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**Innovation in Biology
and Environmental Education Didactics
in Pre-Graduate Training of Secondary Biology Teachers
in the Context of Current Changes
in the Education System**

Abstract

The authors conducted a survey among graduates of Master's courses in Teacher Education in Biology to determine their opinions on the importance of biology and environmental education didactics during their pre-graduate studies. Results of the survey indicated some existing deficiencies in pre-graduate teaching of biology and environmental education didactics and raised suggestions for innovation. The survey of 119 respondents was conducted in 2009. Most respondents considered the benefit of their pre-graduate Teacher Education in Biology degree sufficient for their own knowledge in biology, while considering the benefit of a pre-graduate course for their own pedagogic and didactic competencies a small one. The survey proved that most graduates of Teacher Education in Biology studies ranked the subject of biology didactics among the key modules of their pre-graduate degree course and identified several strengths and weaknesses in the teaching of biology didactics. The respondents who were professionally involved in Environmental Education viewed the absence of special didactics of environmental education and limited time allocation for teaching practice as shortcomings of their pre-graduate course structure. Based on this research, two educational projects were designed, allowing for the implementation of innovated didactics of biology and environmental education together with specialized teaching practice for biology teacher education students in collaboration with several Czech universities and participating foreign lecturers.

Keywords: *didactics of biology and environmental education, innovation, biology teachers*

Introduction

Subject-matter didactics plays an integral part in the curriculum of teacher education (Shulman 1987), as the level of didactic knowledge of the curriculum content and methods of its interpretation to students significantly determine the quality of a given teacher. Didactics of biology has seen, among other things, a growing emphasis on the importance of research-oriented teaching of biology and ecology (Činčera 2007).

In addition to their didactic knowledge of curriculum content, the effectiveness and quality of the teacher's work is conditioned by their teaching skills which reflect didactics to a significant degree (Kyriacou 1996). Teachers should learn the basics of their teaching skills during their pre-graduate studies. It is therefore requisite to continually look for teaching practice innovation throughout the pre-graduate training of future teachers.

The authors, motivated by their efforts to look for optimum means of innovation in the didactics of biology and environmental education, conducted a survey among graduates of Teacher Education in Biology to determine their opinions on the importance of biology and environmental education didactics during their pre-graduate studies. The aim of the paper is to present results of this research and their application in project innovation of didactics of biology and environmental education at Palacky University in Olomouc. The paper also discusses feedback received from the participants in this project innovation in the context of current changes in the education system.

Methods

Research on the target group of graduates of Master's courses in Teacher Education in Biology at Palacky University Olomouc was conducted in 2009 in the form of a questionnaire survey (Chráška 2007). The primary aim of the research was to evaluate the benefit of pre-graduate didactics of biology and environmental education (EE) for teaching practice from the perspective of Master's degree graduates who work as secondary biology teachers teaching the 11 – 15 age range,

exceptionally also as biology teachers teaching the 16 – 19 age range, or working as lecturers of Environmental Education (hereinafter EE).

A questionnaire with closed-ended questions was applied in the research (Gnitecki 1993). The questionnaire was divided into two parts: (1) Basic information about the respondent, (2) Evaluation of the content and benefit of the completed courses of biology and EE didactics during the pre-graduate Teacher Education in Biology studies with respect to its significance for the current teaching practice of the respondent. The respondents were given the option to add their own commentary to the closed-ended questions used in the questionnaire. The questionnaire response rate was 64%. A total of 119 respondents took part in the survey; all of them graduated from Teacher Education in Biology at Palacky University Olomouc between 1999 and 2008.

To determine the degree of reliability of the questionnaire data, comparison of data obtained from two equal samples, formed from the basic sample as a representative selection, was conducted. The rate of agreement between respondent responses in both randomly generated samples was expressed using Cohen's coefficient (Mareš 1983):

$$\kappa = \frac{p_p - p_0}{1 - p_0} \quad (1)$$

where κ is the Cohen coefficient, p_p is the observed agreement and p_0 is the expected agreement. The test of statistical significance of the calculated coefficient κ was calculated by a standardized normal variable using a criterion according to the following formula:

$$u = \frac{\kappa}{\sqrt{\frac{p_0}{n \cdot (1 - p_p)}}} \quad (2)$$

where u is the value of the standardized normal variable and the remaining symbols correspond to those in formula (1).

