

How do mechanical engineering students see their training and learning at university? Findings from a case study

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ABSTRACT: This article draws upon research aimed at investigating teaching and learning in higher education within the so-called Bologna Process. The author discusses the ways in which students acquire engineering education and analyses the implications of redesigning initial training and rethinking teachers' role. Data were gathered through interviews and questionnaires. A questionnaire was designed including both closed and open-ended questions. Four levels of information were included: biographic data (gender, age, initial training, current job position, etc), academic education (reasons for choosing mechanical engineering, reasons for selecting the University of Minho, expectations about the mechanical engineering course, etc), transition from the university to the labour market (difficulties faced, scope and nature of the work, etc) and graduate and post-graduate interests (areas, type and organisation for high level courses, specific courses). Background characteristics, such as years of experience, academic years of experience at the current job were also included. Overall, findings suggest a positive evaluation of initial training, namely, the ways students adapted to the University, relationships between students and the length of their practicum. They also highlighted a number of issues to be improved: a more hands-on approach and a better pedagogical intervention from lecturers.

Keywords: Mechanical engineering education, Bologna declaration, higher education

INTRODUCTION

Understanding the ways in which higher education students live and assess their learning experiences is a key issue in improving the education and development opportunities provided to them, especially in times of change and challenge. Engineering programmes were restructured according to the Bologna Process in Europe [1-4]. Issues related to new modules, new curriculum structure, active learning, student independent work and cooperative learning (as is the case of Project-led education) became key features in this process. Along with this is the discussion of what should be done in terms of teaching and learning, assessment, development of competencies/skills (technical and soft) within the view of lifelong learning in the context of higher education. Thus, an educational paradigm shift is under debate. Traditional teaching and learning at higher education institutions is mostly an outcome-led process, in which key technical competencies are to be acquired and assessed, usually through final examinations. The need to think about higher education teaching and learning from a different perspective is recognised. This implies a different role for both the student and the teacher.

The reasons behind the shift from traditional to more student-centred education in higher education may be associated with a range of reasons, namely, focus on learning rather than on teaching, articulation with professional practice, enhancing critical thinking, better understanding of the subject matter, development of cross-disciplinary competencies, team work, research and communication skills, conflict management, project management, and autonomous and creative work, etc [5][6]. The idea of self-regulated learning also becomes a key issue in a more student-centred process, which is *an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behaviour, guided and constrained by their goals and the contextual features in the environment* [7]. Learning is then seen as a multidimensional process, which embodies personal aspects (both cognitive and emotional), and behavioural and contextual ones [8]. Therefore, learning is a dynamic and open process, which requires students to engage in a wide array of tasks and activities which imply, in turn, careful planning, decision-making and self-reflection.

These are some of the thoughts and ideas that have inspired the author to undertake the present study in order to explore mechanical engineering students' views on their training course at the University of Minho in the context of a deep and complex process of restructuring under the so-called Bologna Declaration [3]. One of the main objectives of the Portuguese law document (Decree-Law no 74/2006, 24/3) is *to assure the qualifications of the Portuguese people,*

applying the Bologna Process, a unique opportunity to enhance people with higher education, to improve quality and relevance of education offer, to promote the mobility of our students and graduates and the internationalisation of our education offer. This requires the need to reform the Portuguese higher education system according to the new learning-teaching paradigm, in order to comply with one of the aims of the Bologna Process, which is the construction of a European Area of Higher Education.

It is within this context that this study was carried out. Thus, the present research deals with initial training of mechanical engineers, in times of change of the educational paradigm within the context of the Bologna Process. It is a study of the conceptions and experiences of mechanical engineers in regard to their initial training, the transition to the labour market and their perspectives on further training and professional development opportunities. It is a descriptive study following a mainly quantitative methodology, although at the beginning a qualitative approach was used. One hundred and sixty-two mechanical engineers were involved in the study which included, in the first phase, an exploratory interview, which constituted the basis for the construction of the questionnaire used in the second phase of data collection. The process of qualitative data analysis was carried out according to a comparative and horizontal analysis. The quantitative data were analysed statistically with the use of commercial software SPSS.

