Extent and Modes of Physics Instruction in European Dental Schools

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Abstract: Changes in dental education towards integration of sciences and convergence of curricula have affected instruction in physics. Earlier studies of undergraduate curricula make possible comparisons in physics instruction. For this study, the websites of 245 European dental schools were explored, and information about the curriculum was found on 213 sites. Physics instruction in the form of a separate course was found in 63 percent of these schools, with eighty-two hours and 5.9 European Credit Transfer and Accumulation System (ECTS) credits on average. Physics integrated with other subjects or into modules was found in 19 percent of these schools. Half of these schools had on average sixty-one hours and 6.9 ECTS credits devoted to physics. Eighteen percent of the schools had no noticeable obligatory physics instruction, but in half of them physics was found to be required or accepted on admission, included in other subjects, or appeared as an elective course. In 122 dental schools, the extent of physics instruction was found to be between forty and 120 contact hours. Physics instruction has been reduced by up to 14 percent in the last fourteen years in the group of eleven countries that were members of the European Union (EU) in 1997, but by approximately 30 percent in last five years in the group of ten Accession Countries to the EU.

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Physics principles are applied in dentistry most obviously in radiology and in dental materials, but orthodontics, prosthodontics, and conservative dentistry also have many physics-based methods and procedures. Furthermore, physics principles are instrumental in acquiring skills, facilitation of lifelong learning, and understanding the scientific basis of dentistry. The answer to the question “is it beneficial for the clinic if dentists are more familiar with the principles of physics?” depends upon perceptions within individual countries and dental schools. This study is an attempt to investigate this perception through presentations of physics instruction in the curricula of European dental schools.

Traditionally, physics was studied during the first two semesters of dental/medical education. In the 1990s, a need for changes in general medical education was recognized, and several steps were suggested in order to improve the teaching process.\(^1\) Recommendations similar to those for the studies of medicine were issued for the studies of dentistry.\(^2\)\(^-\)\(^4\) Horizontal and vertical integration of basic, medical, and dental sciences was proposed. Integration, where possible, of teaching and assessment of the basic and biological sciences into the clinical part of the program was advocated. Educational approaches different from the traditional were suggested.

Unlike in basic medical courses, which are usually taught by doctors of medicine and dentistry, physics instruction is given by physicists. Integration therefore poses a more demanding task for both clinicians and physics instructors. The extent of training in physics, along with other subjects, was reported in earlier studies of curricula collected from dental schools in Europe: in eleven member countries of the European Union (EU),\(^3\) in eight countries of Central/Eastern Europe (CEE),\(^6\) and in ten Accession Countries to the European Union (AC).\(^7\) The examination of physics instruction in dental schools in earlier studies made possible comparisons and conclusions about the trends in physics instruction in European dental schools today. Currently, almost all dental schools have websites, and availability of data on curriculum structure and content is one of the requirements imposed on dental schools.\(^2\) The ability to obtain relevant information from more dental schools than in earlier studies (which relied upon answers to questions asked in letters addressed to the schools) enabled us to conduct a more complete overview of the topic than previously possible.

Methods

As “European,” we considered schools situated in countries listed on the EU website (http://europa.eu/index_en.htm). Geographically, the majority of the listed countries are entirely in Europe although
some have portions in Asia (for example, Russia and Turkey) and one (Armenia) is entirely in Asia.

To obtain information about the extent, modes, and trends of physics instruction, the websites of dental schools in European countries were explored in the period January to June 2011. Information from the curricula for the current school year or for the coming school year, if posted, was used for the majority of schools. If there was no information on the school year for which the curriculum is valid, a further search was performed through timetables and departmental presentations. Finally, all available data for each country were analyzed, and outlying data were included only if substantiated by a straightforward and precise presentation.

Data were collected for the presence of physics instruction and the extent of instruction in hours and European Credit Transfer and Accumulation System (ECTS) credits. ECTS was set up initially for credit transfer as a student-centered system based on the student workload required to achieve the objectives of a program. One ECTS credit corresponds to twenty-five to thirty hours of student work, and it includes lectures, seminars, projects, practical work, self-study, and examinations (contact hours and self-study). The mode of instruction was also recorded: 1) physics as a separate course under different names such as physics, biophysics, medical physics, physics and mathematical bases for biomedical sciences, etc.; and 2) physics integrated with some other subject(s) or integrated within a module (this type of integration accomplished during one school year is considered horizontal integration).

