Table 1. Engineering-based courses in ID departments

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Engineering-based courses | Gazi Uni. | Middle East Technical Uni. | Istanbul Technical Uni. | Izmir University of Economics | Anadolu Uni. | Bahçeşehir Uni. | Marmara Uni. |
| Mechanics-based | Mechanism and Details |  | Introduction to Mechanical Design |  |  | The Way Things Work | Design Construction |
| Manufacturing-based | Manufacturing Methods | Principles of Production Engineering | Manufacturing Methods | Production Technologies | Manufacturing Methods |  | Production Techniques |
| Material-based | Materials | Manufacturing Materials | Statics & Strength of Materials | Materials for Industrial Design | Material Science | Manufacturing Materials | Material Technology |

Table 2. Summary of the courses

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Gazi Uni. | Istanbul Technical Uni. | Bahçeşehir Uni. | Marmara Uni. |
| Course Names | Mechanism and Details | Introduction to Mechanical Design | The Way Things Work | Design Construction |
| Learning outcomes | 1. Understand the basic mechanisms components2. Understand and interpret the mechanism and connection types3. Have full knowledge of exploded view and detail display through mechanisms4. Understand the place and contribution the solution of electronic circuits in mechanism5. Develop mechanism based problem solving | 1. Understand the fundamentals of mechanical systems2. Understand the physical principles of mechanical systems3. Understand the basic elements used in mechanical systems4. Develop the basic skills for analyzing existing mechanisms5. Develop the skills to find mechanical solutions during designing | 1. To identify assembling and disassembling procedures of objects in order2. To explain the circular movement, linear movement and ex-centric movement 3. To differentiate the elements of simple mechanics4. To apply the principles of simple mechanics to the new design of objects5. To compare various power sources6. To support the mechanics and working principles of objects with the renewable energy sources | 1. To evaluate design from a different perspective2. To examine about design development process and development of its applications3. To identify both design and engineering contexts about statics, dynamics and mechanics4. To analyze the basic principles of physics in the context of industrial design5. To explain the relationship between design and construction |
| Assessment Criteria | Midterm examFinal exam | Homework AssignmentsQuizzesMidterm projectFinal project | Homework AssignmentsQuizzesMidterm examFinal exam | Homework AssignmentsMidterm examFinal exam |

Table 3. Three categories of movement mechanisms

|  |  |  |  |
| --- | --- | --- | --- |
|  | Less complex | Complex | More Complex |
| 1 | Worm Wheel | Crankshaft-Rod | Cardan Gear |
| 2 | Sprocket Wheel | Bellcrank | Universal Joint |
| 3 | Belt-pulley | Camshaft | Geneva Drive |
| 4 | Bar-Pendulum Linkage | Drop/Snail Camshaft | Internal Geneva Drive |
| 5 | Double Pendulum | Scotchyoke | Planet Gear |
| 6 | Hoekens Linkage | Ratchet Wheel | Looney Gear |
| 7 | Ball Joint | Scissors Mechanism | Chuck |
| 8 | Gear Train | Scissors Jackscrew | Iris Diaphragm |
| 9 | Elliptical gear | Bevel Gear | Variable Speed Gears |
| 10 | Torsion Spring | Helical Gear | Anchor Escapement |
| 11 | Archimedes' Screw | Tusi-Couple | Ferguson’s Paradox |
| 12 |  | Centrifugal Governor | Withworth Mechanism |
| 13 |  |  | Barrel/Cylindrical Cam |

Table 4. Mechanisms assigned to teams

|  |  |
| --- | --- |
| Teams | Mechanisms |
| Team 1 | Centrifugal Governor |
| Team 2 | Drop/Snail Camshaft |
| Team 3 | Scotchyoke |
| Team 4 | Worm Wheel |
| Team 5 | Crankshaft-Rod |
| Team 6  | Universal joint |
| Team 7 | Archimedes’ Screw |
| Team 8 | Planet Gear |
| Team 9  | Ferguson’s Paradox |
| Team 10 | Iris Diaphragm |
| Team 11 | Camshaft |
| Team 12 | Geneva Drive |
| Team 13  | Cylindrical Cam |
| Team 14 | Withworth Mechanism |