THE BOLOGNA DECLARATION IN SHORT

Over the last few years, a number of works have been dedicated to the issue of the Bologna Declaration, namely, Hedberg [1], Heitmann [2], Teixeira et al [3], Augusti [9] and Grünwald et al [10], to mention just a few. In 1999, the ministers of education of 29 countries and university leaders from the whole of Europe met to discuss the future development of higher education in Europe. The post-summit declaration issued by the ministers - the Bologna Declaration, as it is known - expressed the goal of developing a European Higher Education Area by 2010. This development process is known as the Bologna Process [11]. Two years after the Bologna Conference, the ministers met in Prague and, then, again in Berlin in 2003, and more recently in Bergen in 2005. The number of member countries increased to 40. In fact, the ministers have decided to meet every two years to reconfirm the Bologna Declaration goals, to analyse the results and to set guidelines for the next period.

The Bologna Process defines 10 action lines or objectives on the road towards the achievement of a European Higher Education Area. These goals overlap, or are interdependent, but each goal is important in itself. The objectives defined in the Bologna Process include the adoption of a comparable degree system with two main cycles, aimed at facilitating movement between countries. This, in turn, is a condition for achieving the goal of increased mobility for students, and academic and administrative staff in higher education. The promotion of quality assurance and increased inter-institutional cooperation is also an objective. The 10 action lines defined on the conferences of ministers responsible for Higher Education at Bologna, Prague and Berlin are:

1. Adoption of a system of easily readable and comparable degrees;
2. Adoption of a system essentially based on two main cycles;
3. Establishment of a system of credits, favourably the European Credit Transfer System (ECTS);
4. Promotion of mobility for students and academic and administrative staff;
5. Promotion of European cooperation in quality assurance;
6. Promotion of the European dimension in higher education;
7. Lifelong learning;
8. Higher education institutions and students;
9. Promoting the attractiveness of the European Higher Education Area;
10. Doctoral studies and the synergy between the European Higher Education Area and the European Research Area.

The first 6 action lines were defined in the Bologna Declaration, action lines 7 to 9 were established in the Prague Communiqué and, finally, action line 10 was defined in the Berlin Communiqué. It should be highlighted that the social dimension of higher education may be seen as an overarching or transversal action line. Further information and details on this issue can be found at www.bologna-bergen2005.no. In short, the main objectives of the Bologna Declaration are to increase the mobility and employability of European higher education graduates and, thus, ensuring competitiveness of European higher education on a world scale. Achieving these goals will also require identification and solution of a number of social issues. This article draws upon a broader piece of research aimed at investigating issues of teaching and learning at higher education within the Bologna Process.

RESEARCH METHODOLOGY

The goals of the study reported in this article were twofold: to analyse the perceptions of mechanical engineers in relation to their training at university and to discuss the implications of these for improving the teaching/learning process, in particular the teacher and student's role. Three main research questions were behind this study, namely:

1. How do mechanical engineering graduates from the University of Minho evaluate their initial training (curricular organisation, practicum, theoretical versus practical components of the programmes, activities undertaken ...)?
2. How did they adapt to their workplace?

3. What are the key areas for further training and professional development opportunities? [12].

In order to capture their views on their initial training, on their transition to the labour market and on further training and professional development opportunities, a combination of methods was used. Exploratory semi-structured interviews were conducted with eight mechanical engineers (former students of the University of Minho) in order to examine the ways in which they looked back on their initial training at university. Diversity in terms of age, years of experience and date of completing their degree were taken into account to select the interviewees. The interviews lasted about an hour and were used to explore and identify key dimensions and categories to be transformed into questions to be used during the main phase of data collection. A questionnaire was then designed, which included both closed and open-ended questions.

Several levels of information were included: initial training; practicum; first years in the workplace and further training and professional development opportunities. Background characteristics, such as gender, age, years of experience, academic qualifications and years of experience at current job were also included. The process of qualitative data analysis was undertaken according to two phases: a vertical analysis according to which each of the respondents' interviews was analysed separately [13].

A second phase was, then, carried out according to a comparative or horizontal analysis (cross-case analysis). In this phase, the method of constant comparative analysis was used to look for common patterns, as well as differences [14]. Quantitative data were analysed statistically with the use of SPSS software. Overall, 162 mechanical engineers responded to the questionnaire: 91.4% were male and 8.6% female; 51.9% were 30 years old or younger; 47.5% were aged between 31 and 39; and 94.4% were employed at the moment. Figures 1 to 3 show the results obtained from the mechanical engineers relative to the gender, age and employability, respectively.

