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Evaluation of Teacher Training Needs in Engineering Pedagogy

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Abstract. In European countries, primarily in German-speaking countries, first of all, in Germany (Dresden), the concept of engineering pedagogy (EP) has existed for more than 70 years. In Eastern Europe, particularly in the Russian Federation, the tradition of EP has more than 20 years and shows an extensive network of universities actively participating in IGIP (International Society of Engineering Pedagogy). Several universities offer the IGIP curricula and work on various projects related to majoring in engineering education and pedagogy in Russian Higher Education Institutions. In Spanish-speaking countries the concept of EP is relatively recent. Particularly, since 2014, the Technical University of Dresden (TU Dresden) works in cooperation with Chilean universities to strengthen engineering pedagogy and education in the university context. This goal was concretized through two cooperation projects "Engineering Didactics at Chilean Universities" (PEDING-Project) and "Strengthening engineering training at Chilean universities through practice partner-ships" (STING-Project), both financially supported by DAAD. The main goal of this paper is to present the results of a survey about teaching needs in engineering pedagogy in a Chilean university. In general, the results showed the high level of interest and motivation that a training course on engineering pedagogy specifically oriented for the academic staff of engineering faculties may have. The project was led by the International Center of Engineering Education (CIEI) at the University of Talca (Chile) under the pedagogical support of the TU Dresden (Germany).

Keywords: engineering education, engineering pedagogy, teacher training in Chile, International Society of Engineering Pedagogy

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1. Teacher training in Chilean university context

The pedagogical competences of the academic staff are undoubtedly a key factor in the success of the professional training of students of universities and vocational schools. However, despite the dual profile of the professional work of university teachers (teacher and researcher), aspects of teachers' research competencies are generally emphasized over the pedagogical profile [1–3]. To compensate this situation, the universities and vocational schools design a series of training programs and courses for their academic staff, that seek to strengthen the pedagogical competencies regarding the design and evaluation of teaching-learning processes, the implementation of various active methodological strategies and the generation of "new" teaching resources, among others [4–6]. Pérez Rodríguez [7] characterizes the situation of teacher training programs in Spanish universities, noting that most of the programs consist of general courses, which are principally aimed at promoting the pedagogical competences, as well as the analysis and reflection of the teaching task itself. The author elaborates on this idea in the conclusions of her research, where she emphasizes that the majority of university teachers receive "training that is little linked to their practice and disconnected from their classroom experiences".

In Chile the situation is very similar. In the university context, there is not yet a complete scientific review of all the training programs for university technical teachers. There is public information disseminated by institutions that accounts for pedagogical training programs oriented to all disciplines. For example, the University of Chile offers the following teacher-training program, which characterizes the typical training program for the academic staff in the contemporary Chilean university context [8]:

1. Higher education: contexts and challenges. The main goal is to analyze the current and future characteristics and challenges of higher education in Chile, Latin America and the world.

2. SoLT (Scholarship of Learning and Teaching). The main goal is to identify the implications of the SoLT model in the development, research and innovation in higher education.

3. Teaching for high quality teaching-learning in higher education. The main goal is to establish the implications and scope of high quality and effective teaching and learning, based on empirical evidence, in the context of higher education and the challenges of the society.

4. Innovation, active learning and ICT's. The main goal is to implement active methodologies within the classroom, considering current teaching trends, especially from the disciplines themselves.

5. Learning committed to the environment and the community. The main goal is to design teaching processes linked to the community and the environment which are related to the disciplinary learning and the corresponding graduation profile.

6. Classroom management in contexts of diversity. The main goal is to implement actions, within the classroom, that consider heterogeneity and inclusion capable of committing to the learning of each and every student.

7. Education with a focus on gender and sexual diversity. The main goal is to generate a holistically and comprehensively understand of the teaching and learning processes from the perspective of gender and diversity.

8. Evaluation of learning outcomes in higher education. The main goal is to produce assessment instruments and situations in order to collect evidence of student learning outcomes in higher education.

In general, the training courses are characterized by an educational sciences perspective, accompanied by contents related to the

demands of Chilean society in the 21st century (democracy and tolerance, gender perspectives, and use of learning technologies among others). However, the question remains about the degree of effectiveness of this kind of courses for the teacher training and its real "closeness" with the disciplinary reality of the different modules at students training programs (engineering sciences for instances).