The analyzed survey results were used to design a project of innovation in didactics of biology and environmental education under the Operational Programme Education for Competitiveness (OPEC) called "Environmental Education in Practice" (Machar 2011). Preparation of new study subjects (referred to as "courses" in project terminology) drew on the accentuating activating teaching methods and enhancing research-oriented instruction of biology in teaching practice.

At the end of every project course the course was evaluated by its participants – pre-graduate students of Teacher Education in Biology – in the form of evaluation questionnaires with closed-ended questions. The output of these evaluations served as inspiration for the design of a follow-up project “Partnership for Enhancing Communication in Nature Conservation (KONEV)” under OPEC. This project facilitated the enhancement of pre-graduate courses in both Teacher Education in Biology and Biological Sciences, specifically by including wider application of subject-matter didactics in students’ teaching practice with potential employers.

Results

Determination of reliability of the survey results proved to be satisfactory, as the calculated value of the Cohen coefficient for the survey results obtained was 0.811 and as such may be considered satisfactory with respect to the agreement between randomly selected respondents. This finding therefore meets the requirement for reliability of the research methods applied. The value of standardized normal variable 6.01 upon significance level 0.01 was higher than the critical value (2.58) for the two-tailed test, it may be therefore noted that the calculated coefficient reveals a statistically significant agreement between respondent responses in the conducted survey.

Out of the set of 119 Teacher Education in Biology graduates who studied during the monitored period 1999 – 2008 (Figure 1), most (72%) work in education at present. 69 persons (80%) work as biology teachers at lower secondary schools, 5 persons (6%) work as EE coordinators and 12 persons (14%) work as EE lecturers in non-profit educational organizations. A relatively low number of the respondents (12%) are out of work at present, yet had had a minimum of three years of teaching practice prior to completing the questionnaire. A smaller part of the respondents (16%) work outside the field of their degree, mostly in jobs requiring a university degree as a basic qualification. This group of persons has had no teaching practice since graduating and as such their responses in the questionnaire section relevant to the evaluation of benefits of pre-graduate courses for teaching practice were not included in the research.

The benefits of pre-graduate Teacher Education in Biology courses for knowledge competency in biology are considered sufficient by the majority of the respondents (78%). In their comments on this question, the respondents (34%) stated that the knowledge of biological terminology obtained during pre-graduate studies is significantly more extensive than the knowledge applicable in teaching

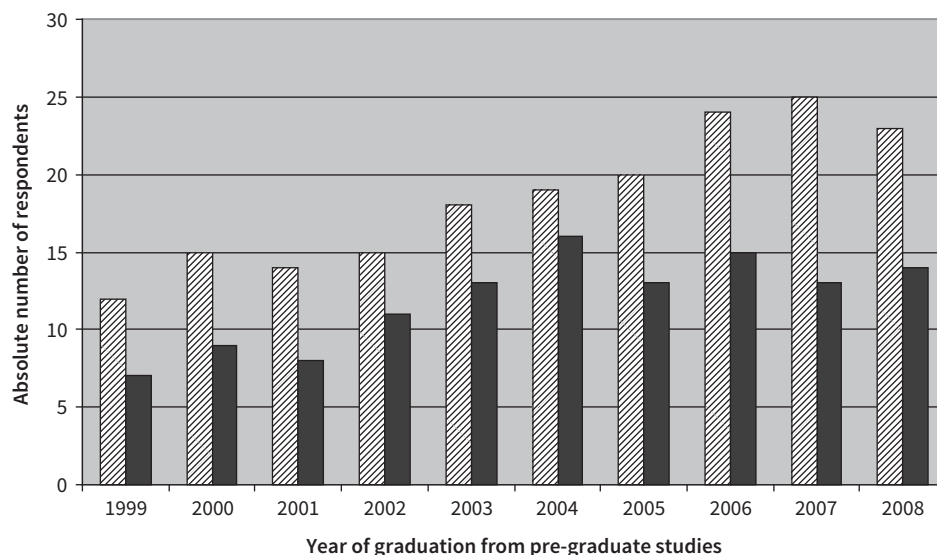


Figure 1. Structure of the studied respondent sample based on the questionnaire response rate and the graduation date in Teacher Education in Biology

practice at lower secondary schools. The most obvious weakness of their knowledge competency in biology, as the respondents see it, is the fact they have virtually no opportunity to follow the latest trends in biological subjects. The following reasons are considered key ones: a) lack of time in the working hours of lower secondary school teachers, b) insufficient funds at lower secondary schools limiting the possibility of journal subscription.