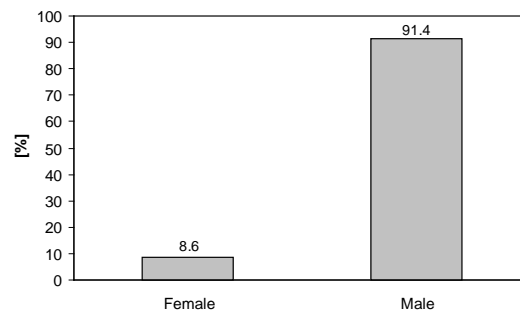


Figure 1: Gender of the mechanical engineers that responded to the questionnaire.

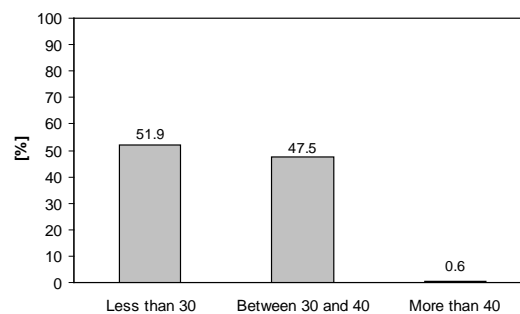


Figure 2: Age of the mechanical engineers that responded to the questionnaire.

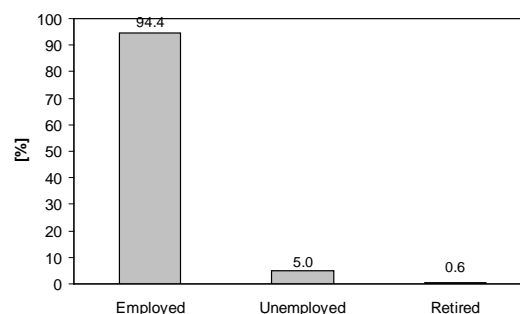


Figure 3: Employability of the mechanical engineers that responded to the questionnaire.

RESULTS AND DISCUSSION

In this section some of the main results and opinions from mechanical engineers relative to the topics included in the questionnaire are presented and discussed. From the data, it is possible to know that 63.3% of the respondents had changed job over the last three years, see Figure 4. The main reasons put forward were better working conditions; better professional career; end of contract; geographical proximity. When asked about the main motives for entering a mechanical engineering course at the University, they pointed out several situations: vocation/calling - 31.5% (1st choice); enjoying working with machines - 19.1%; enjoying working with cars - 18.5%; and employment opportunities - 16.7%. Also of interest is the fact that for the large majority of the respondents (78.9%) Mechanical Engineering, was the first choice in terms of career when applying at a post at university, see Figure 5. This is also the case of the University of Minho, which was the first choice for 65.2% of the respondents, as is illustrated in Figure 6.

When asked about the overall evaluation of the quality of the mechanical engineering course obtained at the University of Minho, the opinion from the respondents was, in general, good, as Figure 7 shows. Several reasons were identified for this positive evaluation, namely, the broad overview of the course, professional opportunities, good technical knowledge-base for future work and adequate curricular organisation of the course. Following are some opinions of the respondents:

The course has provided me with a good basis of technical knowledge. It has prepared me well for the labour market.

It is a very broad course at all levels in the mechanical world. Thus, it opens many doors in terms of future jobs.

I have learned how to identify problems and to look for solutions.

I think the course was useful because I developed technical and scientific knowledge which is relevant to my work and because I have always had several job opportunities.

The majority of the participants in the study (79.5%) revealed that the course met their expectations (see Figure 8). They emphasised the following issues for this: good preparation to face future work/profession; being broad enough in terms of knowledge and competencies; practical component and curricular organisation adequate; lecturers' professionalism. However, 20.5% stated that the course did not meet their expectations and they highlighted the following issues: being too theoretical; the lack of liaison between the University and industry; poor preparation for the labour market; lack of articulation and inadequate curricular organisation; lack of support; and poor pedagogical preparation from some teachers. The following quotations are illustrative of this:

I think the course should be more practical, especially during the early years.

As it is, it is too theoretical, with a poor effect on your real job...

