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A Research on Material and Manufacturing Methods Training in Industrial Design

Cemil YAVUZ[1,*], Nazife Aslı KAYA[2]

[1] 0000-0002-7715-3537, *Eskişehir Osmangazi University Faculty of Art and Design, Department of Industrial Design, Eskişehir*

[2] 0000-0001-8630-8919, *Eskişehir Osmangazi University Faculty of Art and Design, Department of Industrial Design, Eskişehir*

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Abstract

In the field of product design, a thorough understanding of the materials used is crucial. Materials should be thoroughly assessed and integrated throughout the entire design process, from its initial introduction to its eventual incorporation into the final product. Typically, material selection occurs towards the last phases of the product design process in Industrial Design departments. In other words, the product determines the material used. However, the material can also influence the product's design based on its properties and characteristics. Sustainability, aesthetics, and overall appeal are all influenced by the choice of materials and production methods. Therefore, careful consideration of these factors is imperative during product development. For novice designers, acquiring knowledge typically starts in higher education and continues throughout their professional lives. As inquisitive individuals, designers should strive to stay up to date with all developments related to technology and manufacturing, including newly produced materials.

In this research, an evaluation is carried out to assess the efficacy of the Materials and Production Techniques courses offered by the Industrial Design Department at Gazi University in the 2020-2021 spring term. A total of 148 first- and second-year students who enrolled in the course participated in research through online surveys. Upon analyzing the results, it was found that the second-grade students performed better regarding their knowledge of materials and manufacturing methods. Students' perceptions of products made with different materials were measured, as the sensory properties of the material were deemed crucial in addition to its structural and functional properties. The research was conducted with students who participated in the course during the period of distance education due to the COVID-19 and aimed to measure the effect of distance education on teaching material and manufacturing methods.

1. INTRODUCTION

As part of their education, students in the industrial design department must acquire knowledge of materials and manufacturing methods. Novice designers are responsible for selecting suitable materials for their projects, considering the materials' technical properties, manufacturing methods and sensory qualities. Contrary to designing around a chosen material, design students often select materials after the initial design phase. In some project-based courses, such as Design Studio or Product Design, it is not uncommon for the instructor to place limitations on the materials students can employ. As a result, students may be tasked with creating products that are well-suited for the specified materials. For example, a project course may require students to design a pencil holder using exclusively 8mm-thick MDF material and the manufacturing technique of laser cutting and shrink fit.

Materials engineers are constantly developing new materials by exploring their properties. Due to these advancements, the meanings attributed to materials, their accessibility, fabrication techniques, and costs are constantly evolving and refined [1]. Figure 1 displays a material known as Coffeefrom® Strong, produced in Italy, is a hard and high-temperature-resistant material consisting of high-density polyethene (HDPE), and coffee grounds can be given as an example of newly produced materials.

* Corresponding author: cemil.yavuz@ogu.edu.tr

***Figure 1.** Material Called Coffeefrom® Strong and Cups and Plates Made of that Material [2]*

As new materials continue to emerge, designers must remain current with the latest trends and techniques to enhance their knowledge and skills in design and production. According to Van Kesteren [3], two factors influence material selection. The first one is the technological aspects of the material, and the other one is the user interaction aspects. The properties of materials that determine their manufacturability and functionality are known as technological aspects, while their usability and the experiences of end-users are known as user interaction aspects. For example, while the durability of the material used in the phone's body, which falls under the technology aspect, affects the quality of the product, the texture of the phone's body affects how the user interacts with the device, for instance, a texture that prevents slipping while holding the phone and its brightness level can significantly impact the user's experience with the product. While deciding on the material for a designed product, considering both aspects can increase its success.

With the increase in product diversity and competition, companies and product developers have had to make an effort to differentiate themselves. While the sensory aspects of materials were not very important in the past, they have become a crucial factor for companies to stand out. Considering that the material is an intersection in product-user interaction, materials are a distinguishing factor in how a product appeals to the user's senses.

The significance of industrial design cannot be overstated across all fields of production. As the profession covers all areas of industry, designers and novice designers must possess the necessary knowledge of materials for successful production. In terms of production, engineers collaborate closely with industrial designers. Moreover, engineers are the predominant authors of the material literature. The knowledge needs of industrial designers and engineers differ in specific ways. Engineers focus on ensuring that the mechanical parts of materials have technical properties appropriate for the task at hand, while industrial designers approach their work in a user-oriented way, taking into account the multidimensional relationship between the material to be used and the people who will interact with it [4]. This research primarily explores the provision of training in materials and production techniques by Industrial Design departments, the influence of distance education on these courses, and the significance of sensory factors in material decision-making. The research is limited to Turkey.