Dental schools that did not have a noticeable presence of physics instruction in the curriculum were contacted in order to clarify the issue. Schools without noticeable presence of physics were mostly schools with curricula based on a problem-based learning (PBL) approach. Schools that presented insufficient information from which to draw conclusions about physics instruction were also contacted. These were schools that posted two curricula (one with visible physics instruction and one without it but both without school year indication), schools with modular curricula but without clear indication of physics being a constituent part of a module, and schools with ambiguous information about the mode of physics instruction. The missing data were requested by e-mail from relevant persons, usually vice deans for education or physics professors. In order to register trends in the physics input, our results were compared to the results obtained in earlier studies.

## Results

The websites of 245 dental schools were explored. Thirty schools were contacted for additional information, and twelve replies were received. Data (more or less complete) were obtained for 87 percent of the schools explored. Information on the presence and the modes of physics instruction is shown in Table 1.

The extent of physics instruction in schools where physics is taught as a separate course (or two courses in the case of nine schools) is shown in Table 2. For the majority of schools, we were able to determine the extent of physics instruction in hours; for more than half, in ECTS credits; and for less than half, in both (hours and ECTS credits). For twenty schools with this mode of physics instruction, data on the number of hours or ECTS credits were not found. Out of forty dental schools where physics is taught within an integrated course, it was possible to estimate the extent of the segment with physics instruction for twenty-one schools and, for fifteen, only the extent of the whole course in which physics is integrated. The values obtained are shown in Table 3. Thirty-nine dental schools did not mention physics as an obligatory element of instruction in their curricula. Exploration of their admission procedures and our direct enquiries resulted in the data shown in Table 4.

Comparison of hours of physics instruction found in the earlier studies and the present data for the same groups of countries is shown in Table 5. In all three groups of countries, subsets of contemporary data were formed in order to compare the same groups of schools. Physics instruction in countries that are, at present, not members of the EU is included in Table 5. Contemporary data on physics instruction, available in ECTS credits for countries grouped as in earlier studies, is shown in Table 6.

## Discussion

Although the majority of schools in our study reported that it is most appropriate to give physics instruction to dental students in the form of a separate course, a number of schools have managed to integrate physics instruction. However, these curricula reveal that the integration has been achieved horizontally (usually in the first year of study). Vertical integration, defined by the presence of physics instruction both during the first year and later years
ics course, while the workload expressed in ECTS credits is higher. This may be explained by the fact that the mean value in ECTS credits is pronouncedly influenced by French schools, where one ECTS credit comprises 8.3 contact hours and the European average is 12.5. The difference is due to the hours of self-study (fewer contact hours, more self-study), so the workload of physics instruction, whether integrated or not, is much the same.

In the countries that participated in the EU study, the mean number of hours devoted to physics has decreased by up to 14 percent in the last fourteen years. Exemplary is the data from Table 1, which shows the presence and modes of physics instruction in European dental schools in study, by number of schools. The data indicate that physics instruction as a separate course in European dental schools in study (n=114) shows a variability in the number of schools that integrate physics instruction. Table 2 presents the mean number of hours and ECTS credits devoted to physics as a separate course, with 25%, 75%, and percentile values, and shows that the mean number of hours is lower than in dental schools with a separate physics course, while the workload expressed in ECTS credits is higher. This may be explained by the fact that the mean value in ECTS credits is pronouncedly influenced by French schools, where one ECTS credit comprises 8.3 contact hours and the European average is 12.5. The difference is due to the hours of self-study (fewer contact hours, more self-study), so the workload of physics instruction, whether integrated or not, is much the same.

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basic and medico-biological subjects had about 30 percent more hours of teaching than the same group of subjects in the EU study and that it was concluded that convergence towards EU values and trends is needed.

In the AC study, the same conclusion was obtained: science and preclinical subjects have about 30 percent more hours of teaching. However, in both studies, the extent of physics instruction was found to be somewhat less than in the EU study. The extent of physics instruction in AC (or CEE) countries has been reduced, along with other science and preclinical courses. For physics instruction, this step has, in fact, nudged the intended convergence towards divergence.

