ERPA 2014

Professional skills related to creativity and critical capacity in optics and optometry: Assaying a teaching approach for undergraduate training

Alicia Fernández-Olivera, Paz Fernández, María Luisa Oliverasc

aDepartamento de Didáctica de las Ciencias Experimentales, Facultad de Ciencias de la Educación, Universidad de Granada, Campus de Cartuja. 18071 Granada (SPAIN).
bDepartamento de Ingeniería Civil, Escuela Técnica Superior de Ingeniería de Caminos, Canales y Puertos, Universidad de Granada, Campus Fuentenueva. 18071 Granada (SPAIN).
cDepartamento de Didáctica de las Matemáticas, Facultad de Ciencias de la Educación, Universidad de Granada, Campus de Cartuja. 18071 Granada (SPAIN).

Abstract

Higher-education quality does not have an established and closed pattern. Its value lies in the ability to control, review, critique, and continuously update training. After the university training, excellent professionals ought to be upgraded throughout their entire professional life. Creativity and critical capacity become essential for successful lifelong learning. Methodologies that foster creativity and critical capacity in the learning process and, subsequently, in the acquisition of professional skills were the keystone of a teaching-innovation project that we developed at the University of Granada (Spain). Here, we present one of the teaching approaches proposed and applied in the context of this project. The subject-matter involved, related to optics knowledge in undergraduate students, was “Optical and Optometric Instrumentation” (Bachelor’s degree in Optics and Optometry). In the curriculum, the subject was described as “Design, manufacturing, quality control and adaption of optical instruments”. Quality control and adaptation, which requires a great amount of critical thinking and creativity, were tackled essentially in the laboratory sessions. The activities of our project were undertaken in the laboratory sessions, and a technique based on protocols of control and change was introduced. The procedure was aimed at prompting the students to adopt the role of the professionals and to pose questions to themselves concerning the practical content of the subject from that professional role. At the end of our activities, a series of enquiries were delivered to the students. The analysis and statistical treatment of the surveys are shown in detail in this work. Most students recognized the activities as helpful, as a notable contribution to the development of their skills, and as useful for their future as professionals. The results of the approach undertaken, which was focused on the professional skills related to creativity and critical capacity, were quite successful and pleasing also to us as teachers.

Keywords: teaching methodologies, professional skills, creativity, critical capacity, optics knowledge in undergraduate students.

* Corresponding author. Tel.: +34958243976
E-mail address: allila@ugr.es
1. Introduction

The signing of the Bologna Declaration laid the foundation for the development of a common sphere of learning in the spirit of European integration. Under the aegis of the European Higher Education Area (EHEA), Spanish universities are moving towards new models of teaching and learning. Since this change affects not only the structural arrangement but also teaching dynamics, the introduction and implementation of new teaching methodologies is required (De Miguel et al. 2006). In this context, the pedagogical systems of the university demand novel and innovative approaches which assist in the acquisition of professional skills.

To guarantee that students are prepared beyond the academic environment, their university training should take into account professional skills based on the creativity and critical thinking. Students of scientific and technical degrees need to be prepared to transcend literal and technical knowledge to generate creative thoughts and thereby meet the challenge of unpredictable operational tasks (García-Restrepo. 2011).

In scientific and technical subjects in higher education, it is usually difficult to draw students’ attention to the reflection and metacognition because mathematical approaches and exercises are often used without delving into the causes and consequences of actions. Hence, it is important to set objectives to stir the students’ lateral thinking, their own enthusiasm for the ability to solve diverse problems, and their self-management of intellectual and professional growth. In this framework, motivational tools are required to capture the interest of trainees with the goal of generating creative thinking.

In previous works, pedagogical changes based on innovative methodologies were sought (Benitez et al., 2000; Oliveras, 2005, 2006; Oliveras, et al., 2008; Oliveras & Gavarrete, 2012; Oliveras & Albanese, 2013). This experience has led our interdisciplinary group to work together in order to meet the present requirements of our university. In this work, we present an approach proposed and applied in the context of a teaching-innovation project developed at the University of Granada, Spain. This project involves a subject matter related to knowledge of Optics among students of the Bachelor’s degree in Optics and Optometry. The aim of the project was to implement teaching methodologies that promote creativity and critical capacity in the learning process and, subsequently, in the acquisition of professional skills.

1.1. Creativity and professional skills

High education quality does not have an established or closed pattern. Its value lies in the ability to control, review, critique, and continuously update information. Excellent professionals, after studying at the university, keep updating their knowledge throughout their entire professional life. Making lifelong learning a reality implies promoting creativity (European Commission, 2009). From an open and extensive concept of creativity, we propose that experts such as optometrists have several sources of lifelong learning, such as the self-control in administering their own knowledge and in the relationships that may be established between this knowledge and real-life situations.

