Instruction of applied physics in industrial product design

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Abstract

Physics can be found in the syllabus of Industrial Product Design education as a requirement for the degree in order for students to use technology correctly and efficiently in product design, to comprehend the new technologies, to solve mechanism problems during product development and to establish a common discourse with other engineers during multidisciplinary work. This study focuses on the content of physics and related classes that belong to the curriculum of Industrial Product Design Department (IPDD). It deals chiefly with the efficiency of applied physics instruction in IPD education in Turkey. The study inspects the importance of physics class for the students of Industrial Product Design and mentions Turkey’s related status in IPDD in terms of the issue.

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1. Introduction

Like a perfect product that cannot sell, like a problem which is solved only at functional level, a design which is lacking in terms of technical know-how is away from an integral solution. Therefore, students of industrial product design should be equipped with technical and engineering knowledge. It is doubtless that Physics represents the main source for technical and technological domain as well as for the accumulated engineering knowledge; as a result, product design is connected with this field and is continuously fed from there.

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The hypothesis of this study is that Physics classes in Turkey are not lectured in a manner specific to IPDDs and that ‘technical or applied Physics’ is not known in the IPDD circles. Consequently, the objective of the present study is to inspect IPD education in Turkey in terms of its association with the main laws and concepts of applied Physics and the efficiency of its presentation as lectures. In order to support the hypothesis, the study considers subjects in the curricula of foreign universities which contain technical knowledge and inspects the related conditions and approaches therein. From Turkey, IPDs of MSGSU and ITU were chosen because they are the oldest and established educational institutions and because they each represent different backgrounds (ITU has an engineering history while MSGSU has a fine arts background). When it comes to foreign universities, Stanford in America, and TU Delft in Europe are known as leading centres in terms of design philosophy, research, and education (Altıparmakoğlu et al., 2011). Making use of research results in line with the the hypothesis of the study, a model study was developed for Physics subject sources on the basis of designed products. To support the study, lecturers of Physics from ITU, MSGSU, and METU were interviewed. In these interviews, the lecturers were asked about the contents and techniques of their presentation of Physics, as well as about the content and methods that should be presented by universities to IPD students. The study continued with a survey which was administered to the students on the same issue. The survey inquired about students’ basic Physics knowledge, the efficiency of the class, the lacking parts in the presentation of the knowledge, as well as their needs. The data and information gleaned from the instrument were put into tables and inspected. The comparison of data from interviews and survey directed the study to its conclusion.

2. Physics and related issues in IPD departments at national and foreign universities

Two of the oldest and major universities in Turkey, ITU and MSGSU play a significant part in IPD education. Stanford University is the most significant educational institution both of America and of the world while TU Delft is the most renowned university in the field of engineering and design in Holland which has a state-of-the-art and forward-looking education system and technology. Therefore, Physics classes in IPD education are considered taking as basis these two educational institutions.

2.1 Istanbul Technical University

IPDD was founded at ITU in 1993 with the objective of creating new products and systems by training designers who could accurately use design knowledge and technologies, and who have perfected their design skills, and who are creative entrepreneurs and have leader characteristics (ITU, 2013). Physics is presented as the pool (shared) subject by all departments. Out of the total 153.5 course credits at IPDD, ITU, 7 credits belong to Physics and related sciences. These credits include those of Physics I, Physics I Lab, and Statics & Strength of Materias.

2.2 Mimar Sinan Fine Arts University

MSGSU started its industrial product design education in 1971. The current objective of IPDD, MSGSU curricula is to train the best and perfect industrial engineers who bear the scientific and artistic identity of the university, and who will realize creative designs which are most suitable for the purpose (MSGSU, 2013). The Physics courses in this department are electives and very few students feel inclined to choose them.