Contemporary data on physics instruction, expressed in ECTS credits, show that the average physics workload in AC (or CEE) countries is two ECTS credits lower than in the countries covered in years. The CEE study and the AC study covered primarily schools from the same countries. Hence, the relatively small difference in physics instruction (7 percent in mean values) for these two groups of countries is not surprising (Table 5). This difference would have been even smaller if the data of the CEE study were not influenced by the overrepresentation of one country (Hungary), as the authors remarked. The difference is negligible (less than 2 percent) when all available contemporary data are taken into account (for about twice as many schools as in previous studies, in each group of countries).

The mean reduction of physics instruction in dental schools in AC (or CEE) countries is about 30 percent in the last five (or thirteen) years (Table 5). The majority of reductions were instituted after 2006. One of the explanations for this significant reduction could be the fact that the CEE study revealed that basic and medico-biological subjects had about 30 percent more hours of teaching than the same group of subjects in the EU study and that it was concluded that convergence towards EU values and trends is needed. In the AC study, the same conclusion was obtained: science and preclinical subjects have about 30 percent more hours of teaching. However, in both studies, the extent of physics instruction was found to be somewhat less than in the EU study. Nonetheless, the extent of physics instruction in AC (or CEE) countries has been reduced, along with other science and preclinical courses. For physics instruction, this step has, in fact, nudged the intended convergence towards divergence.

Table 5. Trends in physics instruction in European dental schools expressed in hours

<table>
<thead>
<tr>
<th>Group of Countries</th>
<th>Year of Study</th>
<th>Number of Schools in Study</th>
<th>Mean (hours)</th>
<th>SD (hours)</th>
<th>25% percentile (hours)</th>
<th>75% percentile (hours)</th>
<th>Min (hours)</th>
<th>Max (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In EU study</td>
<td>1997*</td>
<td>&lt;30</td>
<td>103</td>
<td>–</td>
<td>60</td>
<td>132</td>
<td>16</td>
<td>190</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>11*</td>
<td>99</td>
<td>45</td>
<td>60</td>
<td>120</td>
<td>45</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>46</td>
<td>89</td>
<td>36</td>
<td>60</td>
<td>119</td>
<td>27</td>
<td>180</td>
</tr>
<tr>
<td>In CEE study</td>
<td>1998*</td>
<td>14</td>
<td>102</td>
<td>33</td>
<td>75</td>
<td>128</td>
<td>45</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>13**</td>
<td>78</td>
<td>24</td>
<td>60</td>
<td>98</td>
<td>42</td>
<td>105</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>30</td>
<td>65</td>
<td>21</td>
<td>45</td>
<td>75</td>
<td>42</td>
<td>105</td>
</tr>
<tr>
<td>In AC study</td>
<td>2006**</td>
<td>18</td>
<td>95</td>
<td>28</td>
<td>74</td>
<td>107</td>
<td>45</td>
<td>143</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>16**</td>
<td>71</td>
<td>27</td>
<td>52</td>
<td>105</td>
<td>42</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>31</td>
<td>66</td>
<td>24</td>
<td>45</td>
<td>90</td>
<td>42</td>
<td>120</td>
</tr>
<tr>
<td>Non-EU</td>
<td>2011</td>
<td>34</td>
<td>79</td>
<td>31</td>
<td>56</td>
<td>98</td>
<td>13</td>
<td>150</td>
</tr>
</tbody>
</table>

Note: In Year of Study column, all years except 2011 are years when the study was published.
*Cannot be claimed that the subset of schools is the same as the one in the EU study.
**Same schools as the ones in the CEE or AC study.

