmail.com

In this article, we present fundamental principles and concepts for a postgraduate program focused on educating university lecturers in Science, Technology, Engineering and Mathematics (STEM). This program is being designed by the Science, Technology, Mathematics and Engineering (STEM) research group (GPEECE), which is linked to the State University of Rio Grande do Sul. Theoretical parameters are presented, as well as the actions needed to support a postgraduate program focused on students who have taken courses in the areas of Science, Technology, Engineering and Mathematics (i.e., future teachers of STEM). The results showed that the great differential of the course in relation to other similar courses is the specific focus in the classroom. This was one of the aspects that were most remembered by the students of the specialization course that represented the previous work for the proposed course.

Keywords: mathematics education; engineering education; education in the sciences; education for STEM

1. Introduction

The Science, Technology, Mathematics and Engineering (STEM) research group (GPEECE) [1] was created at the State University of Rio Grande do Sul (UERGS) and its main goal is education in STEM (Science, Technology, Engineering and Mathematics). These subjects represent an important component of a country's social and economic development in a *society of knowledge* [2], and a society's evolution depends on the way it deals with technological transformations enabled by bold policies that permit access to more detailed knowledge. Therefore, we are seeing demand for the advancement of STEM education [3–10], and this requires concentration of efforts to develop a shared vision for educational innovation. Engineering education research has not followed all the current technological transformations [4, 5] and as such our suggestion is to prioritize an epistemological position based on active learning [6, 7], promoting student engagement throughout the education process.

One of the aspects that contributes to improving achievement of academic qualifications in engineering is its integration with secondary education[8], since in the early years of education it is easier to identify weaknesses in teaching methods which need to be addressed.

Analyses of technical and technological education reality in Brazil (mainly in the State of Rio Grande do Sul) show that there is distance between technical and pedagogical points. The majority of teachers who are experts in their areas of study do not have the necessary tools to change their teaching methods and pedagogy. With few exceptions, there are insufficient education programs to meet the demand for training university lecturers in order to make them sufficiently qualified to understand and implement different theories and methodologies in the subjects that they teach, and to organize inter-disciplinary and/or multi-disciplinary tasks in which practical problems can be proposed for the benefit of their students' education. With this in mind, this article presents a case for a *stricto sensu* postgraduate course in STEM education for university lecturers, outlining the regional, institutional and local context based on the international situation. The article considers the following:

(i) The international and institutional context for education in this area;
(ii) The academic context in this area; and
(iii) The local scenario that necessarily informs this proposal, as certain aspects are particular to education in this region;

Figure 1 presents a conceptual map of the cate-

* Accepted 17 April 2018.