1.1. Factors Affecting Material Selection

The choice of material in a product determines how that product will be produced, how it will affect the product's function and how the user experience will be shaped after its interaction with the user. To gain a thorough understanding of how design choices influence the user experience, designers must adopt a multidimensional perspective. This involves considering not only the functional aspects of a product but also its aesthetics and the perceptions and emotions it evokes in users. Through meticulous material selection and deliberate design decisions, designers can craft products that excel not only in functionality but also in visual appeal and emotional resonance with users. Selecting suitable materials for product design can pose a significant challenge. It involves considering various factors such as functional requirements, production limitations, economic feasibility, environmental impact, material properties, and cultural significance, which are often interdependent and linked [5]. There are five main factors that designers consider when selecting materials for a project: functional properties, structural properties, cost, production suitability, and sensorial properties (as shown in Figure 2).

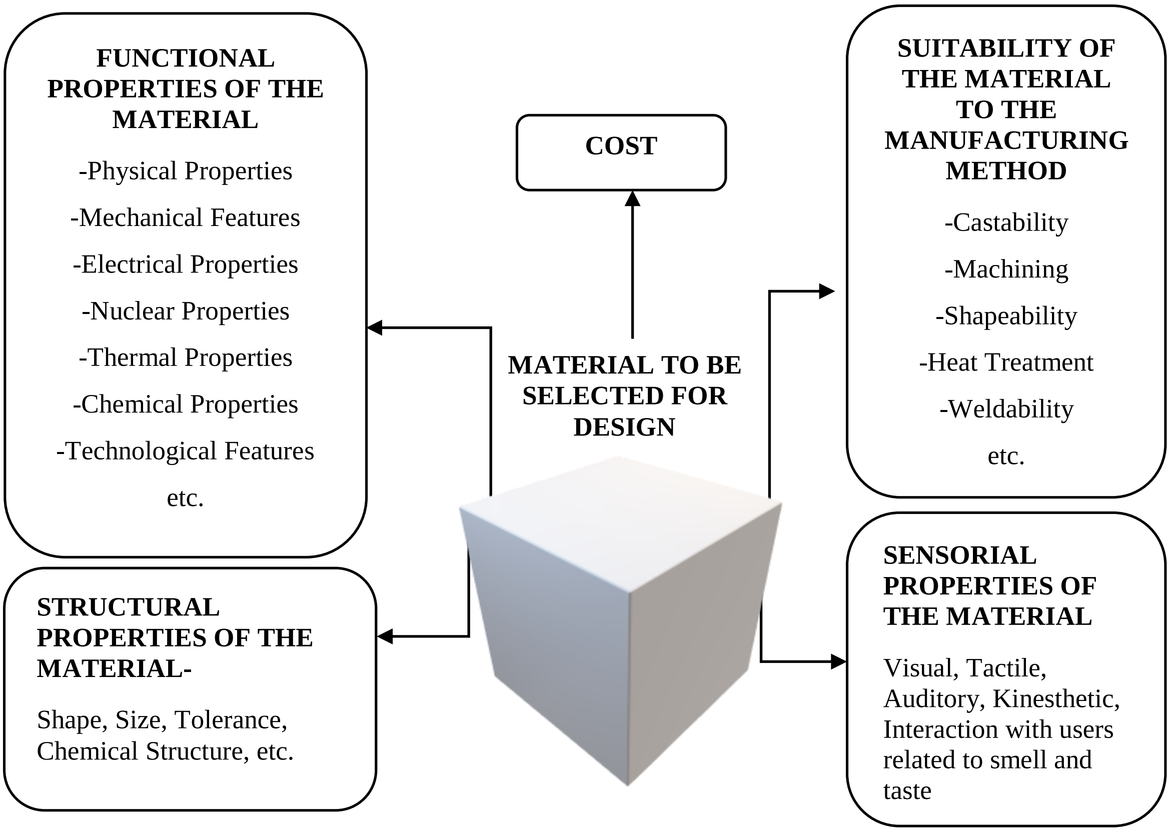


Figure 2. *Factors Affecting Material Selection*

Instructors in the industrial design course assess the material selection choices made by students concerning the products they create. However, the selection of materials within the industry has far-reaching effects on product cost, sales, and production methods. Yet, the material choices made by the designer students during the education process can only affect the student's grades. Students who create a product prototype using the actual materials can learn whether their design suits production because they will gain firsthand knowledge of the material's tolerances and suitability for the production method. Due to current economic conditions, students face challenges acquiring materials for their product designs. Therefore, students prefer to make the models of the products they present in their projects using materials such as cardboard, MDF, and styrofoam rather than the polymer or other industrial materials they propose. The cost of materials and suitable production conditions for a specific production method, such as using an injection moulding machine to produce phone covers made of polymer material, can significantly impact the success of using recommended materials. In addition to the education they receive, students also prefer to research information about materials and production methods on the Internet. It is possible to access many videos on YouTube about the production methods of almost all materials. In order to facilitate material selection during the design process, on sites such as Materially (www.materially.eu), MaterialConnexion (www.materialconnexion.com), material samples from many design agencies can be accessed. Pagev (https://pagev.org/plastik-cesitleri) is one of the websites where you can get information about polymer types.