The University of Talca offers a training program for the academic staff of all faculties called "Pedagogical training program based on the competency model". The program consists of the following four modules:

1. Determination of new demands and needs for professional training. The main goal is to strengthen the capacities to establish relationships between social and technological changes and exercise the academic professions and professional teaching practices.

2. Achieving significant learning. The goal is to strengthen the ability to design significant learning situations according to the logic of competency-based education.

3. Assessment, evaluation, and decision making. The goal is to strengthen the ability to assess the progress and learning of the students, in a coherent and valid way to the competency-based teaching framework.

4. Designing a syllabus. The main goal is to design a competency-based module program (syllabus) according to the requirements of each study plan based on the institutional format.

In comparison with the program of the University of Chile, the program from Talca is more "general" and strong oriented to didactical design (planning) and assessment. The training program is also based on the constructivist theory of the active learning process but specifically presents the conception of "competency-based" training.

Another case is a program offered by INACAP[1], a Chilean university of applied sciences and vocational school (post-secondary education) with more than 27 campuses in different regions of Chile. INACAP offers a program called "Diploma on Teaching in Higher Education". The program consists of the following modules:

1. Teaching in the Context of Higher Education in 21st Century. The main goal is to ponder on required teaching competencies to face the paradigm change caused by competence training.

2. Neuroeducation. The main goal is to establish a dialogue between neuroscience and its contribution to education in order to improve proposals and learning experiences.

3. Innovation. The main goal is to bring the teacher closer to an innovation process that mainly describes networking through INACAP ecosystem to promote innovation and entrepreneurship.

4. General Didactics. The main goal is to bring teachers closer to new teaching-learning processes and procedures linked to the competency-based approach and use of technologies.

5. Learning Evaluation. The main goal is to provide assessment tools necessary to improve student learning with a competency-based approach.

6. Teaching Learning Planning. The main goal is to provide teachers with the curricular knowledge needed to improve their students learning within a competency-based approach.

7. B- and E-learning teaching. The main goal is to offer theoretical elements necessary for blended and online teaching.

In the case of INACAP, it is interesting that the modules for the academic staff are strongly oriented towards university teaching (but without specialization in a scientific field), and also incorporate elements of neuroscience and the use of educational technologies and new resources for online learning.

[1] INACAP is an Integrated System of Higher Education, constituted by the INACAP Technological University of Chile, the INACAP Professional Institute and the INACAP Technical Training Center, which share a common Mission and Institutional Values. URL: https://www.learnchile.cl/en/instituciones/universidad-tecnologica-de-chile-inacap/ (accessed 19.07.2021).

2. Engineering pedagogy in university context

In European countries, primarily in German-speaking countries, particularly in Germany (Dresden), the concept of Engineering pedagogy (EP) has existed for more than 70 years [9]. In Eastern Europe, particularly in the Russian Federation, the tradition of EP is much younger, however there is an extensive network of universities actively participating in the International Society of Engineering Pedagogy – (IGIP). Several universities offer the IGIP curricula and work on various projects related to majoring in engineering education and pedagogy [10–12]. In Spanish-speaking countries, the reality is very different and the concept of EP is relatively recent.

The research project on implementing Engineering Pedagogy at Chilean Universities (PEDING 2014–2018) caused a scientific discussion on the EP concept and established clear guidelines and concrete activities for its installation and development at the Chilean university context [13]. The project tried to improve the quality of engineering education through the participation of the engineering teaching staff in a needs-based continuing education training program. The course presented a specific orientation to engineering education and was aimed at teaching staff of faculties of engineering, with modules built and structured specifically for engineers and included relevant examples for this group [14]. The training course consisted of six modules according to the curriculum of the training program "International Engineering Educator ING.PAED.IGIP" of the IGIP center at the TU Dresden, Faculty of Education. The course consisted of the following modules each of 1,5 SCT-Chile (ECTS) [14]:

1) Teaching and Learning Process Design in Engineering Education (EE),
2) Communication – Design of communicative processes in Teaching and Learning,
3) Didactic Media in EE,
4) Control and Evaluation of the Learning Results in EE,
5) Laboratory Didactics in EE,
6) Project-Based Learning (PBL) in EE.

As far as the participants of this training course were from different Chilean universities in different Chilean cities, the face-to-face sessions were carried out via video streaming (REUNA-ZOOM). Autonomous and collaborative work was promoted through the use of technological tools in the course platform (Moodle). The evaluation was primarily formative and the lecturer of each module requested a final product that allowed to demonstrate the developed competences of each participant [14].