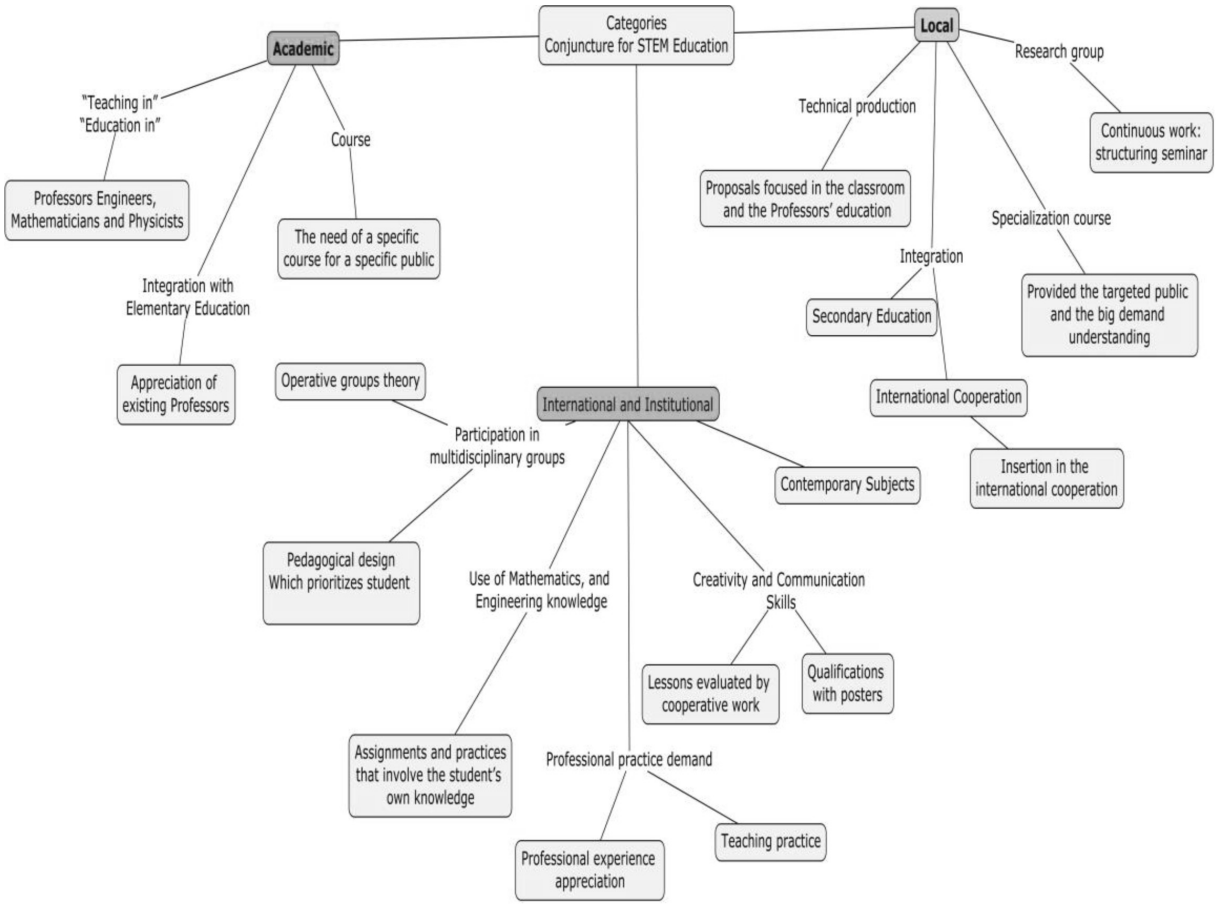

Fig. 1. Categories analysed for lecturer training in STEM.

gories that were analysed. Subsequent sections give more detail about each category.

2. Literature review

2.1 The international and institutional context of STEM education

Engineering education has become an increasingly important topic in terms of its inter-disciplinary nature as well as in the context of social development [9], making it necessary to review some aspects of engineering education, for instance those promoting creativity and communication skills [10, 11].

Some international academic societies try to promote research on engineering education. For example, at the American Society of Engineering Education (ASEE) annual event, there is a specific division that deals with postgraduate affairs (Graduate Studies Division), and their 12 main goals include: innovation and creativity; online courses; encouragement of future graduate students to take postgraduate courses; and the need to consider the career practicing demands. In Europe, the European Society of Engineering Education (SEFI) contributes to the development and improvement of engineering education across the continent, highlighting its importance and the significance of engineers in society. SEFI targets the improvement of teaching techniques in higher education. In an effort to establish international parameters in engineering education, the ABET (Accreditation Board for Engineering and Technology) criteria represent an important starting point for analysing the targets and proposals for education in this area. There are a number of challenges to trying to achieve important ABET criteria results [12]. Some relate to: (i) the implementation of mathematics knowledge in science and in engineering; (ii) ability to conduct experiments (iii) ability to be part of multi-disciplinary groups; (iv) communication ability; and (v) knowledge of contemporary subjects. In this article, we propose an evaluation matrix for these different criteria, with the aim of achieving the desired results.

2.2 The academic context

In Brazil, the academic movement that involves an inflexion in the so-called hard areas or applied research about ''education in'' or ''teaching of'' is relatively new, especially in light of the current emergence of multidisciplinary research. Around

30 years after these programs were created, we can safely assert that there are significant results from those pioneering actions that aimed to create a critical community specialized in education in Science, Technology, Engineering and Mathematics. A good example of mathematics education establishment is shown among the programs currently recognized by CAPES[1]. This highlights the pioneering program of postgraduate study in mathematics education at the UNESP (São Paulo State University)—Rio Claro, where the Master's degree program began in 1984 and the PhD degree program in 1993, and where there is also a journal that contains international contributions.

In the field of science and mathematics education, 155 programs are highlighted in Brazil and 22 of them are in the State of Rio Grande do Sul, where UERGS (State University of Rio Grande do Sul) is located. This scenario structure was determined by the UNESP proposal for mathematics education but there was an expansion in the teaching targets in order to reach other sciences.