1.2. The Place of Material in Industrial Design Education

Many universities in Turkey currently offer industrial design programs to students interested in pursuing this field of study. The education in these departments commences with project-specific basic design courses and progressively broadens its scope as students advance through semesters. Material knowledge is essential in Basic Design education, where practices are similar to the Bauhaus education. The Materials and Manufacturing Techniques course taken in the departments also interacts with other courses that involve production (such as model, model making, and studio courses). The curricula of the top three ranked state and private Turkish universities were compared based on their acceptance of students with the highest scores on the 2023 Higher Education Entrance Exam for Industrial Design programs in Turkey. The courses and semesters they deliver for material education are given in Table 1. The courses were spread over three semesters (Material and Manufacturing Techniques 1-2-3) at Gazi University Industrial Design Department, where the research was conducted.

Table 1. *Material Courses and Semesters Given in Industrial Design Departments of State and Foundation Universities*

Name Of University	Name of Course	Course Period
METU / State University	Principles of Production Engineering	3. Semester
	Manufacturing Materials	4. Semester
İTU / State University	Materials in Design	2. Semester
	Strength of Materials	
	Manufacturing Methods	3. Semester
Mimar Sinan University / State	Material and Manufacturing Methods-I	1. Semester
	Material and Manufacturing Methods-II	2. Semester
TOBB ETU / Foundation	Material and Manufacturing I	2nd Year Summer Term
	Material and Manufacturing II	2nd Year Fall Term
Özyeğin University / Foundation	Statics and Strength of Materials	1. Semester
	Material and Production	3. Semester
Bahçeşehir University / Foundation	Production Materials I	2. Semester
	Production Materials II	3. Semester

Although the names of the courses differ from each other, they are similar in terms of content. When the objectives of the courses are examined, it is aimed to create and develop awareness and broad knowledge about selecting materials and production processes suitable for various industrial design projects. Topics such as properties of industrial materials (including plastics, metals, woods, composites, glass, and ceramics) and manufacturing methods, complementary finishing processes and joining methods are also included in the contents of the courses.

1.3. Methods Used in Materials and Production Techniques Training

Methods and approaches employed in industrial design education to impart material knowledge can be categorized and explored under three primary headings.

• Theoretical methods: These methods include traditional teaching tools such as lectures, books, presentations and seminars explaining the basic concepts, physical properties, classification and selection of materials science [6].

• Applied methods: These methods include interactive learning tools such as workshops, laboratory experiments, prototyping activities and industrial visits that link material knowledge with design practice.

• Creative methods: These methods include innovative learning tools such as project-based learning, problem solving, scenario building and gamification that integrate material knowledge with design creativity.

While there are thousands of materials available globally, it is only feasible to cover a select few in a single course. Furthermore, it is not sufficient for students to memorize the names of the materials; they are also expected to learn the appropriate production methods for each material. In addition to these, as mentioned in the introduction, knowing the sensorial properties of materials is one of the requirements for correct material selection. Material training is delivered through the courses listed in Table 1. However, the education about materials continues in other courses as well. Courses such as Model/Mockup Making, Mechanisms and Detail, and Project courses are the ones where materials and production methods are thoroughly examined and discussed.

Practical methods in materials education are constrained by the resources available within university departments, including laboratories and workshops. Model Making is a course in which students can shape accessible materials to them and physically experience the products they design by making them three-dimensional. The same applies to making models or prototypes of the products they developed in the project course. The students' design process initiates with paper sketches, proceeds with computer modeling, and culminates in the creation of a three-dimensional prototype once the final product is determined. Since the design process is a process that needs to progress with improvements, students can physically experience ergonomic factors with the model they have developed and revise it if necessary. Engaging with the product relies on our senses coming into contact with the materials used in the product. Students observe the colours of materials, feel their texture and weight, and hear the sounds they make. Therefore, conscious use of materials is vital to create these sensorial perceptions. [7]. Learning by doing will be more memorable for students. Product development is more likely to reach new ideas by touching and holding, that is, by practising [8]. In his thesis, Derviş [4] proposed the establishment of a materials studio in a dedicated physical space for higher education-level materials education. He describes the studio as an application-based studio environment where the material course can be carried out in parallel with the project course, where technological developments in materials can be closely followed, students can interact with concrete materials, and material and product examples can be learned by experience.