2.3 Stanford University

Product Design Program is placed as a main branch among departments and interdisciplinary programs at the faculty of engineering at Stanford University. In brief, it is a department focusing on the concepts of design and product. The vision of the design program is to train prospective designers as leaders of thought whose designs could provide solutions for the complicated problems faced by our industry, society and planet. The department teaches design process which encourages creativity, workmanship, and personal expression. They also put an emphasis on brainstorming in the department and teach how to discover human needs which have remained
unnoticed so far or for which no services have been provided. Students doing a degree in Product Design are required to attend mechanical engineering syllabus as well as to meet the requirements of the degree in Product Design (Stanford University, 2013). Physics and related classes in Product Design Program consist of ‘Physics 41’, ‘Physics 43’, ‘Physics 45’, ‘Solid Mechanics (ENGR 14)’, ‘Mechanics of Materials (ME80)’ and ‘Mechanical Systems Design (ME112).

Programs of Product Design at Stanford University are conducted in collaboration with Mechanical Engineering and the Department of Art & Art History. The program consists of courses of science, engineering, and art. Therefore, Physics courses given in the scope of Product Design education at Stanford are directly aimed at all physics laws governing industrial products; what is more, these Physics courses, and related courses which include concepts and topics of Physics in their content are drastically more than the courses in IPDD, ITU, and IPDD, MSGSU. These courses make up 16% of the whole course credits of the department. It is just over three times more than the Physics courses given at IPDD, ITU.

2.4 TU Delft University

Industrial Design Engineering School started in 1969 in collaboration with faculties of architecture and engineering (Collina & Simonelli, 2001). The department explicates design as developing or improving new products that people need a lot every day at home or office, and emphasize the importance of having a knowledge base in “structure and engineering” along with the related fields in product design. “Structure and Engineering” is becoming more and more significant in the context of sustainable design.

At TU Delft, rather than directly given, Physics is embedded in various technical, technological and engineering courses. For instance, Mechatronics contains subjects of Physics, such as Mechanics and Electronics, and thus makes it possible to teach these classes both under theoretical engineering knowledge and in the scope of applied workshops. All Physics knowledge required for ‘Product Design’ is taught feasibly in the scope of technical and engineering knowledge; in addition to normal classes, it is presented to product design students in accompaniment of workshops, computer-assisted activities, and question-and-answer sessions.

Mechatronics Engineering Design (IO1071) course contains solids mechanics, mathematics, materials science, and industrial production topics and related theoretical information as directories.

Product Dynamics class (IO2021) is a combination of the mechanics (dynamics) and electronics as applied in consumer products. Taking this class provides a better understanding by taking into consideration the dynamic behaviour of the product during product or detail design. Mechatronics (IO3050), as a method of product development is the substitution of traditional or complex mechanisms by mechatronics systems (TU Delft, 2013). The use of applied physics in design solutions, designing and assembling by taking into consideration the product parts and the mechanical features of the materials, and the fact that shaping the product in the processes of materials selection and production is taught in the scope of Mechanical Engineering Design course openly show that Physics knowledge is easy to integrate into product design projects and helps to find successful solutions. That Product Design at TU Delft focuses on an engineering program at Bachelor’s degree points to the necessity to consider design more in forward-looking, scientific, and technological terms. Physics and related courses comprise 15% of the total 202.5 credits of IDE department.

3. Investigation of Applied Physics in the Scope of IPD education

Physics course for IPDDs is given the name Applied Physics, and should be taught by establishing associations with design materials. Firstly, to draw a picture of the current condition, lecturers who teach this course were interviewed.

3.1 Interviews with Physics instructors

When it comes to investigating the – theoretical or applied – instruction of Physics in the scope of IPD education, it is essential to start with the instructors who conduct these courses because it is the Physics instructors who can
answer whether the content of Physics course and related knowledge base support the theory or application of product design, or which design objects should be chosen to illustrate which topics while teaching Physics.

3.1.1 Interview with Prof. Dr. Ahmed Togo Giz

Upon our interview, Prof. Dr. Ahmet Togo Giz, Head of Department, Physical Engineering, Faculty of Science and Letters, ITU, gave the following support: “If the Head of IPD Department makes an official demand, a commission could be set up in the Department of Physical Engineering to make special preparations to teach Physics courses to students of IPDD that could be supported and illustrated by using items or course content from industrial product design…”

3.1.2 Interview with Prof. Dr. Yaşar Yılmaz

Because Yaşar, instructor of Physics, teaches Physics to all engineering fields, he does not provide information related to specific ways in which the course could be presented in the scope of Industrial Product Design education. As Physics is a common course for all departments at ITU, it has the same course content for all departments in which it is given. According to Yaşar, the same content could be lectured in all departments with but little difference. However, while lecturing, the instructor could provide examples related to that field, and may pose questions and prepare activities which establish links between the field and Physics. To him, learning about analytical thinking starts with learning Physics. He defends that students should turn Physics into a way of thinking in order to find solutions to any kind of problems.