Our proposal involved a theoretical characterization of creativity based on certain indicators especially adapted from a fuzzy mathematical model used for evaluating professional skills elsewhere (Oliveras, 1999). These signs or indicators comprise diverse facets of creativity and the following:

- Maintaining flexibility of thought.
- Searching for alternative methods to solve problems.
- Establishing new working hypotheses.
- Exploring new sources of information.
- Proposing new interpretations of the errors and deadlocks at work.
- Applying specific methods or theories from one particular field to another.
- Adapting of systems or tools to new uses.
- Creating new theoretical or instrumental elements based on existing ones.
- Drawing non-trivial conclusions.
- Developing intuition concerning potential novelty in a field of study.
- Establishing relationships between the abstract and concrete.
• Integrating various scientific and technological fields in the development of new projects.
• Expressing the personal thoughts in social terms, with reference to scientific or technological concepts

1.2. Optometrists’ and Opticians’ professional skills related to creativity and critical capacity

The subject matter involved was: “Optical and Optometric Instrumentation” (Bachelor’s degree in and Optics and Optometry). For this subject, the activities of our project were conducted in the laboratory sessions.

In the curriculum of the Bachelor’s degree in and Optics and Optometry, the subject “Optical and Optometric Instrumentation” is described as “Design, manufacturing, quality control and adaption of optical instruments”. The aim of the subject is to provide a basic and integral training in the instruments frequently used by Optometrists and Opticians. In this context, the laboratory sessions involve backgrounds, composition, characteristics, and applications of optometric and optical instruments in order to help the students implement this knowledge. Instrumental design and manufacturing is broadly treated in theory classes but quality control and adaption are undertaken only in the laboratory sessions. Quality control and adaptation requires a great amount of critical thinking and creativity, since different devices and instruments may have errors that evidence the validity range that theory will have in practice.

Optometrists and Opticians as professionals must bring together two different but complementary lines: on the one hand, they need to be able to solve scientific problems related to Optics, and on the other, they should be healthcare professionals who provide primary vision care. Therefore, the range of skills needed to define their profession is extremely broad and varied.

Our project focused on these skills, requiring higher amounts of creativity and critical capacity:

• Thinking critically about clinical, scientific, and social ethics involved in the practice of Optometry, while understanding the scientific basis of Optics and Optometry.
• Critically evaluating the terminology, clinical trials, and research methodology related to Optics and Optometry.
• Delivering expert opinions and appropriate optometric reports when necessary.
• Judging and incorporating technological improvements necessary for the proper development of their profession.
• Planning and carrying out research projects that contribute to the production of knowledge in the field of Optometry, transmitting scientific knowledge by conventional means.
• Locating new information and interpreting it in a given context.
• Understanding the general structure of Optometry and its connection with other specific and complementary disciplines.
• Demonstrating and implementing methods of critical analysis, developing theories and their application to the discipline of Optometry.
• Participating effectively in work groups and multidisciplinary projects related to Optometry

In addition to the former professional skills, we also placed attention on certain cross-curricular skills of the Bachelor’s degree related to creativity:

• Maintaining flexibility of thought.
• Ability to communicate orally and in writing.
• Facility to manage information.
• Capability to solve problems.
• Aptitude to work in team.
• Capacity to develop critical thinking.
• Initiative to develop independent learning
2. Method

The methodology developed includes different techniques that were adapted to the specific curriculum of each subject matter involved in the project. The techniques have a common social-constructivist cognitive background, in which knowledge is considered to be a construct achieved through social consensus among equals in the interaction between students and teacher.

In the case of the subject “Optical and Optometric Instrumentation”, the aforementioned interaction was undertaken in small work groups (2-3 students) and medium-sized work groups (group of practices that range from 17 to 24 students), and we used the technique based on protocols of control and change. The modus operandi was focused on prompting the students to adopt the role of the professionals and to raise questions to themselves concerning the practical content of the subject from the standpoint of that professional role. The goal was for the student, by brief questions, to be able to detect the key points for the report related to each laboratory set-up.

The questions focused on: detecting weaknesses in the experimental devices of each practice (quality-control test), comparing theory with practical application (assessment of divergence between theory and its application to actual experimental devices) and create variants of the practices (changes in the method or in the device to adapt it to other uses, to improve parameters or optimise variables involved). Proposed issues were worked on individually or in small groups in order to foster independent learning or teamwork.

A group of 63 students were involved in the activities related to the totality of the laboratory sessions (7) and experimental set-ups (10) of the subject matter. At the end of our activities all the students were surveyed with a series of questions, which were to be returned for analysis and statistical treatment. The statistical analysis of the survey is shown in the next section.

3. Results and discussion

The survey administered to the students was composed of two parts: the first included closed enquiries and the second, open-ended questions.

In the first part of the survey, the students were asked to select one of the alternatives (level qualifiers) offered in order to assess different features of the activities. Figure 1 and Table 1 present the results of these closed enquiries. Percentages refer to the total activities performed by the students.