Outside Brazil, there is an important example of higher education teacher training programme developed by the Institute of Education Science of Universitat Politècnica de Catalunya—Barcelona Tech [13], which is in the similar area of this proposal. The methodology was based on ''identifying the skills that a teacher should developed and analyzing previous training programmes''. The programme strucuture is shown below (each course has nine hours teaching class):

(i) 6 basic courses: social skills, teacher methodology, system based on skills, work groups, teaching innovation, oral and write communication and investigation on Education
(ii) 6 projects on teaching innovation
(iii) 3 optional or complementary courses

Regarding the proposed new postgraduate program, its goal is to prepare professional people to teach in technical and technological levels, including subjects in higher education courses in engineering. This characteristic confers a differential to the program focusing on professional individuals who wish to teach and making it possible for them to find an important reflection locus on didactic and pedagogic productions to be applied in the classroom. Registrations in higher education courses of technology have increased significantly in recent years: in 2013,they made up 13.6% of registrations for higher education courses, against 2.9% in 2003 [14]. The same growth has been noted for secondary school technical courses. According to the National Service of Industrial Education (Sistema Nacional de Educação Industrial—SENAI), registrations in technical courses increased by 88% from 2008 to 2014 [15]. The Postgraduate National Plan (Plano Nacional de Pós-graduação—PNPG) for the period 2011–2020 is also relevant [16]. This document devotes an entire chapter to elementary education and this is a challenge to the Postgraduate National System (Sistema Nacional de Pós-Graduação—SNPG).

The proposal for a ''professional teacher'' for STEM, as presented in this article, addresses PNPG concerns, since the activity that guides the strategies that sustain the concept for this course is precisely the exercise of teaching in elementary school, in particularly looking at technical courses. When the PNPG recommends the interaction between PPGs (Postgraduation Programs) and other higher education courses, encouraging participation in postgraduate courses in other areas of knowledge, in addition to education, in matters that concern the improvement of the quality of elementary education, it is clear that the proposal for ''professional professor'' for STEM is a move in the right direction. PNPG also encourages the development of studies aimed at science education format in elementary schools, which is at the core of the educational plan presented in this article.

2.3 The local scenario

Although the State University of Rio Grande do Sul has existed for only a few years, it has implemented a significant number of actions for professors and students at its two campuses, where there are engineering courses, in an aim to strengthen cooperation between mathematics [17–19] and engineering education for the comprehension of, approach to and elaboration of answers to the learning issues that might occur when one studies formal sciences, applied sciences or technology.

There are four aspects to the basis of support for a Professional Master's Degree in this local university community new phase:

(1) the research group—GPEECE;
(2) the specialist course in STEM;
(3) the projects regarding increasing partnerships with elementary schools; and
(4) cooperation in research with international institutions.

2.4 The research group—GPEECE

The Science, Technology, Mathematics and Engineering (STEM) research group (GPEECE)

[1] In Brazil, the CAPES Foundation (Coordination for the Improvement of Higher Education Personnel) linked to the Ministry of Education, through committees formed by researchers chosen amongst their peers, attributes concepts to postgraduate programs offered in several areas of knowledge.

increases and optimizes scientific practices in engineering education, mathematics education and science education. Among the group members' initial publications, we highlight the ones regarding the educational environment for mathematics in engineering education, didactics activities for the application of differential equations in the study and difficulty of liquids draining through holes. More recently, the group forged an international cooperation with Porto University—FEUP (Portugal) and some collaborative projects have already been carried out [20–22].

2.5 Cooperation with secondary education and basic education (Extension)

During the research carried out by the group, some projects, funded by federal government, were developed that integrated higher education with technical education. One of them aimed both to contribute to the training of students of a state technical school, and to increase students' interest in engineering and similar areas. Another action was the research project "The Robot and Mathematics: Problem-Based Learning Model (ABP)", also with support from the Federal Government, which aimed to provide conditions to reduce the evasion that occurs in the first years of engineering courses and to arouse the vocational interest of secondary education students in the profession of engineering and in scientific and technological research. Finally, we highlight the research project that seeks to analyse the impact of Operative Group Theory and the use of GeoGebra in the teaching of Analytical Geometry and the use of geometric solids for the teaching of spatial geometry [27].