Figure 3. *Use of Material Information Cards for a Design Project [9]*

Creative teaching methods in materials education are less common compared to traditional methods. While knowledge transfer is mainly preferred through books, presentations or videos, recently, with researchers' suggestions, educators have also preferred methods such as gamification. An example of a creative application can be seen in the material cards developed by Kesteren [9], depicted in Figure 3. On one side of the cards, there are visuals of products made with that material, while on the other hand, there is a surface where they can experience the material sensually. In this way, it is ensured that the user interacts with the material visually and tactilely.

1.4. Distance Education in Industrial Design Education

New tools are seen integrated into educational processes with the developing information technologies. As a result of the widespread use of the Internet, the software developed, and the new opportunities brought by the digital age, in many areas, business is carried out over computers or phones. Rather than physically going to markets or stores for shopping, people now meet their needs by ordering online. While it used to be necessary to go to educational institutions or other physical locations to take courses, it is now possible to access the desired courses online at a desk. While information technologies undeniably simplify human life, it's also a reality that they decrease face-to-face communication and tangible interactions. Digital platforms that offer online education provide cost-effective courses that can be accessed anytime and anywhere, breaking away from the confines of traditional classroom-based education [10]. The COVID-19 pandemic compelled higher education institutions to embrace distance education as a mode of instruction. While distance education was previously an option, it became mandatory during the pandemic. All university departments, including Industrial Design, were required to switch to remote learning. To ease this transition, universities implemented distance education software and communication tools like Zoom, Microsoft Teams, and Google Meet to maintain connectivity with students.

Numerous academic studies have delved into distance education and its effects on practical courses. In a recent research study examining the feasibility of distance education in practical architecture courses, specific queries were conducted. According to the study, 64% of the students reported difficulty learning new information related to practice in applied courses, such as technique and structure. Furthermore, 68% of the instructors reported difficulty teaching these courses [11]. These findings illuminate the difficulties encountered by students and instructors in practical courses conducted via distance education. Similarly, in a study examining students' satisfaction in their fields, it has been observed that the "Higher Education Council Satisfaction" of the students in health sciences and engineering, where applied sciences courses are intense, is relatively low compared to other fields. [12]. In programs like Industrial Design and Architecture, where hands-on practical courses are intensive, the foundation is built upon design, development, and production steps. 'Learning by doing' is a method that actively involves students in material exploration and the developmental phases of building projects, bridging the gap between theory and practice to enhance comprehension and experiential learning [13].

2. METHOD

The method used in the research is explained under the headings in this section.

2.1. Purpose and Sub-Problems of the Research

This study aims to examine the distance education process during the COVID-19 pandemic period from the perspective of undergraduate students and to measure the differences in learning and sensorial approach between classes in the Materials and Manufacturing Methods course. For this purpose, answers to the following questions will be sought:
- What difficulties were encountered in Materials and Manufacturing Methods-I and Materials and Manufacturing Methods-III courses during distance education?
- What are the students' cognition levels about materials and production methods in design during the distance education period? Is there a significant difference between 1st and 2nd-year students?
- Is there a significant difference between students at different education levels in sensorial interaction, which is one of the factors affecting material selection?
- What are the students' views on teaching the Materials and Manufacturing Methods course?
- What are the students' views on the effectiveness and efficiency of the distance education process?

2.2. Research Design

Case study design, one of the qualitative research methods, was used in this research. The distinctive feature of a qualitative case study is to investigate one or multiple situations thoroughly [14]. A case study can be defined as a method in which one or more events, environments, programs, social groups, or interconnected systems are examined in depth. [15]. This study aimed to gather feedback from undergraduate students who enrolled in Materials and Manufacturing Methods I and Materials and Manufacturing Methods III courses during the distance education period. The students' opinions were collected through surveys and presented in tables and graphs after qualitative analysis. The student quotes were reported verbatim to maintain the authenticity of their feedback.

2.3. Study Group of the Research

A random sampling method was used to select the study group, with each unit in the population having an equal and independent chance of being chosen. The study group consists of first and second-year students of Gazi University, Faculty of Architecture, Department of Industrial Design. In the selection process for the study group, priority was given to those who received distance education during the COVID-19 pandemic. The research was conducted on first and second-year students to compare their knowledge levels. The data collected from 148 students who participated are shown in Table 2.