The aim of the second Project on Engineering Pedagogy of the authors was called "Strengthening engineering training at Chilean universities through practice partnerships" (STING-Project). The main goal of the project was the development and testing of training modules for students (either for electrical or mechanical engineers) and teaching qualifications of teaching staff in academic Engineering Education based on employment requirements of German and Chilean companies. For this reason, a questionnaire was developed as part of a stage of information gathering to obtain the strategic positioning and future development of the participant enterprises. The strategic staff (experts) of seven companies answered to the question "What are the most important competences for engineers?" The results showed many different competences like "leadership", "team working" and "autonomy" as the most valuable skills for companies. Another question was oriented to the importance of innovation and research. The companies were asked also, "How relevant is for you that engineering students have experience in innovation and research project through their university time?" The tendency to appreciate the experience of students in innovation and research projects was noticeable. In relation to needs for technical software for electrical and mechanical engineers, the most popular option was Microsoft Office (which includes Excel, Power-Point, Word, and Outlook) and also skills in using AutoCAD among others [15].

3. A needs analysis on engineering pedagogy

3.1. Methodology

The main goal of the research was to identify the opinion of the academic staff of an engineering faculty on the training course. The participants had to specify their particular needs on EP. In general, the instruments and indicators seek to obtain information about: (i) the characteristics of lecturers (gender, subject matter, fields of teaching experience, previously teacher training, etc.), (ii) the needs related to engineering didactic fundamentals, (iii) the requirements for structuring teaching-learning forms in a university context, (iv) needs for the development of teaching-learning strategies in engineering, (v) demands of setting the objectives and contents of engineering programs, and (vi) identification of strengths and weaknesses of their currently teaching practice.

Based on their previous experience in engineering pedagogy research projects implementation in Germany and Chile, the authors developed categories and indicators, which later were used in the data collection instrument about the teaching needs of the engineering school. Specifically, the instrument dimensions seek to obtain information about [13, 14]:

1) characteristics of lecturers (gender, years of experience, subject matter, etc.),

2) needs about the "Design of teaching-learning processes in engineering sciences" (psychological bases of teaching and learning; theoretical/practical bases of engineering didactics; structuring of the teaching-learning processes in engineering education –EE-; and didactic principles in EE),

3) needs about the design of "Didactic media for teaching in engineering" (concepts and classification of didactics media in EE; functions of didactic media and technological tools; and elaboration of didactic media in EE),

4) needs about "Communication processes in EE" (design of communication processes; and conflict identification and resolution),

5) needs about the "Design and implementation of different teaching forms in EE" (preparation of lectures; problem- and project-based learning),

6) needs about "Laboratory activities, practical training and self-study" (laboratory training; experiment functions in the teaching-learning processes; and exercises and self-study planning).

7) needs about "Design and implementation of engineering internships, written reports, and research colloquium" (engineering internship preparation and research preparation; support systems for internships and for autonomous research).

3.2. Research design and instrument

The survey was designed using a mixed model of qualitative and quantitative methods. Through a concurrent triangulation strategy, Creswell [16] states that quantitative and qualitative data can be collected simultaneously. The aim is to use two different survey methods to confirm, supplement, or validate the research results. The main goal of the design was to integrate the opinions of the participants (academic staff) with the assessment of engineering-pedagogical needs that are most required for the teaching-learning process of engineers. Due to the location of the participants (Chile), the questionnaire was developed in Spanish and consisted of 28 items on a 5-point Likert Scale (5 levels) according to the instrument dimensions (see above). The questionnaire was applied online, ensuring the absolute anonymity of the participants. The first part collected general information of the participants (gender, subject matter, fields and years of teaching experience, previous teacher training, etc.). The second and third parts correspond to the information collection of the closed questions. The statistical analysis applied was exploratory-descriptive to raise problems [17]. The fourth part consists of open questions. These open questions were analyzed through textual analysis by codifying the discourse of each participant, based on the item generating conceptual categories. The instrument considers ethical aspects according to the Chilean social sciences research criteria.