3.1.3 Interview with Assoc. Prof. Dr. Meriç Bakiler

M. Bakiler is an instructor of Physics in the Physics Department at MSGSU, and he also teaches “Physics103” and “Physics104” at IPDD. Bakiler explains that the majority of students admitted to MSGSU may not have previously taken Physics during their high school education and these students could include Fine Arts High Schools. Therefore, he adds, the course is presented very basically under main sub-headings such as Mechanics, Heat, Electronics, and Optics. However, this course is an “elective”, which makes it impossible for all students to attend it. Practical work is not readily available on a regular basis. Nevertheless, Bakiler thinks practical activities are beneficial at least while teaching Mechanics.

3.1.4 Interview with Assist. Prof. Dr. Evren Akar ile görüşme

Explanations by Physics instructor, E. Akar, show that in IPPD at Middle East Technical University (METU) Physics is taught throughout one whole academic year. This course is subdivided into mechanics, optics, and electric-electronics. The course includes practical activities in the form of simple mechanisms built by the students. Akar states that basic laws of Physics make up 50% of the course. This shows that laws of Physics are very important during IPDD Physics instruction. At the same time, giving the course directly in the department program METU-IPPD attaches more importance to scientific subjects during design instruction than ITU-IPPD. Akar’s endeavors to teach Physics by showing various objects of product design help students to adopt the subject they are lectured on. Product discussions during the class provide the students the opportunity to associate abstract concepts of Physics with tangible problems of design; they show which branches of Physics could help in which design problems or on which subjects more attention should be paid.

4. Survey given to IPD Students on the content and instruction of Applied Physics and Its Results

None of the Physics instructors denied the importance of the knowledge of applied Physics in IPD education. Especially answers by Evren Akar clearly establish how and with what viewpoints Physics instruction should be given to IDP students and even how it could be made department-specific. In the light of this information, the study also asked IPD students about their thoughts.
4.1 Scope of the survey

The survey was realized by participation of students from ITU and MSGSU. Sophomores, juniors, and seniors were included in the survey. Freshmen did not have an idea of the application of the laws of Physics as they had not completed their course of Physics and had not started project classes, and as such, they were not included in the survey. The survey obtained students’ thoughts about basic laws and concepts of Physics, the degree to which they used these laws as well as their thoughts about its position, feasibility, and the way it is lectured.

4.2 Findings from the survey

1. Have you ever used laws or concepts of Physics in your projects throughout your education?

![Graph for the 1st Question of the Survey](image)

Fig. 1. Graph for the 1st Question of the Survey

72.5% of the participants indicated that they have used physical concepts and laws in their projects. The adoption by the majority of the necessity to use Physical laws and concepts show the significance of the field in industrial product design education.

2. In the paper scissors below:

![Scissors](image)

Fig. 2. Scissors.

<table>
<thead>
<tr>
<th>Table 1. Options of the 2nd Question of the Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Answer 1</td>
</tr>
<tr>
<td>Answer 2</td>
</tr>
<tr>
<td>Answer 3</td>
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<tr>
<td>Answer 4</td>
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<tr>
<td>Answer 5</td>
</tr>
</tbody>
</table>
This question aimed to check participants’ knowledge about basic Mechanics. Only 34% of the students chose the correct option. Yet, the fact that the first option was circled at a rate of 32.5% and that wrong answers were selected by the minority show that although students have an idea of what a lever is, they cannot make correct association with the function of the product.

3. Do you agree that the content of Physics instruction you have received throughout your education in Industrial product design department and the way it was presented to you has been useful? Please explain.