2.6 International cooperation

Cooperation and exchange, both national and international, allows the students and lecturers to participate in internships, undergraduate, specialization, masters and doctoral degree courses, and advanced research in the area of interest. By these means it is possible to deepen specific knowledge in their field of studies, learn other working methods and participate in investigations, relating its output with the Brazilian reality in search of new ideas and solutions that may assist in improving lecturer training and the development of the country. The Pro-Lecturer program has a partnership with the University of Minho, based on completion of an interinstitutional master's degree that has already resulted in some publications [28, 29]. More partnerships were established with the Faculty of Engineering of the University of Porto [20–22], with the University of Santiago de Compostela and with the Czech Republic.

3. Proposal to create a post-graduation program

The proposal presents the creation of the Graduate Program in Teacher Training for Science, Technology, Engineering and Mathematics—Pro-Teaching in STEM—to which the Professional Master's Degree is linked to be offered at the UERGS Unit in Guaíba, where the course of Computer Engineering exists and the Research Group Seminar in STEM Education occurs. In view of its professional nature, it is intended that the program focuses on lecturer education to prioritize the classroom, its characteristic events concerning teaching and learning processes, as a research object for reflection and proposition of new methodologies. The proposal is that the Professional Masters is organized by the Structuring Seminar, and by a set of compulsory disciplines and another set of elective disciplines.

3.1 Previous work— the specialist course for STEM

In 2015, the research group designed, developed and had approved the commencement, in April 2016, of the first UERGS (State University of Rio Grande do Sul) Specialization Course aiming to attract professional people who graduated in engineering or other science subjects and mathematics who are either teachers or are interested in teaching. The course is named Specialization in Engineering Education, Science Related Subjects and Mathematics.

3.1.1 Course goals

The general goal of this course is to provide the necessary teaching information and knowledge to allow participants to integrate knowledge from their earlier studies graduate with the appropriate methodological, didactic and pedagogical basis. It aimed to train professionals to practice teaching and thus deal with trends in educational theories and methodologies alternatives to the existing traditional teaching; applications from different disciplines in the future profession of technical courses students; aspects related to the history of technology and technology; use of educational technologies.

3.1.2 Course structure and sub-areas

We tried to innovate in the design of the course to sustain it in four areas: (i) Historical Evolution of Science and Technology; (ii) Cognitive Theories; (iii) Didactic-pedagogical Strategies and Methodology; (iv) Technologies Applied to Technological Teaching. Rather than structuring differently, the idea was that the students would effectively feel encouraged and challenged to innovate in their

teaching practices or to take up teaching as their natural area of activity.

The course is in the closure phase and the students are developing their research addressing, among others, the following topics: mathematics and EAD integrative projects, use of simulation models in production engineering, teacher training in educational robotics, use of educational games to support learning, preparation for teaching in engineering, inclusion policies for students with special needs, use of information and communication technology in teaching of structural mechanics, methodology of active learning for engineering classrooms, didactic sequences for engineering labs, mapping of competences for the use of learning objects in mathematics and physics, among others.

3.1.3 Dissemination and demand for the course

Wide dissemination in the State of Rio Grande do Sul was made with the support of important entities such as the Brazilian Association of Engineering Education (Associação Brasileira de Educaçãoem Engenharia, ABENGE) and the Regional Engineering Council (Conselho Regional de Engenharia, CREA-RS). Electronic channels were also used for dissemination such as Facebook and the discussion lists of scientific communities such as the Brazilian Society of Mathematical Education (Sociedade Brasileira de Educação Matemática, SBEM).

The demand for the course was a surprise to the group due to the significant number of candidates—155 registered for 30 vacancies offered—allowing the selection of a special group of candidates with different training and professional backgrounds. The publication of articles [24, 25], the production of YouTube channel videos [26] for low-cost physics experiments, and the creation of an online experience blog are all examples of productions made in the course subjects.

3.1.4 Student feedback

As part of the quest to improve the course through adjustments in specific items and in the overall journey, so far, two surveys were carried out with the students; the tools were prepared via Google Docs. The intention was to collect contributions that could provide information for the lecturers of the course and for the management, aiming at what we call correction of micro-alterations, to maintain the course stability and, consequently, the engagement of all in the work of formation of a lecturer for Exact and Technological Sciences.

The first questionnaire, titled "Survey on specialization—2016/1", had a total participation of 22 students. Among the issues raised, one of them sought to know the degree of satisfaction of the student regarding the academic staff. It turned out that about 76% of the students said they were satisfied with the lecturers. Some reports demonstrate the engagement of the students in the course, some excerpts being as follows:

> "(...) the course has added a lot, contributed to my teaching practice and prompted the willingness to apply the new teaching and learning methodologies presented in class. I feel different ... I see myself wanting more and more. I'm giving myself to the course."
>
> "The impact of the teachers' initial presentation was very positive. The effort of all to be available at that time, proving to be accessible to the students, and demonstrating the interest they have in the course, was worth very much for the meaning of the moment. Something we are not accustomed to with the educational institutions in which we studied."