Table 6. Physics instruction in three groups of countries expressed in ECTS credits, 2011

<table>
<thead>
<tr>
<th>Group of Countries</th>
<th>Number of Schools Studied</th>
<th>Mean (ECTS)</th>
<th>SD (ECTS)</th>
<th>25% percentile (ECTS)</th>
<th>75% percentile (ECTS)</th>
<th>Min (ECTS)</th>
<th>Max (ECTS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In EU study</td>
<td>37</td>
<td>7.2</td>
<td>2.0</td>
<td>6</td>
<td>8</td>
<td>2.8</td>
<td>13</td>
</tr>
<tr>
<td>In CEE study</td>
<td>25</td>
<td>5.2</td>
<td>1.5</td>
<td>4</td>
<td>7</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>In AC study</td>
<td>27</td>
<td>5.3</td>
<td>1.5</td>
<td>4</td>
<td>7</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>
the EU study (Table 6). Obviously, the reduction in physics instruction in AC (or CEE) countries was greater than necessary for convergence. According to contemporary data, in European dental schools in countries that are not at present members of the EU, the mean number of hours devoted to physics instruction is greater than in the group of countries covered by the AC (or CEE) study but is less than in the group of countries covered by the EU study.

Schools without noticeable physics instruction were not mentioned in earlier studies. However, in the EU study an unspecified number of schools were treated as outliers concerning the number of hours of instruction, and in the AC study one school was excluded from the study due to the specific educational system. In our study, in the group of thirty-nine schools without noticeable physics instruction, fourteen schools were initially covered by two of the previous studies. We believe that those schools are the ones that were treated as outliers in previous studies due to the lack of physics instruction.

Although our study found that thirty-nine schools did not have noticeable obligatory physics instruction in the curriculum, this does not mean that students in all those schools do not have any contact with physics. Some schools require a physics course on admission, and we were informed that some have several hours of physics instruction within radiology and dental materials. In a number of schools, only a part of the student population gets physics instruction, either in the form of a physics course that is accepted on admission but only as one of the alternatives or a physics course that is included in the curriculum but as an elective course. Twelve schools do not require a physics course on admission (even as an alternative) and do not have any physics instruction during the studies. For nine schools, there was no sufficient information on their websites, and since they did not answer our inquiries, no decisive information about their physics instruction is available.

Conclusions

Contemporary physics instruction in European dental schools is diverse. The extent of instruction ranges from zero to 180 hours, from zero to thirteen ECTS credits, from zero to two courses, and physics can be required on admission or not. The majority (82 percent) of European dental schools in our study have physics instruction: 63 percent as a separate course and 19 percent as an integrated course. The curricula of 122 schools contain physics instruction in the range from forty to 120 hours. Some of these dental schools that do not have physics instruction in their curricula require, or accept as an alternative, physics on admission to studies (6 percent). Few of the schools (2 percent) have elective physics courses, and even fewer (1 percent) have several hours of physics instruction submerged in radiology and dental materials where physics instruction is given by persons in charge of these disciplines. Ten percent of schools in our sample do not have or seem not to have any physics at all. The majority of these schools most probably did not have physics instruction in the past either; in other segments of dental curricula, their system of education for dentists is in most cases also specific.

Horizontal integration of physics was evident in forty dental schools in our study, while vertical integration was sporadic and was registered in only four schools. While horizontal integration is the association of physics and subjects like biology, chemistry, informatics, or statistics, the integration of physics with preclinical and clinical subjects is much more challenging and, though potentially more rewarding, is probably too demanding to implement at this stage of curricular reforms. The fact that we did not find physics being incorporated into any of the PBL-based curricula is an indication of the above. Organizational difficulties or the lack of physics instructors should not be excluded as factors complicating the task. In twenty-one of the schools, the workload of the physics segment was comparable to the workload in dental schools with a separate physics course. In fifteen schools, the structure and extent of the integrated courses formed was such that, in general, physics instruction was reduced and most probably fell below the level of physics instruction in the majority of European dental schools.

According to the findings of our study, reduction of the extent of physics instruction, irrespective of the mode of instruction, is evident in European dental schools. In the group of eleven countries that were members of the EU in 1997, physics instruction has been reduced in last fourteen years by up to 14 percent. In ten Accession Countries to the EU, it has been reduced by approximately 30 percent in the last five years. Moderate reductions of physics instruction are inevitable consequences of the integration process and, in some cases, of the intention to obtain the convergence of curricula. However, substantial reductions are to be attributed to the formally introduced reforms towards convergence of the curricula.
and the absence of interest in physics instruction, which is considered to be of secondary importance for dentistry.

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REFERENCES