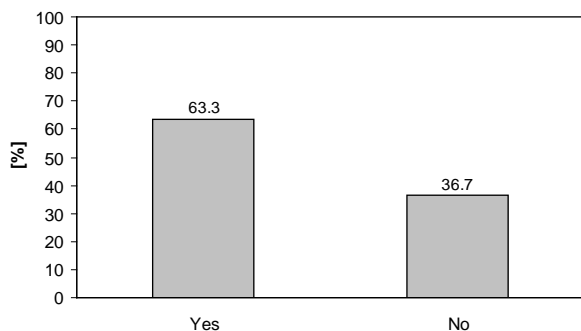


Figure 4: Did the mechanical engineers change their job over the last three years?

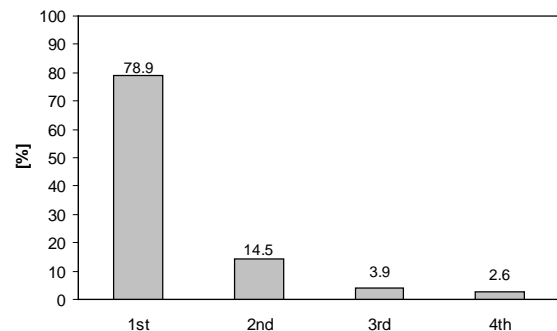


Figure 5: Option for choosing mechanical engineering course when entering at the university for the first time.

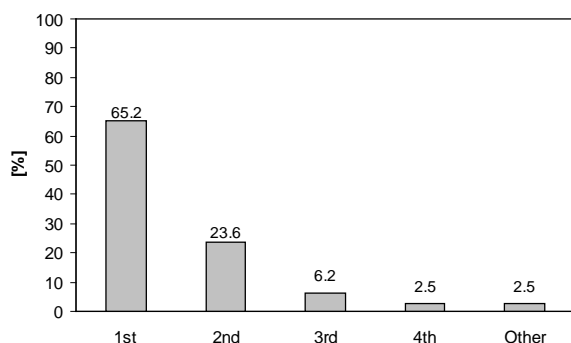


Figure 6: Option for choosing the University of Minho.

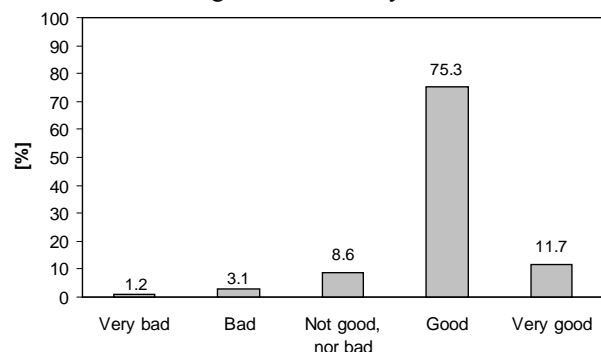


Figure 7: Overall evaluation of the quality of mechanical engineering course.

In the present study, the respondents also identified a number of issues related to their course at the University of Minho in relation to which they felt more or less satisfied. Concerning the adaptation to the University of Minho, 41.6% of the respondents were completely satisfied. In relation to the range of professional options in terms of job/career, 58.0% of the respondents were satisfied. 35.2% of the respondents were neither satisfied nor dissatisfied with the teacher/student relationship, development of social and professional skills. Concerning access to laboratory work and study visits during the course, 30.4% of the mechanical engineers were dissatisfied. Finally, 21.4% of the respondents were completely dissatisfied with the support from the University in finding a job. Figures 9 to 13 show these opinions.

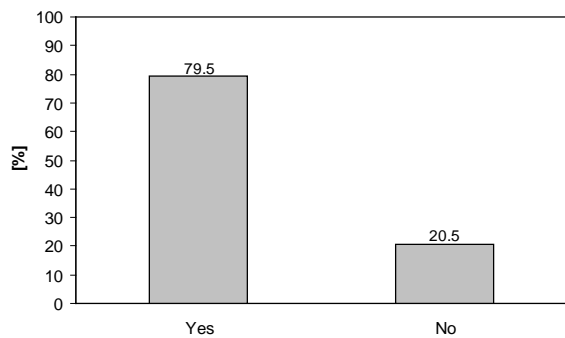


Figure 8: Does the mechanical engineering course correspond to the initial expectations?