In the second questionnaire, "Satisfaction Survey on the Specialization Course in Engineering Education and Teaching of Science and Mathematics—2017/1", the questions sought to identify if the course and the reflections made by the disciplines supported the students in their teaching practices, as well as whether the skills gained were reflected in their work as lecturers. Some excerpts from the students are presented below:

> "I highlight: power of argumentation, construction of my identity as a researcher, use of technological tools and the adoption of education through problem situations. These skills are reflected in my teaching practice as I realize that they articulate in my mind while pursuing a meaningful education. They appear, currently, when I work with a project-based pedagogy, where students are authors and not viewers."
>
> "Due to the heterogeneity of the undergraduate courses and profiles of participants, a range of knowledge was made possible that during the graduation was not available, this due to the experience and work developed by each participant (students and teachers). Another point was the knowledge of so many authors, a reference in teaching methodologies, which certainly has made a great difference at times of lesson preparation."

These markings and full reports of the students show that the objective of the course has been achieved in the short time in which it was arranged, demonstrating that we are treading a certain and innovative way when the subject is lecturer training of subjects graduated in the area of Exact and Technological Sciences.

3.2 Course objective and alumni profile

The proposal is that the course will receive secondary education teachers of technical courses as well as of higher technology courses, education and bachelor degrees, in the areas of Exact and Technological Sciences, considering educational policies and aspects that place the demand for training: (i) significant changes in the curricular proposals that, by reason of occupational profiles outlined,

require new teaching and pedagogic techniques; (ii) expressive difference between the secondary education environment and the higher education environment, considering the purposes, approaches, objectives and working methods for learning, (iii) sciences advance and demand new visions about the dynamics of the classroom regarding the cognitive and subjective aspects. In addition, the following will also be needed: (i) the ABET criteria for engineering training. (ii) contemporary research in STEM Education; (iii) the curricular guidelines in which the National Education Council defines the desired training profiles for the fields that comprise the Exact and Technological Sciences area; (iv) the search for actions that improve the quality of the regional education; and (v) guidelines that aim to stimulate lecturers who work in the technological teaching classroom to seek constant improvement.

The relevance of the project is based on requirements that define new trends for academic training and for technical training prevalent in didactic work that supports the construction of mathematical and physical concepts, key for engineering and technological courses. The alumni are committed to the understanding and application of innovative methodologies in the classroom to: (i) develop interdisciplinary/multidisciplinary research that contributes to the teaching of engineering, science and mathematics, (ii) use educational tools associated with classroom methodology that promotes student learning, and (iii) prepare materials, learning aids, didactic sequences and other resources that will lead students to overcome inherent learning difficulties.

3.3 Research lines, area of concentration and disciplines

The area of concentration to which the course is connected is Science Teaching and Mathematics Education combined with Engineering Education. The actions in these fields are intended, in the first instance, to investigate which variables define the educational practices at various levels of education, to describe and to analyze how the learning processes occur to produce methodologies, didactic materials (digital or not), assessment and criteria that modify the classroom.

The research lines, concerning the aforementioned areas, to which the members of the GPEECE are affiliated, which structured the Specialization Course and which are proposed for the Professional Master's Degree, aligned with the training needs of the engineer for the 21st century [3], are two: (i) Digital Technologies in Teaching Practice—aiming to enable students to work with computerized technological resources and develop innovative educational materials (ii) Epistemologies and Methodologies in teaching practice—aiming at the study of theoretical concepts about access to knowledge as well as different learning methodologies, based on epistemology driven by active learning, already mentioned here in the categories of analysis.

Related to the research lines, four compulsory subjects are proposed: (i) Early Epistemological Notions, (ii) Teaching-Learning Methodology Trends, (iii) Fundamentals of Digital Technologies in Teacher Training and (iv) Practices, and Approaches to Learning and Technologies. The curriculum grid is completed with ten other elective disciplines. The set of disciplines was designed to provide teacher training that considers aspects of pedagogical, didactic and philosophical nature.