Table 2. *Data on the Students Who Participated in the Study*

	Female	**Male**	**Unwilling to Specify**	**Total**
1st Grade Students	51	14	3	68
2nd Grade Students	46	25	9	80
			General Total	148

To ensure anonymity of the participants, their names were coded as S1, S2, and so on, where S1 corresponds to Student-1.

2.4. Data Collection Tools

The data was collected through online surveys at the end of the Spring semester of the 2020-2021 academic year. The survey was divided into three sections, comprising a total of 19 questions. The first section contained four questions pertaining to students' opinions on distance education. The second section encompassed nine questions that focused on the level of education provided in the Materials and Manufacturing Methods course. Finally, the third section consisted of six questions that evaluated the sensorial approaches to the material and the product.

2.5. Analysing the Data

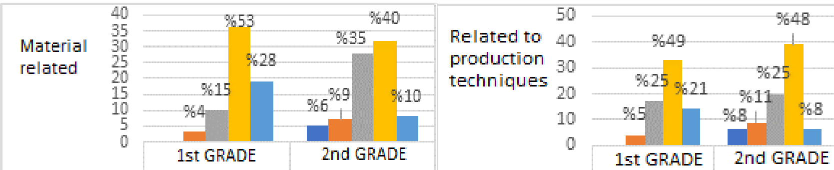
The numerical analysis technique of the qualitative data obtained from the forms was used to analyse the research data. Digitizing qualitative data is a form of data analysis, and qualitative data can be digitized by two methods: simple percentage calculations and word frequency calculations. [14]. The number of answers given to the close-ended questions in the survey within the scope of the research was transferred graphically. Since the text and imaginary data are dense in open-ended questions, in the analysis phase of the data, there is a need for a sorting process in which certain parts of the data are focused on and the rest of the data are ignored [16]. To process the data obtained from the open-ended surveys, the responses were categorized into different groups and analysed. The qualitative information is converted into quantitative data, measuring word usage frequency and relevance to the topic. The results were then presented in tables to make them easier to understand.
The research was conducted in four stages. The first stage involved digitizing the data from the close-ended questions. The second stage involved creating main headings and categories for the answers to the open-ended questions. The third stage involved digitizing the qualitative data based on the determined headings. The final stage involved identifying and interpreting the findings.

2.6. Validity and Reliability

The methodology ensured that the participants were guaranteed anonymity, providing a conducive environment for them to express their genuine opinions without any fear of repercussions. This approach is commonly employed in academic research to elicit authentic responses from research subjects.

3. FINDINGS

The survey's initial question aimed to determine whether courses during the period of distance education had improved the participants' understanding of materials and manufacturing techniques. The findings indicated that 81% of first-year students responded positively regarding materials, whereas the percentage dropped to 50% among second-year students. Figure 4 illustrates these results.



Material related	1st GRADE	2nd GRADE
Strongly Disagree	0	5
Disagree	3	7
Neutral	10	28
Agree	36	32
Strongly Agree	19	8

Related to production techniques	1st GRADE	2nd GRADE
Strongly Disagree	0	6
Disagree	4	9
Neutral	17	20
Agree	33	39
Strongly Agree	14	6

Figure 4. *Answers to the Question About Whether Their Level of Knowledge About Materials and Production Techniques has Increased*

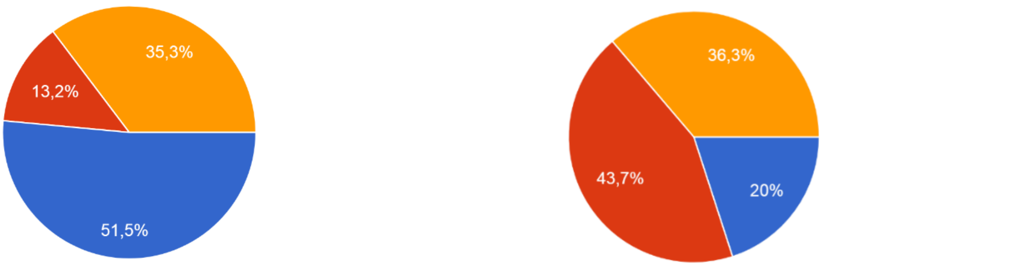
Regarding whether their knowledge of production techniques increased, 70% of the first-year students expressed a favourable opinion. In comparison, only 56% of the second-year students stated that their knowledge of this subject increased. While the ratio in materials was higher in first-year students than in production techniques, the situation was the opposite in second-grade students.