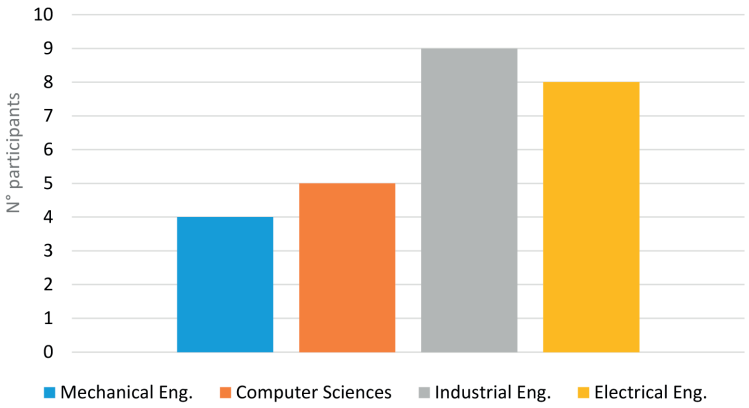

Fig. 1. Participant's distribution by engineering school at INACAP campus Talca

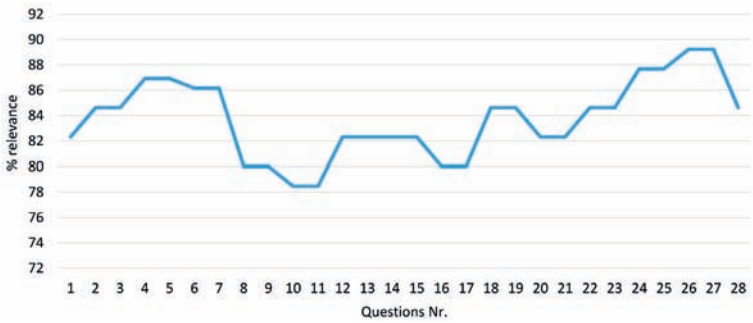

Fig. 2. Relevance of different aspects of the needs in engineering pedagogy

3.3. Population and available sample

The sample of the study was composed by 32 academics of four Engineering Schools of INACAP campus Talca: Industrial Engineering, Mechanical Engineering, Electrical Engineering, and Information and Computer Engineering. Only 26 questionnaires were considered for the analysis because they were fully completed. The selected sample was approximately 20% of the total number of academics attached to each Engineering School at INACAP. In total, 26 academics were gathered with 35% women (9) and 65% men (17). Of the total respondents, 92% were engineers by profession (24), the rest had similar professions that help to complement the total training of the future engineers. Regarding the age ranges of the respondents, 73% (19) of the survey participants are between 30–39 years old, 15.4% (4) are between 40–49, and 11.5% (3) are over 50 years old.

Concerning the years of teaching experience, over 54% of the respondents are between 1–5 years (14) and 30% are between 6–10 years (8). Of the total number of participants, approximately 70% (18) have already participated in university teaching trainings. *Figure 1* presents the participant's distribution by engineering school at INACAP campus Talca.

3.4. Results of INACAP's survey.

Closed questions. The results about the respondents' perception regarding the need for different skills and pedagogical tools for university teaching in engineering careers are presented in this section. It was asked, "How necessary do you consider the following aspects of engineering pedagogy concerning your teaching experience?" For this section, 28 aspects were considered based on the indicators of the *Table 3*.

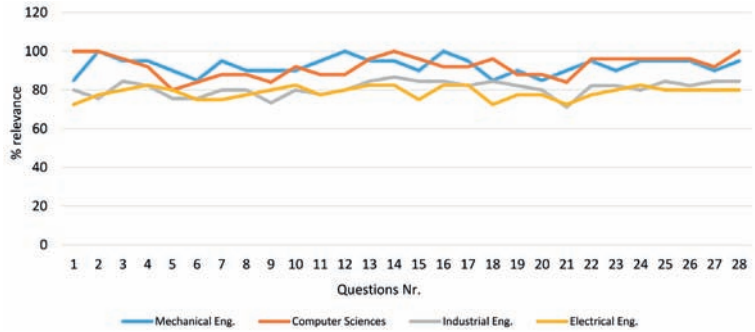

Fig. 3. Relevance of different aspects of the needs in engineering pedagogy by school