3.4 Structuring seminar—methodology of research-action

Discussions on lecturer training in mathematics and science have always been on the agenda. Among the various aspects concerning the training of lecturers in science and mathematics, of particular note are the guidelines for integration of the professional and academic formation of the lecturer through the research in mathematics education and science teaching. As scientific practices, discourses that constitute them form formal objects that can be referred to as mathematical and scientific speech. Ultimately, they relate to the psychology of mathematical thinking and the revolution of scientific thought structures. In addition to the training aspects related to scientific production itself, it is desirable and emphasized that lecturers should be trained so that they can be independent to have guaranteed the freedom to choose contents and methodologies, combining scientific competence to political commitment.

In a way, this concept about the professional formation that will carry out the teaching activity can and should include professionals graduated in engineering or technology courses who did not have the opportunity to reflect and study about educational subjects directly related to teaching and learning in the area of exact sciences in which they were qualified. In order to consolidate this lecturer training intended for staff trained in sciences, technologies, engineering and mathematics, conferring a sense of belonging to the program, a Structuring Seminar is established, already in progress, having been signed by the Science, Technology, Mathematics and Engineering (STEM) research group (GPEECE).

It is understood to be 'structuring' because it is the *alma mater*, to meet the demands to constitute a place—time and space for the affiliation of its members—as a permanent discourse that aims to

respond to the teaching and learning problems faced by its members.

The Structuring Seminar is the possibility to specify a discourse in which talk and action are not separated, a discourse that assumes that the word contradicts what is stated, a dialectical discourse of a group, and must provide an affiliation to these subjects. That is, the characteristic that is being conferred on the Structuring Seminar is that it is a place of possible diversities when hosting lecturers-supervisors and students of masters and undergraduate programs, interested in the constitution of a local community aiming to interrupt the cycle of existing traditional teaching.

The Structuring Seminar, understood as a Research-Action Group, provides a forum where subgroups developing specific projects can report and discuss their activities and have support from everyone in regards to planning, decisions and assessment of interventions The existence of the forum of debate that characterizes the methodology of research-action offers the possibility of imaginary and symbolic identification of the participants with a group; it is through such identification that individuals become subjects. In this sense, in the form that is presented today, it has a page to publicize its activities [1]. It is hoped that scientific production and material production will be produced in these subgroups and published or presented at conferences, including international ones. In conformation with the theoretical aspects underpinning the research-action modality, the members of the subgroups are considered lecturers-researchers.

4. Conclusions

It is believed that a great deal can be contributed to the Post-Graduate Program in STEM when a program is proposed that effectively addresses a professional portion where little or almost nothing is achieved by traditional programs. Rather than being in line with the contemporary demands for training in STEM, this proposal intends to discuss the use of technology, establish a critical view on the pedagogical processes and their implications in courses of a technical nature, to intensify interactionist and active epistemologies.

Previous experience in the specialization course has brought excellent prospects to the future program in Brazil, since the works that are being finalized by the students are being evaluated as a very good level. In addition, the testimonials of the students show the importance and relevance of a proposal such as this. The main difference between the programme designed and the Specialist course is the academic level. The theoretical depth is greater in the new program, especially because it is a master's degree. In contrast to other programmes in the area, the great differential is focused on classroom teaching experiences.

It is believed, finally, that future initiatives can and should be considered in this area, since the case study presented here is an example of how such proposals can be structured and systematized.