The evaluation of the benefits which pre-graduate studies brought to the respondents' teaching and didactic competencies was altogether different (Figure 2). Only 4.2% of the respondents stated that pre-graduate studies in Teacher Education in Biology provided them with all the necessary teaching and didactic competencies for the profession of a biology teacher or EE lecturer. Most respondents considered the benefit of pre-graduate studies for their own teaching and didactic competencies as limited (73.2%) or virtually non-existent (22.6% of the respondents), requiring additional self-study.

Respondent evaluation of the importance of Didactics of Biology module in pre-graduate courses was relatively unambiguous: most respondents (77.3%) considered Didactics of Biology to be one of the key modules of their university programme in Teacher Education in Biology. In their comments on this question,

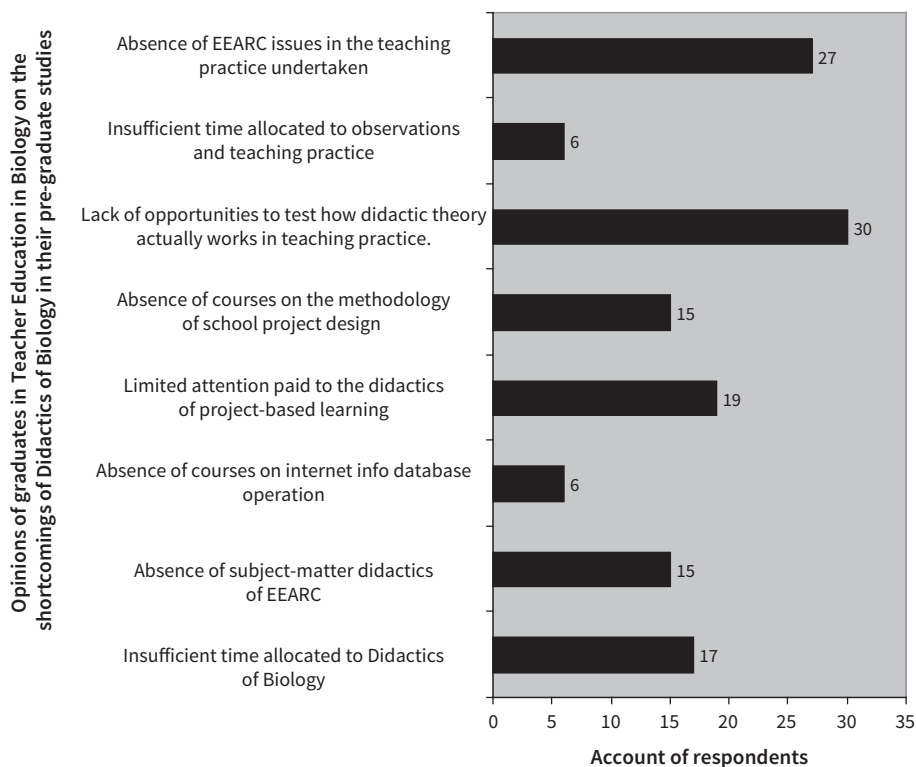


Figure 2. Analysis of shortcomings of the Didactics of Biology module in pre-graduate studies in Teacher Education in Biology as viewed by the graduates

the respondents (34%) considered the Environmental Education and Science Experiment Practice modules highly contributing. All the three modules listed above are didactics-oriented. Four respondents gave identical comments, saying that knowledge of manuals for laboratory science exercises gained in the Science Experiment Practice module together with the knowledge of basic principles of textbook evaluation provided by Didactics of Biology were greatly contributing to their teaching practice. The remaining comments contained a wide range of the respondents' opinions about lecturers of individual modules. These opinions were probably laden with subjective memories of unique personal experiences of individual respondents and as such were not subject to evaluation. Comments focusing on content deficiencies of the Didactics of Biology module provided valuable information (Figure 2). A total of 17% respondents more or less agreed in their

responses that Didactics of Biology received insufficient time allocation in their pre-graduate course and that they would like this module to “be more in-depth oriented”. Virtually all the respondents who are professionally involved in EE would have welcomed special subject-matter didactics focusing on environmental education during their studies. In their comments, the respondents also pointed out that little attention was paid to educational projects, including the methodology of preparing school educational projects, seeing this as a shortcoming of Didactics of Biology. In their comments regarding the importance of Didactics of Biology, the respondents mentioned the teaching practice undertaken, where didactics of biology was reflected. They considered the limited time allocated to teaching practice in their pre-graduate course to be a shortcoming of the teaching practice structure, saying that they would consider teaching practice more focused on immediate application of biology didactics greatly beneficial. Application of the research results in the project innovation of subject-matter didactics of biology and environmental education in biology teaching is shown in Figure 3.