![Fig. 1. Students’ responses to the closed enquiries about the activities (percentages refer to the total activities developed by the students).](image)
As can be seen, the students found most the activities easy in general terms (48% of activities were found very easy and 38%, moderately easy). When laboratory tasks were compared with homework, the students considered the laboratory tasks slightly easier. It bears noting the high usefulness of the activities for the understanding of the theoretical concepts related with the subject, as reported by the students (67% of the cases). Nevertheless, according to the students’ responses, the learning of new theoretical concepts through the activities was moderate. Finally, these enquiry results shown that the students enjoyed the activities most (47% of the activities were highly enjoyed and 39%, moderately).

Table 1. Students’ descriptions of the activities from closed enquiry responses. Percentages refer to the total activities developed by the students and expressed with a 1% in uncertainty.

<table>
<thead>
<tr>
<th>Level qualifier</th>
<th>General easiness</th>
<th>Laboratory task easiness</th>
<th>Homework easiness</th>
<th>Usefulness for understanding theory</th>
<th>New theoretical learning</th>
<th>Enjoyment</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>48%</td>
<td>48%</td>
<td>42%</td>
<td>67%</td>
<td>27%</td>
<td>47%</td>
</tr>
<tr>
<td>Medium</td>
<td>38%</td>
<td>35%</td>
<td>40%</td>
<td>22%</td>
<td>47%</td>
<td>39%</td>
</tr>
<tr>
<td>Low</td>
<td>15%</td>
<td>17%</td>
<td>17%</td>
<td>10%</td>
<td>25%</td>
<td>13%</td>
</tr>
</tbody>
</table>

The second part of the survey included open-ended queries in which the students were asked to describe in their own words how their skills benefitted from the activities, and how these skills would be useful for their future as professionals. After a qualitative analysis, 15 emerging categories were found and, on average, 10% of them were provided by each student. Table 2 presents the results of qualitative and qualitative analysis of the open-ended questions. Percentages refer to the total number of students involved.

Table 2. Students’ opinions about the activities from the open-ended-query analysis. Uncertainty of percentages = 1%.

<table>
<thead>
<tr>
<th>Activity contribution (emerging categories)</th>
<th>Percentage of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training for future professional tasks</td>
<td>22</td>
</tr>
<tr>
<td>Organization of ideas, clarity of expression, and acquisition of specific professional vocabulary</td>
<td>17</td>
</tr>
<tr>
<td>Reasoning ability and drawing conclusions</td>
<td>14</td>
</tr>
<tr>
<td>Problem solving, resolution of doubts and difficulties</td>
<td>13</td>
</tr>
<tr>
<td>Assessment and recognition of advantages and disadvantages of the professional instruments</td>
<td>13</td>
</tr>
<tr>
<td>Analysis and discussion of the results derived from the experimental data</td>
<td>13</td>
</tr>
<tr>
<td>Systematic working and structuring</td>
<td>11</td>
</tr>
<tr>
<td>Lack of time to take more advantage of the activities</td>
<td>11</td>
</tr>
<tr>
<td>Teamwork</td>
<td>10</td>
</tr>
<tr>
<td>Application of theoretical knowledge, comparison of theory and practice</td>
<td>10</td>
</tr>
<tr>
<td>Critical attitude</td>
<td>6</td>
</tr>
<tr>
<td>Not sufficiently targeted at trading and commercial purposes</td>
<td>6</td>
</tr>
<tr>
<td>Detection of errors committed in the laboratory</td>
<td>5</td>
</tr>
<tr>
<td>Professional responsibility</td>
<td>3</td>
</tr>
<tr>
<td>Raising unperceived questions</td>
<td>2</td>
</tr>
</tbody>
</table>

As shown, the data reveal that 22% of the students regarded the activities undertaken as a training for future professional tasks while 17% also found the activities useful to develop their capacity for expression and to extend their professional vocabulary. On the other hand, 11% of the students mentioned a lack of time to take more advantage of the activities and a 6% considered them not sufficiently targeted at commercial purposes.
4. Conclusions

In this work, we present the methodologies proposed and applied in the context of a teaching-innovation project developed at the University of Granada, Spain. The main objective of the project was to implement teaching methodologies that promote creativity and critical capacity in the learning process and, subsequently, in the acquisition of professional skills.

This project involves a subject matter related to knowledge of Optics in undergraduate students: “Optical and Optometric Instrumentation” (Bachelor’s degree in and Optics and Optometry). For this subject, we used the technique based on protocols of control and change. The modus operandi was focused on prompting the students to adopt the role of the professionals and to ask themselves questions concerning the practical content of the subject from that professional role. This mechanism boosted the critical capacity and the independent-learning ability of the students.

The results were in general very positive, during the execution itself and in the follow-up activity carried out by the students. At the end of our activities the students were surveyed, the responses of which were asked to be returned for analysis and statistical treatment. The survey was composed of closed and open-ended questions. Both quantitative and qualitative methods were used to study the results.

Most students recognized the activities as helpful, as a notable contribution to the development of their skills, and as being useful for their future as professionals. The results of the approach undertaken were quite successful and pleasing also to us as teachers.

Acknowledgements

The authors express their appreciation to the Vicerrectorado de Ordenación Académica y Profesorado de la Universidad de Granada, Spain, for financing teaching-innovation projects 11-212, 12-124 and 2013-206.

References