As can be seen from the graph in Figure 4, a great majority of the participants (94%) find the content of physics they received as well as they way it was presented to them as inadequate. The explanations mostly pointed to the fact that the Physics education given at universities was the continuation of the Physics education they received at high schools. The students saw the Physics instruction at university as a system based on memorization and problem solving, similar to high school instruction. To participants, Physics is lectured as a theoretical class and lacked practical work. From the explanations of the students of both ITU and MSGSU, it is understood that physics instruction does not have a content related to their occupation.

4. Choose your relation with physical laws and concepts during design process.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Answer 1</td>
<td>I do not think about the laws of Physics.</td>
</tr>
<tr>
<td>Answer 2</td>
<td>I do not need the laws of Physics.</td>
</tr>
<tr>
<td>Answer 3</td>
<td>I make use of my university education.</td>
</tr>
<tr>
<td>Answer 4</td>
<td>I make use of my high school education.</td>
</tr>
<tr>
<td>Answer 5</td>
<td>I significantly make use of both levels of schooling.</td>
</tr>
</tbody>
</table>

The answers students gave to this question are thought-provoking. 70% of the participants explained that they made use of the training they received at high school. Those who found the education given at university useful were only 8.5%. The rate of students who make use of both levels of schooling is 12.5%. While the rate of students who felt no need for Physics education was 11.5% at MSGSU, this option was not chosen by anyone at ITU (0.0%).
The findings gleaned from this question; the thoughts of students who learn product design at IPD Department at ITU prove that they are more inclined to the technical sphere of design.

5. Radiation in Infrared Heater, as One of the Many Researched Illustrations for Applied Physics Principles

Nowadays, heaters which target heating a certain area by using infrared waves are becoming more and more popular.

The heater needs the reflector to direct the light. The type of direction is directly related with the shape of the reflector. In the design of these heaters, being knowledgeable about the laws of basic radiation and about the basic features of electromagnetic waves could help the designer to canalize his/her thoughts quickly and accurately. Which of these reflectors below is the most suitable solution for a heater that uses infrared waves?
Table 3. Definition of products by the Physics laws/concepts in a morphologic box (or sense-separating matrix) provides examples for the students and gives an idea about what product operates with what physics law or concept.

<table>
<thead>
<tr>
<th>Product</th>
<th>Garden Shears</th>
<th>Car Headlight</th>
<th>Thermos</th>
<th>Table</th>
<th>Faucet</th>
<th>Infrared Heater</th>
</tr>
</thead>
<tbody>
<tr>
<td>Law or Concept</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Heat Transference</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lever/moment</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light breakage:</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snell’s Law</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light reflection</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ohm’s Law</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hooke’s Law</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the table above, various designs are put in a morphologic box along with related Physics laws and concepts with the objective to teach the principles of physics. Students’ preknowledge about what designs belong to what physics law may at first seem unnecessary for some. For instance, the rule of lever is related to the proportional length of the mouth and the arms in the garden shears, while with the diameter of the head in the faucet. And Hooke’s Law is have to be considered when determining about material choice, size and shape as the law deals with changing elasticity under load. All this information will help sustainable design in the future, with more conscious and safe designs that use fewer materials with more accurate details, and more economical designs that have fewer spare parts and are easier to produce.

6. Conclusion

In the scope of both the interviews made with the instructors and the survey administered to students, the results of the study put forth the following views and suggestions for consideration:

1. Physics should be given more with the help of examples from everyday life besides mathematical data and theoretical lectures.
2. Concepts of Physics should be supported with applied activities. For this purpose, it is essential that Physics should direct students’ thoughts usefully by showing when and how the rules and concepts of Physics are used with the help of objects of design.
3. Instructors teaching Physics at IPD Department should be knowledgeable about design, its process, safer and more economical products, should teach the application of Physics by giving examples and assignments and provide hands-on learning.
4. In product design project, necessary Physics knowledge should be taken into consideration along with the knowledge and skills from other technical and technological fields that are necessary in the project.

As Product Design is a field that is not composed solely of decoration, aesthetics, and pleasure, the requirements for the physical laws of functionality make it necessary to teach additional hours of Physics in a more conscious manner in IPD Departments.
References