Table 5. Submissions and timing

|  |  |  |
| --- | --- | --- |
| Project Phases | Week | Submissions |
|  | 1 | Team member selection |
| Theoretical knowledge of mechanism |  | Assignment 1-Research report on 3 mechanisms-Presentation of detailed technical drawings of mechanisms-Selection of 2 mechanisms per each team for further phase |
| Practical knowledge of mechanism | 2 | Assignment 2-3D modeling of two mechanisms in Fusion 360-Motion study of two mechanisms in Fusion 360- Selection of one mechanisms per each team for 3D prototyping |
|  | 3 | Assignment 3- 3D printed prototypes of the selected mechanisms |
| Application of mechanismMechanical Game Design | 4 | Preliminary Jury-Presentation of research, technical and perspective drawings-1/1 physical mock-ups |
|  | 5 | Final Jury-Presentation of research, technical and perspective drawings-1/1 physical model |

Table 6. Basic statistics of the results of post-project questionnaire part 1

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Total(n) | 1(%) | 2(%) | 3(%) | 4(%) | 5(%) | Total(%) | Mean | SD |
| Research | 37 | 10,8 | 10,8 | 37,8 | 24,3 | 16,2 | 100 | 3,24 | 1,188 |
| Technical drawing | 37 | 5,4 | 16,2 | 35,1 | 21,6 | 21,6 | 100 | 3,37 | 1,163 |
| 3D computer modeling | 37 | 2,7 | 2,7 | 8,1 | 29,7 | 56,8 | 100 | 4,35 | 0,949 |
| Animating | 37 | 0 | 13,5 | 21,6 | 27,0 | 37,8 | 100 | 3,89 | 1,075 |
| 3D printing | 37 | 2,7 | 10,8 | 16,2 | 27,0 | 43,2 | 100 | 3,97 | 1,142 |
| Creating concepts | 37 | 0 | 10,8 | 18,9 | 35,1 | 35,1 | 100 | 3,94 | 0,998 |
| Application to design project | 37 | 0 | 8,1 | 21,6 | 24,3 | 45,9 | 100 | 4,08 | 1,010 |

Table 7. Results of paired-samples t-test of post-project questionnaire part 3 (level of knowledge and competency on Autodesk Fusion 360)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Total(n) | Beginner(%) | Average(%) | Above average(%) | Expert(%) | Total(%) | Mean | SD | Sig. (2-tailed) |
| Before | 37 | 5,4 | 43,2 | 43,2 | 8,1 | 100 | 2,5405 | 0,730091 | ,000 |
| After | 37 | 2,7 | 21,6 | 62,2 | 13,5 | 100 | 2,864865 | 0,673390 |

Table 8. Results of post-project questionnaire part three (level of knowledge and competency on 3D printing)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Total(n) | Beginner(%) | Average(%) | Above average(%) | Expert(%) | Total(%) | Mean | SD | Sig. (2-tailed) |
| Before | 37 | 45,9 | 45,9 | 8,1 | 0 | 100 | 1,6216 | ,63907 | ,000 |
| After | 37 | 0 | 54,1 | 43,2 | 2,7 | 100 | 2,4865 | ,55885 |

Table 9. Basic statistics of the results of post-project questionnaire part four

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Total(n) | Strongly disagree(%) | Disagree(%) | Neutral(%) | Agree(%) | Strongly agree(%) | Total(%) | Mean | SD |
| Q1 | 37 | 2,7 | 5,4 | 8,1 | 32,4 | 51,4 | 100 | 4,24 | 1,011 |
| Q2 | 37 | 0 | 10,8 | 24,3 | 27 | 37,8 | 100 | 3,91 | 1,037 |
| Q3 | 37 | 0 | 5,4 | 10,8 | 35,1 | 48,6 | 100 | 4,27 | 0,871 |
| Q4 | 37 | 2,7 | 10,8 | 27 | 29,7 | 29,7 | 100 | 3,73 | 1,097 |
| Q5 | 37 | 8,1 | 24,3 | 37,8 | 16,2 | 13,5 | 100 | 3,03 | 1,142 |
| Q6 | 37 | 0 | 0 | 8,1 | 43,2 | 48,6 | 100 | 4,41 | 0,644 |
| Q7 | 37 | 5,4 | 13,5 | 13,5 | 40,5 | 27 | 100 | 3,70 | 1,175 |
| Q8 | 37 | 8,1 | 5,4 | 16,2 | 43,2 | 27 | 100 | 3,76 | 1,164 |
| Q9 | 37 | 0 | 8,1 | 13,5 | 40,5 | 37,8 | 100 | 4,08 | 0,924 |
| Q10 | 37 | 0 | 0 | 8,1 | 45,9 | 45,9 | 100 | 4,38 | 0,639 |