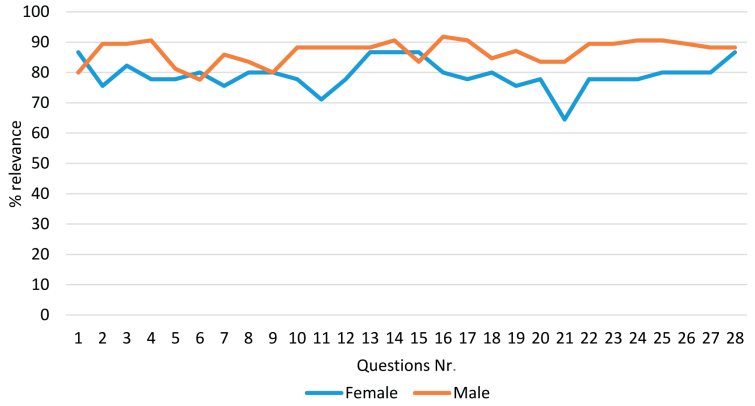

Fig. 4. Relevance of different aspects of the needs in engineering pedagogy by gender

The relevance of the different aspects of the needs in engineering pedagogy is presented in *Figure 2*. All aspects were considered relevant for more than 75% of the participants. The most relevant aspects are related to evaluation methods, among which the following aspects stand out with more than 86% of the preferences "Evaluation and assessment of achieved learning" and "Knowledge about design for effective measurement of achieved learning", followed by aspects with more than 82% of the preferences: "Use and development of new didactic means in the training of engineers", "Structuring of teaching-learning processes in the scientific training of engineers", and "Use of didactic resources and information and communication technologies (ICTs)", for instance: "Knowledge about procedures of collection and measurement of achieved learning", and "Support elements such as projector, blackboard, materials, etc.".

Regarding to the results obtained in the 11 questions about strengthening of teaching methods (see *Figure 3*), the respondents considered all aspects with relevance over 70%. Among the aspects considered, the most relevant of them are: "Design, choice and use of didactic means", "Use and development of new didactic means in the training of engineers", and "Planning and structuring of teaching-learning processes at the university level", all of them with more than 75% of the preferences by engineering schools. The aspects with the lowest relevance were: "Curriculum development for academic training at the university level", "Planning and materialization of evaluation and evaluative processes", "Resolution of specific problems on the design of instruments for the assessment of teaching-learning processes", and "Realization of communicative processes for teaching at the university level".

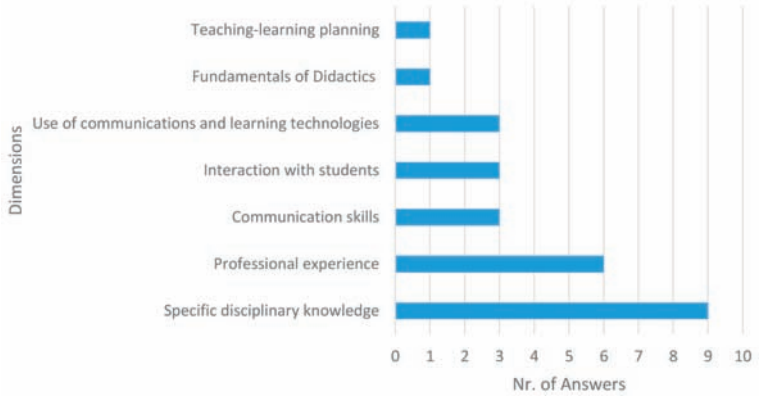

Fig. 5. Professional strengths in engineering pedagogy

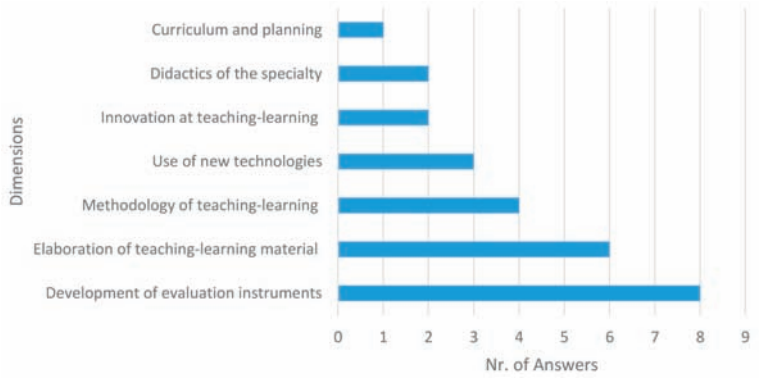

Fig. 6. Professional weaknesses in engineering pedagogy (to be improved)

By grouping the participants by gender (*Figure 4*), the female participants (9) have more than 86% of preferences on aspects related to "Evaluation" and "Teaching and learning structuring", for instance: "Evaluation and assessment of achieved learning" and "Planning and materialization of evaluation and evaluative processes", but also "Structuring of teaching-learning processes in the scientific training of engineers". The worst evaluated aspects by the female gender correspond to "Knowledge about the design of didactic means for the teaching-learning processes" and "Dialogic and monological communicative processes for teaching", with 70% and 65% of preferences respectively.