The second question was, "Do you think you have become competent on the following topics during distance education?" The answers are presented in Table 3. While 63% of the first graders expressed a positive opinion about choosing the suitable material, this rate remained at 55% in the second graders. Regarding the sensorial interaction between materials and users, 69% of first-grade students and 53% of second-grade students stated that their competence in this subject had increased. Considering that they receive education without touching the material in distance education, they consider sensorial interaction only in the visual dimension.

Table 3. *The Answers Given by the Students who Participated in the Research*

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
On choosing the right material;					
1st GRADE	1	6	18	37	6
2nd GRADE	5	6	25	39	5
In terms of designing in accordance with the Production Method;					
1st GRADE	1	6	26	28	7
2nd GRADE	4	10	34	27	5
On the topics that are effective in the design process					
1st GRADE	-	5	10	43	10
2nd GRADE	3	6	25	39	7
On the sensorial interaction of materials and users					
1st GRADE	-	4	17	33	14
2nd GRADE	3	16	19	34	8

The third question in the survey asked whether the course was delivered effectively during distance education. Among the first-year students, 35 answered yes, 9 answered no, while 24 were undecided. However, the second-year students had a lower rate of positive responses, with only 16 out of 80 students, or one-fifth of the class, answering yes, while 35 students answered no (as shown in Figure 5).



1st GRADE 2nd GRADE

Figure 5. *Answers to the Question About Whether the Material Course is Taught Effectively Through Distance Education*

In the first part of the survey, students were requested to provide their opinions on additional subjects that could be included in the materials course. The feedback was analysed and transformed into numerical data using common phrases and words (Table 4).

Table 4. *Students' Comments on What Could be Done in Addition to the Teaching of the Course*

1st GRADE	N	2nd GRADE	N
Seeing the materials in their true form	10	Learning by touching and experiencing materials	8
Learning production methods not by watching videos but by practicing them	6	The practical part of the course should be increased	5
More space should be given to video lectures	4	Applications on examination and observation should increase	3
Seeing production methods in the factory, i.e. on site	3	Learning on site by organizing technical trips to factories	3
Longer lesson duration may be given	3		

Upon reviewing Table 4, it becomes apparent that the students preferred a more hands-on approach to learning, with 10 in first-year and 8 in second-year students stating that tactile and experiential learning would be more advantageous. Additionally, many students felt that the course should incorporate more practical components. Some opinions on this subject are as follows:

Opinions of 1st grade students on the subject:
S1: "For the information learned in the course to be more effective and memorable, the course should be held in places with materials related to the subjects covered."
S2: "In addition to the material course, with some activities in which we examine the products around us and try to determine the materials, we can be more active in some classes."
S3: "To be able to actually see the materials in order to understand them better, also to apply production methods"

Opinions of 2nd grade students on the subject:
S4: "The application [of materials] phase of the course should be increased since there is too much information, and it is challenging to keep all in mind with only narration and visuals. Nevertheless, it is also impossible to practice due to the pandemic."
S5: "I think that one-to-one contact with the material is important in terms of comprehending this course and gaining competence."
S6: "To better analyse and comprehend the functioning of machines and products, in addition to this course, a lab (laboratory) course can be taken under the name of material course."

The second part of the survey aims to assess the level of learning in Materials and Manufacturing Methods course by asking specific questions about products shown in Figure 6.

Figure 6. *Product Images Used within the Scope of the Research*

In the first six questions of the second section of the survey, questions were asked about the materials or production methods of the products in Figure 6, and the answers given are presented in Table 5.

Table 5. *The Answers Given by the Students to the Questions Asked About the Materials and Production Methods in the Products*