References

1. Science, Technology, Mathematics and Engineering (STEM) research group—Grupo de Pesquisa para Educação em Engenharia e em Ciências Exatas—GPEECE, http://www.gpeece. mat.br Accessed 13 November 2016.
2. G. W. Ellis and Y. Zhang, The Development of 21st Century Skills in the Knowledge Building Environment. *International Journal of Engineering Education*, **32**(3A), 2016, pp. 1160–1170.
3. A. Rugarcia, R. M. Felder, D. R. Woods and J. E. Stice, The future of Engineering Education I. A vision for a new century, *Chemical Engineering Education*, **34**(1), 2000, pp. 16–25.
4. M. Besterfield-Sacre, M. F. Cox, M. Borrego, K. Beddoes and J. Zhu, Changing Engineering Education: Views of U.S. Faculty, Chairs, and Deans, *Journal of Engineering Education*, **103**(2), 2014, pp. 193–219.
5. A. Johri and B. M. Olds, The Cambridge Handbook of Engineering Education Research and Reflections on the Future of the Field, *Journal of Engineering Education*, **103**(3), 2014, pp. 363–368.
6. R. M Felder and R. Brent, *R. Teaching and Learning STEM—a practical guide*. Jossey-Bass, San Francisco, 2016.
7. M. Prince, Does Active Learning Work? A review of the Research, *Journal of Engineering Education*, **93**(3), 2004, pp. 223–231.
8. L. Salas-Morera, M. A. Cejas-Molina, J. L. Olivares-Olmedilla, M. S. Climent-Bellido and L. Garcia-Hernandez, Preparing Students for Success in Engineering Degrees: A Combined Strategy Between High School and University, *International Journal of Engineering Education*, **32**(2A), 2016, pp. 712–725.
9. M. Borrego, M. L. Foster and J. E. Froyd, What Is the State of the Art of Systematic Review in Engineering Education? *Journal of Engineering Education*, **104**(2), 2015, pp. 212–242
10. G. K. Wilkins, B. L. Berstein and J. M. Bekki, Measuring Communication Skills: The STEM Interpersonal Communication Skills Assessment Battery, *Journal of Engineering Education*, **104**(4), 2015, pp. 433–453.
11. S. R. Daly, E. A. Mosyjowski and C. M. Seifert, What is the State of the Art of Systematic Review in Engineering Education? *Journal of Engineering Education*, **103**(2), 2014, pp. 417–449
12. R. M. Felder and R. Brent, Designing and Teaching Courses to Satisfy the ABET Engineering Criteria, *Journal of Engineering Education*, **92**(1), 2003, pp. 7–25.
13. D. López, A. Perez-Poch, A. Adam and M. J. Delgado, Diseño del posgrado STEM de formación del profesorado ICE-UPC baseado en competencias, *CIDIU's Journal*, (3) (2016), 2016.
14. Enrolment in Technical Courses HasIncreased 5.4% (Matrículas em cursos tecnológicos aumentam 5,4%.) http://www.brasil.gov.br/educacao/2014/09/matriculas-em-cursos-tecnologicos-aumentam-5-4, Accessed 3 April 2016.
15. Enrolment in Secondary Education Technical Courses Has Increased 88% in the last 6 years in Brazil (Matrículasem-cursostécnicos de nívelmédiocrescem 88% no Brasilemseisanos), http://www.portaldaindustria.com.br/cni/imprensa/2015/07/1,67494/matriculas-em-cursos-tecnicos-de-nivel-medio- crescem-88-no-brasil-em-seis-anos.html, Accessed 14 March 2016.
16. PNPG—Post Graduation National Plan 2011/2020. (Plano