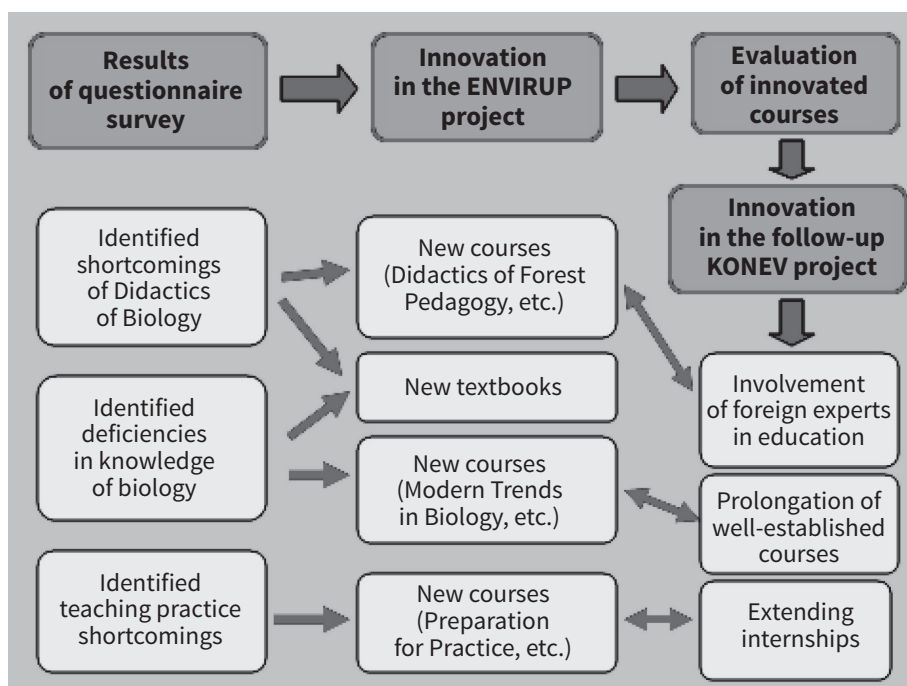


Figure 3. Application of survey results in the project innovation in subject-matter didactics of biology and environmental education in the Teacher Education in Biology at Palacky University Olomouc

The deficiencies in pre-graduate modules of biology didactics identified by the research resulted in the introduction of four new subject-matter didactics courses for students of Teaching Education in Biology: Didactics of Forest Pedagogy, The introduction of Didactics of EEARC, Didactics of Care for the Environment and Didactics of Nature Conservation.

Deficiencies in the biology teachers' expert knowledge of new trends in biological sciences, as identified in our survey, inspired the publication of new study materials and introduction of new courses: Modern Trends in Biology, Environmental Ethics and Global Learning and Development Education.

The respondents' additional comments on the closed-ended questions of the survey yielded interesting suggestions regarding teaching practice in pre-graduate courses. Informed by them, a set of several modules was prepared under the project innovation, significantly extending the practical competencies of pre-graduate students towards enhancing their future employability. The Preparation for Practice module is a set of seminars led by experts from nature conservation institutions and non-governmental organizations focusing on EE. This course is popular with pre-graduate students. It is followed by the course EE in Practice, which includes a long-term internship (4 weeks) with potential future employers at EE centres. The second follow-up course EE and Forest Pedagogy Practice is a two-week group workshop for pre-graduate students of Teacher Education in Biology. It offers them the chance to become acquainted with the basic principles of forest pedagogy under the tuition of forest pedagogy lecturers.

Evaluation of student feedback on the innovated didactic modules informed the design of the follow-up KONEV project. This project, whose primary focus is to establish a collaboration network of six Czech universities with professional practice, extends pre-graduate courses in both Teacher Education in Biology and Biological Sciences, specifically by including new possibilities of subject-matter didactics application in students' teaching and professional practice. They are given the opportunity to take long-term individual or team internships in renowned nature conservation institutions which are actively involved in EE and collaborate primarily with lower secondary schools. These internships focusing on environmental education are mostly taken in national parks.