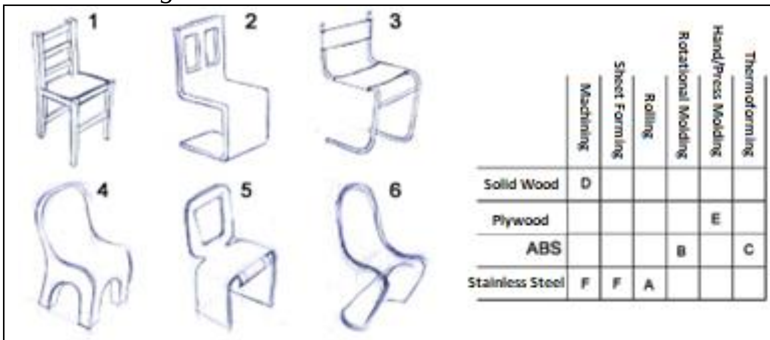
	1st GRADE	N	2nd GRADE	N
 What material is the toy in the figure made of?	Wood (MDF, chipboard, solid, etc.)	42	Wood (MDF, chipboard, solid, etc.)	40
	Polymer (PS, PA, ABS, PP, vs.)	26	Polymer (PS, PA, ABS, PP, vs.)	33
	No comment	-	No comment	7
 What material is the body of the bicycle in the figure made of?	Metal (Steel, Aluminium, iron, etc.)	34	Metal (Steel, Aluminium, iron, etc.)	55
	Polymer (ABS, polyurethane, nylon, etc.)	17	Indicating Production method instead of material	3
	Composite (carbon fiber, etc.)	14	Composite (carbon fiber, etc.)	19
	No comment	3	No comment	3
 What material are the pitchers and cups in the figure made of?	Ceramics (Porcelain, clay, etc.)	43	Ceramics (Porcelain, clay, etc.)	71
	Polymer (ABS, melamine, PC, etc.)	13	Polymer (ABS, melamine, PC, etc.)	3
	Wood (bamboo, etc.)	7	Wood (bamboo, etc.)	4
	No comment	5	No comment	2
 Which material are the glasses in the figure made of?	Glass	43	Glass	67
	Polymer (plexy, polycarbonate, SAN, etc.)	23	Polymer (plexy, polycarbonate, SAN, etc.)	9
	No comment	2	No comment	4
 Which production method was used to produce the lighting element in the figure?	Daubing	2	Daubing	10
	Other (casting, injection, plate bending, etc.)	30	Other (casting, injection, plate bending, etc.)	32
	Specifying material instead of production method	17	Specifying material instead of production method	23
	No comment	19	No comment	15

Table 5 (Continue). *The Answers Given by the Students to the Questions Asked About the Materials and Production Methods in the Products*

	1st GRADE	N	2nd GRADE	N
 Which production method was used to produce the product group in the figure?	Various answers (carving, laser, whittling, molding, etc.)	31	Various answers (CNC, carving, laser, whittling, molding, etc.)	47
	Specifying material instead of production method	20	Specifying material instead of production method	17
	No comment	17	No comment	16

The last three questions in the second part measured students' knowledge of materials and production methods. The questions are selected from the book Materials and Design by Ashby and Johnson [17]. Students were given a table of products and asked to match them with their corresponding material-production methods. The answers given are presented in Table 6. G1 represents the answers given by the first-year students, and G2 represents the answers given by the second-year students. The data of the two of these three questions will be shared in the conclusion section, and the answers will be discussed in this section.

Table 6. *The Answers Given by the Students to the Questions Asked About the Chair-Material-Production Method Matching*



*** Note:** The ones marked with yellow means the correct answer.

	A		B		C		D		E		F	
	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2
Chair number 1:	3	6	1	3	1	-	**59 %87**	**67 %84**	3	4	1	-
Chair number 2:	19	10	11	16	4	3	4	2	20	34	**10 %15**	**15 %19**
Chair number 3:	**13 %19**	**32 %40**	5	6	4	7	1	4	5	4	40	27
Chair number 4:	3	5	**25 %37**	**45 %56**	24	13	1	5	11	8	4	4
Chair number 5:	12	13	9	7	12	11	2	3	**18 %26**	**16 %20**	15	30
Chair number 6:	9	6	16	16	**30 %44**	**46 %58**	1	4	5	3	7	5

Six questions were asked in the third part of the survey to evaluate sensorial approaches to the material and the product. The study selected ten groups of opposing adjectives from the book Materials and Design by Ashby and Johnson [17] to help measure the sensory aspects of the materials and the product. Participants were asked to describe their sensory experiences based on the products shown in the previous section. The results showed that most first- and second-year students selected similar adjectives for five out of six products. Therefore, Table 7 only shows the data for the product where the students expressed different opinions based on the adjectives they chose.

Table 7. *Selected Groups of Adjectives given to Measure Sensorial Approaches*

	1st GRADE	2nd GRADE		1st GRADE	2nd GRADE
Aggressive	38 (%56)	37	Passive	30	43 (%54)
Cheap	49 (%72)	47 (%59)	Expensive	19	33
Handmade	4	7	Mass Production	64 (%94)	73 (%91)
Witty	36 (%53)	38	Serious	32	42 (%53)
Nostalgic	56 (%82)	63 (%79)	Futuristic	12	17
Disposable	6	3	Permanent	62 (%91)	77 (%96)
General	55 (%81)	75 (%94)	Personalized	13	5
Fancy	55 (%81)	63 (%79)	Simple	13	17
Sensitive	47 (%69)	63 (%79)	Sturdy	21	17
Honest	43 (%63)	55 (%69)	Deceptive	25	25

The product received different feedback from first-year and second-year students in two adjective groups. Most first-year students described the product as aggressive, while second-year students characterized it as passive. Additionally, there was a difference in how the students perceived the product in terms of humour and seriousness. Specifically, 53% of first-year students found it humorous, while 53% of second-year students perceived it as serious.