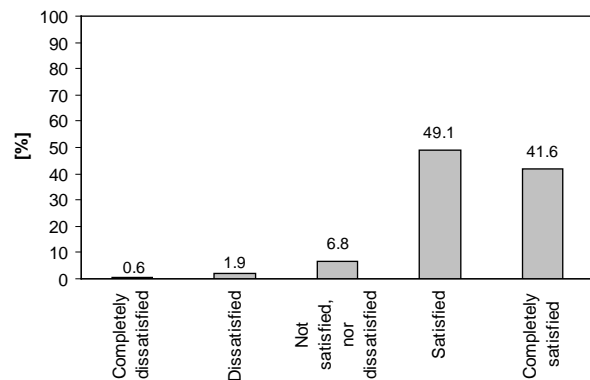


Figure 9: Degree of satisfaction relative to the adaptation to the University of Minho.

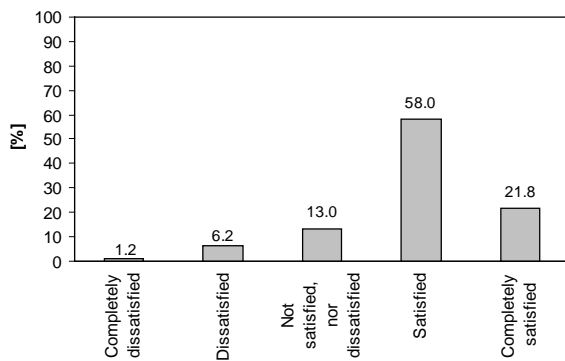


Figure 10: Degree of satisfaction in relation to the range of professional options in terms of job/career.

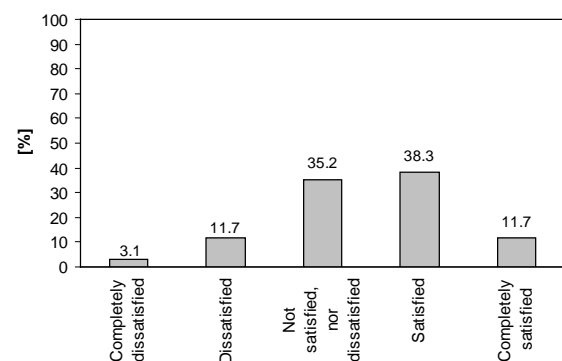


Figure 11: Degree of satisfaction in terms of the teacher/student relationship.

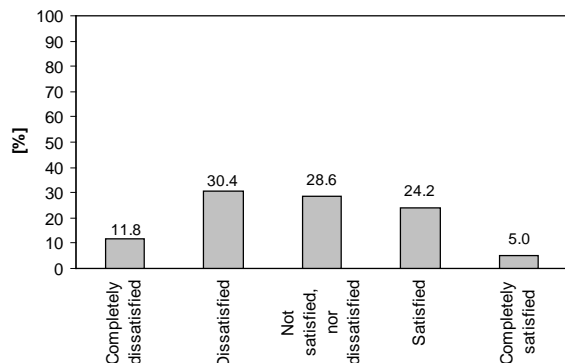


Figure 12: Degree of satisfaction in relation to the access, during the course, to laboratory work and study visits.

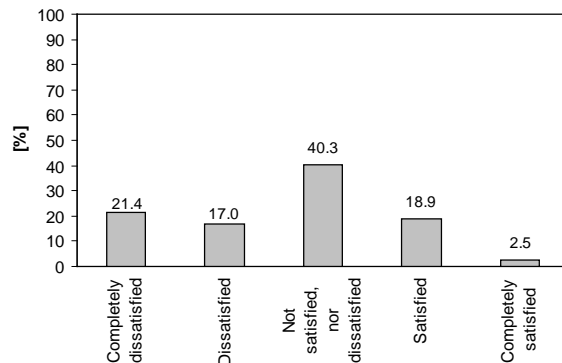


Figure 13: Degree of satisfaction in terms of the support from the University in finding a job.

Along with this, a number of key issues needed to be improved, according to the participants in this study. They referred to a more hands-on perspective from the beginning of the course; the introduction of curriculum units related to resource management; a better pedagogical approach from some teachers/lecturers; more emphasis on transversal competencies, such as teamwork, communication skills, leadership, etc.; better articulation between what is taught at a university and in secondary education; and better articulation between university and industry. To some of them:

I think the curricular structures of the course need improvement, namely in regard to the practicum. It will help to develop and apply knowledge if you have more hands-on experience.