Discussion

The ongoing changes in education are naturally also reflected in subject-matter didactics through curriculum changes (Walterová 1994). In relation to the trans-

formation of the education system, conceptual and content changes affect biology education significantly as well. The pedagogical and psychological constructivist and psycho-genetic principle must act as the cornerstone of biology education, bearing in mind that far from all scientific biology findings may be applied in the lower secondary biology curriculum (Švecová 2001). Owing to this, model-based teaching will be increasingly applied in science education, demonstrating biological knowledge on specific, didactically suitable selected examples while applying activating teaching methods (Grecmanová, Urbanovská 2007). Future teachers, however, need to learn how to use activating teaching methods in their pre-graduate courses (Oravcová 2004). With the onset of a new millennium, learning and education cannot be properly implemented at schools without paying attention to their environmental aspects (Orr 2004). The results of the presented survey indicate that some biology teachers lack knowledge competencies in environmental education didactics. Didactics of environmental education stresses the importance of the educational role of story-telling, play and project-based education (Eilam, Trop 2011). Some researchers (Gallová, Švecová 1996) indicate that biology is the key subject in environmental education. The results of our survey revealed that pre-graduate students of Teacher Education in Biology are aware of their knowledge deficiencies with respect to the latest trends in the field. With this in mind, our project innovations deliberately focused on introducing new modules and study materials which present students with the latest findings in the modern biological applications in education and the corresponding subject-matter didactics (Papáček 2006).

Nevertheless, the issue of the significance and position of biology within environmental education remains a subject of discussion. The evolution of environmental education abroad followed approaches which aspired to pass on the knowledge about nature, education in nature or education towards nature protection (Disinger 2005). Starting with the 1970s, however, we have been able to witness the trend of a gradual shift of environmental education focus “away from nature” “towards society”.

Environmental education traditionally understands ecological knowledge as one of its “target levels”, whereby the target attainment of this level should be to “provide learners with sufficient ecological knowledge to permit them to make ecologically sound decisions with respect to environmental issues” (Hungerford, Volk 1990). The existing definition of horizontal issues in framework education programmes stresses the importance of ecological knowledge. Future development of the field in the Czech Republic will probably take place in the context of a nation-wide discussion about the curriculum reform.

The accelerating process of globalization faces new challenges in conceptualizing biology education, which the didactics of global learning and education is trying to reflect (Carvalho 2008). Our project innovation in didactics of biology and environmental education echoes this process by introducing a new course called “Global Learning”, for which new study support was prepared (Máchal et al. 2012).

The conducted survey on the opinions of Teacher Education in Biology graduates helped to support the respondents’ professional self-reflection, which is an integral skill of the teaching profession (Urbanovská 2004). The participants in the research presented in this paper positively valued the importance of knowledge of didactics of science laboratory work. The project innovation which followed the research endeavoured to follow the modern trend of shifting the traditional concept of science laboratory work towards research-oriented learning (Papáček 2010).

It is probable that without the possibility of financial support from OPEC projects the implementation of the relatively costly innovation in subject-matter didactics would not have been possible. The same may be generally said about all innovations in university education which primarily focus on enhancing the employability of university graduates (Ryška et al. 2012). Educational projects similar to those presented in this paper are being implemented at other universities as well. Yet, the real effectiveness of such projects has been very rarely evaluated in expert publications (Koucký et al. 2008). The required sustainability of OPEC projects after the termination of their funding will lead to a gradual downturn in individual project activities. In this context, the importance of lifelong learning should be stressed, as it may support the sustainable maintenance of teachers’ didactic competencies.

Conclusions

The current development of biological sciences steers towards gradual integration, which is reflected in the trend favouring modular teaching in the didactics of biological subjects. Increasing demand for new attractive forms of biology learning at lower secondary schools (research-oriented learning, cross-curricular projects) together with accentuated horizontal application of environmental education increases the demand for didactic skills in teachers. The results of the presented research revealed that lower secondary biology teachers and EE lecturers view didactics-oriented disciplines as key ones in their field. The presented project

innovation in subject-matter didactics was implemented by a multi-disciplinary team driven by their effort to enhance the teaching competencies of future natural science and environmental education teachers. The authors would appreciate it if the results of their work contributed to the discussion about subject-matter didactics of biological disciplines.

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