4. CONCLUSION, DISCUSSION AND RECOMMENDATIONS

When choosing a suitable material for a product, it is crucial to consider various factors such as production limitations, weight, and texture. More than simply stating metal, wood, or plastic is required. For instance, metal can refer to different materials such as steel, aluminium, or copper. Therefore, it is crucial to carefully assess whether a material is suitable for the intended product by considering its specific properties and characteristics. Different materials are also used in 3D printing technologies. Recently, the prevalence of 3D printing technologies in the construction sector and architectural applications has increased significantly, and it is seen that cement-based materials are used in 3D printing technologies in the construction sector [18]. Materials have different properties and can be used for different purposes. Some materials can be welded, while others cannot. Some can be moulded, while others cannot. These differences also apply to other material groups. Therefore, selecting the appropriate material requires understanding its functional and structural properties, production methods, cost, and sensory properties. According to Zuo [19], materials' sensory properties exhibit objective and subjective qualities. While physical attributes like colour and texture can be measured objectively, perceptions of softness, roughness, heat, and coldness are subjective and influenced by personal experiences.

The verbal, written and visual materials used during a project process, the way the course runs, the physical equipment of the studio, the communication, interaction and criticism between the student-instructor and their peers constitute the studio culture [20]. Therefore, face-to-face interaction is important not only in materials education courses but also in product design studios. In the context of this study, the factors affecting the selection of the material, training on materials and production techniques in higher education and the impact of distance education on materials education were examined. Materials education is given to design students more as a technical subject, so issues related to design, such as user experiences and context, are often not considered much [1]. Distance education predominantly depends on visual perception, lacking the provision of materials for auditory and tactile perception. Furthermore, the effectiveness of distance education in applied courses still needs to be satisfactory. The lack of connectivity infrastructure in rural areas and the challenges faced by underprivileged students who cannot afford computers raise concerns about equal opportunities.

According to research conducted among students, the overall evaluation of the findings indicates that first-year students perceive the course materials as effectively presented through distance education. Conversely, second-year students hold a different perspective. This suggests that while theoretical aspects of the course may suffice at the first-year level, as the course delves into practical applications in the second year, it becomes crucial to equip students with both practical information and theoretical knowledge. More than half of the students participating in the study believe that learning about materials and production techniques through distance education is efficient. However, some of their answers raised doubts about this statement. The second part of the study allows for insights based on responses to three questions related to matching materials and production methods.

As for the chair-material matching question, most students in both grades correctly answered chair number 1. However, only second-year students provided correct answers for chairs 4 and 6, with accuracy slightly exceeding 50%. The percentage of correct responses for the remaining three chair-material pairings stayed below 50% for both grades. Similar patterns were observed in the questions about bicycles and opener products. Neither class achieved over 50% accuracy on five different bicycle examples. A similar trend was observed for the opener question. Overall, regarding all three questions, second-year students had a proportionally higher rate of correct answers, with 9 out of 15 matching questions answered correctly. In 5 questions, first-year students answered at a higher rate than second-year students, while they had the same rate in 1 question. Since the number of material education courses taken by the second-year students is higher than the first-year students, it can be considered normal that the ratios are found this way.

Hence, even though students reported an increase in their knowledge levels, distance education may not be highly effective in material learning. It is anticipated that students may struggle to differentiate between similar materials, such as plastic-coated wood and glass-plastic when their judgments rely solely on product images without physical interaction. Therefore, the sense of touch, one of our five senses, is crucial for assessing material quality.

The responses provided by students when evaluating products solely based on digital images lack consistency and clarity in perceptual associations. This suggests that multiple factors, including culture and environment, play a significant role in shaping individuals' perceptions. In the case of bicycles, common associations are more widespread compared to other products. A successful design should have the capacity to resonate with a diverse audience due to its distinct product identity and character. The ability of individuals to connect with a product on a sensory level signifies that the designer's intended message has been effectively conveyed and received.

Educators should stay informed about emerging materials and share innovations with their students. Design students are often characterized by their curiosity and inquisitiveness, which makes them enthusiastic learners. They should acquire knowledge through practical experience rather than mere memorization to ensure a lasting understanding of the subject. This approach enables them to develop a profound grasp of the material and apply their knowledge effectively in real-world contexts. Consequently, design students who adopt a hands-on approach to material properties tend to make more well-informed decisions regarding suitable materials and production methods for their designs. They can establish more consistent and decisive design choices by developing a profound understanding of the material rather than merely observing it from a distance.

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