In the case of men (17), the most of the aspects were considered with a relevance over 85%. Such aspects as "Use of didactic resources and information and communication technologies (ICTs)", "Development of didactics media in EE", "Recognition and resolution of conflicts within the classroom", "Planning of activities for individual study" have preferences of 90%. Other high valued aspects (over 86%) are "Evaluation and assessment of learning achieved" and "Knowledge about the design for effective measurement of learning achieved". For males the worst evaluated aspects correspond to "Psychological foundations for teaching and learning" and "Knowledge about strategies to support professional practices and independent research activities" with 80% and 78% of preferences respectively.

Open questions. This part of the survey presents the answers of the participants regarding four aspects: (1) strengths in engineering pedagogy; (2) aspects to be improved in the teaching task; and (3) the interest and availability to train in the engineering pedagogy area.

The answers for the aspects 1 and 2 are presented in *Figures 5* and *6* respectively.

Regarding the interest to take part in a teacher training course, all the participants are interested in a training course of this type, but 86% of participants will participate in a "more oriented" or "specific oriented" training course for engineering educators. The design of a specific teacher training course should consider applicable knowledge, dictated by a specialist with expertise on teaching and learning in engineering, promote the design evaluation of engineering education, with innovative methodologies and tools focused on students of the 21st century, among others.

4. Conclusions

This research project was aimed at showing the pedagogical and didactic needs and new possibilities for raising qualification of the academic staff who teach in engineering schools of a big Chilean educational institution like INACAP, which works at university and vocational school (post-secondary) level. Based on the knowledge and experiences in the field of engineering pedagogy of the TU Dresden and the University of Talca, various aspects and differences between generic training programs for university teachers and training programs focused on engineering pedagogy were presented.

From the results of the research, it is possible to conclude that a training course on EP specifically designed for the academic staff of engineering faculties has a high level of interest and motivation. The academic staff of INACAP sees the need for continuous learning to improve their teaching strategies and methods taking into account the demands of students and society of the 21st century as a whole but from a specific view of the engineering educational context. For those reasons, the academic staff of the International Center of Engineering Education at the University of Talca has designed a teacher training course specifically based on the detected needs. At the time of this publication, the course is still in the implementation process. We hope that its results will serve as a basis for the continued promotion of the academic training in engineering pedagogy in Chilean universities and vocational schools.

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Оценка потребностей преподавателей в подготовке курса по инженерной педагогике

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Аннотация. *В европейских странах, прежде всего – немецкоязычных странах, особенно в Германии (Дрездене), концепция инженерной педагогики существует уже более 70 лет. В Восточной Европе, особенно в Российской Федерации, традиция инженерной педагогики насчитывает более 20 лет. За это время создана обширная сеть университетов, активно участвующих в IGIP – Международном обществе по инженерной педагогике. Ряд университетов предлагают учебные программы IGIP и работают над различными проектами, связанными со специализацией в области инженерного образования и инженерной педагогики. В испаноязычных странах концепция инженерной педагогики появилась сравнительно недавно. Так, с 2014 г. Технический университет Дрездена сотрудничает с чилийскими университетами в плане развития инженерной педагогики и инженерного образования. Цель сотрудничества – реализация двух проектов: "Инженерная дидактика в чилийских университетах" (PEDING) и "Совершенствование инженерной подготовки в чилийских университетах с помощью практических партнёрских стипендий" (STING); оба проекта получили финансовую поддержку со стороны DAAD. Цель статьи – представить результаты исследования потребностей в преподавании инженерной педагогики в одном из чилийских университетов. В целом можно констатировать высокий уровень заинтересованности и мотивации преподавателей в отношении учебного курса по инженерной педагогике, специально ориентированного на преподавательский состав инженерных факультетов. Проект осуществлялся под руководством Международного центра инженерного образования (CIEI) при Университете Талька (Чили) при педагогической поддержке Технического университета Дрездена (Германия).*

Ключевые слова: *инженерное образование, инженерная педагогика, подготовка преподавателей, Международное общество по инженерной педагогике IGIP, Университет Талька, Технический университет Дрездена*

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