Nacional de Pós-Graduação 2011/2020), http://www.capes.gov.br/images/stories/download/Livros-PNPG-Volume-I-Mont.pdf, Accessed 13 may 2016.
17. R. R. Baldino and T. B. C. Cabral, Profitability of qualified-labour-power production, *Journal for Critical Education Policy Studies*, **13**(2), 2015, p. 67.
18. T. B. C. Cabral, Alternative Methodologies and its Difficulties: Teaching Mathematics to People Specialized in Engineering. Mathematical Education Perspectives—Metodologias Alternativas e suas Vicissitudes: ensino de matemática para engenharias, *Perspectivas da Educação Matemática*, **8**, 2015, pp. 208–245.
19. R. R. Baldino and T. B. C. Cabral, The Productivity of students schoolwork: an exercise in Marxist rigour, *Journal for Critical Education Policy Studies*, **11**, 2013, pp. 70–84.
20. D. Urbano, L. Andreatta-da-Costa, J. C. Marques, F. Chouzal and T. Restivo, Experimental Training in Engineering. In: *Global Engineering Education Conference—EDUCON 2016*, 2016, Abu Dhabi. EDUCON 2016, 2016.
21. L. Andreatta-da-Costa, D. Urbano and T. Restivo, Haptic Interaction with Virtual Interface to Learn Strength of Materials. In: *Global Engineering Education Conference—EDUCON 2017*, 2017, Athene.
22. L. Andreatta-da-Costa, Using Learning Objects to Teach Structural Engineering, *International Journal of Online Engineering (IJOE)*, **12**, 2016, pp. 14–16.
23. L. Andreatta-da-Costa and T. Restivo, VR Stress Test, https://remotelab.fe.up.pt/vr_exp/vr_stress_test.php, Accessed 15 March 2017.
24. E. Fehlberg, G. Vargas and L. Andreatta-da-Costa, The Use of Virtual Laboratories to Teach Chemistry to Young People and Adults—"New Technologies in Education" magazine / A utilização de laboratóriosvirtuais no ensino de Química para a educação de jovens e adultos. *RENOTE. Revista Novas Tecnologias na Educação*, **14**, 2016, pp. 1–10
25. C. D. Zanrosso, D. S. Lima, T. C. Machado, V. M. Souza and L. Andreatta-da-Costa, Operation "Coffee Making": a Pedagogic Perspective for Teaching Chemical Engineering" / Operação Café Passado; uma perspectiva didático-pedagógica para o ensino em Engenharia Química, *Química Nova*, **40**(8), 2017, pp. 957–962.
26. Specialization in Engineering Education -/Especialização em Educação em Engenharia, https://www.youtube.com/channel/UCyrOa5ZPFfAuQJ78sRDNKBQ, Accessed 14 April.2017.
27. T. B. C. Cabral, L. Andreatta-da-Costa and A. Blauth, Learning Spatial and Analytic Geometry Using Geomectric Solids and Educational Sotwares: Contributions to the Theory of of Operative Groups—National Seminar for Mathematical Education /Aprendizagem em Geometria Espacial e Geometria Analítica com o uso de Sólidos Geométricos e Softwares Educativos: contribuições da Teoria dos Grupos Operativos. Encontro Nacional de Educação Matemática. São Paulo: SBEM, 2016.
28. R. M. Santos, L. Andreatta-da-Costa and M. A. S. Ramos, The Use of ICT (Information and Communication Technologies) in a Classroom located in the city of Sao Francisco de Paula, State of Rio Grande do Sul, Brazil / A realidade do uso das TIC's na sala de aula em uma escola de São Francisco de Paula, Rio Grande do Sul, Brasil. *RENOTE. Revista Novas Tecnologias na Educação*, **14**, 2016, pp. 1–10.
29. G. Falavigna and B. D. Silva (Org.). Educational Subjects: Technology, SustainabilityTeaching and Resources/Temas Educacionais: Tecnologias, Sustentabilidade, Docência e Recursos. 1. ed. Porto Alegre: Edipucrs, 2016, **1**, p. 116
30. L. Andreatta-da-Costa and J. A. Nitzke, Engieneering Education: Theoretic*al Basis and pedagogical Possibilities / Educação em Engenharia: Fundamentos Teóricos e Possibilidades Didático-Pedagógicas.*Editora da UFRGS, Porto Alegre, 2012. 250p .

Luciano Andreatta Carvalho da Costa—Civil Engineering degree (1994), Mathematics Bachelor's degree (1999), Civil Engineering master degree (2000) and doctorate in engineering (2004), all of them from Federal University of Rio Grande do Sul. Review of the Brazilian Journal for Engineering Education and Science and Engineering Journal. Advisor of masters and doctorate in the Program of Post-Graduation in Education in Sciences of UFRGS and of masters in the Program of Post-Graduation in Education of UERGS. Has experience in STEM Education, acting on the following subjects: Constructivism approaches on education, online learning, structural engineering education, Remote Labs and haptic interaction with virtual reality.

Tânia Cristina Baptista Cabral—Bachelor's degree in Mathematics from Federal University of Rio de Janeiro (1984), master's degree in Education from Universidade Estadual Paulista Júlio de Mesquita Filho (1992) and doctorate in Education from University of São Paulo (1998). Has experience in Mathematics Education, acting on the following subjects: Mathematics education and psychoanalysis, teaching and learning calculus in STEM, teaching and learning mathematics, discourse and classroom methodology and psychology of mathematical thinking. Review of International Journal of Science and Mathematics Education and Annual Conference in Psychology of Mathematics Education.

Fabrícia Damando Santos—Has a degree in Computer Science from the Pontifical Catholic University of Goiás (1998), specialization in Media in Education by the Federal University of Rio Grande do Sul (2010), master's in Electrical and Computer Engineering by Federal University of Goiás (2003) and PhD In Computer Science in Education by the Federal University of Rio Grande do Sul (2016). Currently from Rio Grande do Sul State University, Federal University of Rio Grande do Sul and Review of the Journal of Competence—Journal of Higher Education at Senac-RS. Has experience in the area of Computer Science, with emphasis on Methodology and Computer Techniques. Focused, mainly, in the subjects: Educational Data Mining, Affective Computing, Virtual Environments of Teaching and Learning, Systems of Recommendation.