It needs to be more in line with Portuguese industry needs...

We need a better articulation between university and industry, and therefore better integration into the labour market...

The course should include more projects during the five years and more hands-on work especially during several periods of time in industry...

Even though there are teachers/lecturers with good pedagogical preparation, there are other, who need training on pedagogy skills, namely in approaching the content and relating to students... Some of them have spent too many years on the job without training... I think teachers/lecturers should be evaluated in order to distinguish between good and not so good teachers...

Overall, the findings suggested a positive evaluation of initial training, namely, the ways students adapted to university, relationship between students, and the length of their practicum. They also highlighted a number of issues to be improved: a more hands-on approach, better pedagogical intervention from lecturers, a more adequate articulation between content knowledge at secondary school and university education. For instance, in relation to graduate and post-graduate interests, namely, in concerns about the first priority for thematic areas of interest, the respondents emphasised the importance of management, energetics and new technologies, as it is illustrated in Figure 14.

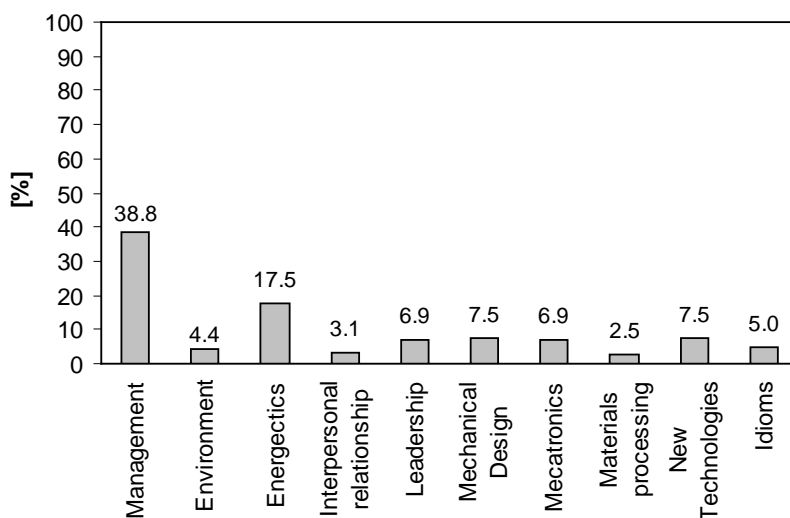


Figure 14: First priority for thematic areas of interest in post-graduate courses.

CONCLUDING REMARKS

In this article, results from a study carried out at the University of Minho in 2006 are presented and discussed. This study was concerned with the initial training of mechanical engineers, within times of change of educational paradigms and within the context of the Bologna Process. It was a study of the conceptions and experiences of mechanical engineers in regard to their initial training, the transition to the labour market, and their perspectives on further training and professional development opportunities. In the sequel to this process, the roots and aims of the Bologna Declaration were also presented.

In general, results pointed to the relationship between expectations and reality and a balanced, globally-positive attitude to the mechanical engineering course. On the other hand, the respondents felt dissatisfied in relation to some aspects, which need to be reorganised within the context of a restructuring process of the course.

Data suggest that mechanical engineers feel dissatisfied in relation to the support of the University when searching for their first job, as well as access to laboratory activities during the course. Mechanical engineers were more satisfied with the duration of the practicum and the adaptation to the University of Minho. They highlighted as aspects to be improved within the context of initial training: the need for up to date subject matter in scientific terms, the existence of short-term practicum in enterprises throughout the course, a more hands-on approach, a greater emphasis on the learning of transversal competencies related to the labour market, and a deeper articulation between the University and the labour market.

On the other hand, mechanical engineers described the beginning of their careers as being both difficult and easy, depending on a number of factors. They said that they looked for support from colleagues from work, superiors and chiefs, lecturers from the University and supervisors to solve the problems and difficulties, such as lack of experience, relating to other people, adaptation to the work environment and the lack of preparation from initial training.

As far as further training and professional development are concerned, themes include, among other things, environment, energetics, interpersonal relationships, leadership, projects, ICT, and so on. They also stated a preference for an intensive course after work, guided by specialists from industry. These and other findings suggest implications for restructuring the curricula, for the articulation and pedagogical coordination and for the pedagogical training of teachers at higher education.

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BIOGRAPHY



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