# USABILITY OF A MATERIAL SELECTION TOOL FOR ARCHITECTURE STUDENTS AS A SUB PROCESS OF BUILDING ELEMENT DESIGN

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**ABSTRACT**

Material selection as a sub process of building element design is a hard task especially for the architecture students with a minimum material knowledge. In order to overcome such a problem one of the approaches is the use of methodical support tools within the process. With respect to that approach a systematic material selection tool is developed. The material selection tool intends to define the main steps of the process and to guide the students. In order to investigate the usability of the tool and for further development, the tool is applied by the 2nd year architecture students in Bilgi University as a part of their "Building Materials and Technologies" course and a usability questionnaire is conducted.
In the paper, firstly the methodology of the work is explained; the development process of both, the "material selection tool" and the questionnaire. Secondly, the relationship of the material selection process with the architectural detail design process is issued. The application of the tool is stated and finally, the results of the conducted usability questionnaire are presented and discussed.

**Key words**: Material selection tool, Building element design, Architectural education

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## 1. INTRODUCTION

Selection of the “right” materials satisfying the expected performances is significantly important for any design. Today, with the constantly evolving and developing technologies, there are more than numerous options of materials to be used in an architectural design. In such a wide material “pond” it is even more crucial to make the “right” choice of materials. At this point, the necessity of the use of some support tools is arising, therefore the necessity of being more systematic.
The material selection tool that is to be developed has to systematize the “intuitive approach” in material selection process. The issued material selection tool is mainly developed for educational purposes and trying to show a more methodic way of material selection in architectural detailing for the use of architecture students with the minimum knowledge of materials. What are the encountered problems of an architecture student in a material selection process of detail design? How could this process be systematized? How could the material selection process become more practical? For that purpose, the existing “methodic approaches” for the material selection process has to be examined, simplified and transformed to be more “practical” with the addition of a data base usage. The developed tool should be setting the basic steps of material selection process in architectural detail design, aiming to be guiding, easily applied, fast, and result oriented.

## 2. METHODOLOGY

The steps that are followed in this work starts with a literature review. Existing material selection tools are researched and examined. A main flow chart of the "material selection tool" has been developed via those. After a research on the data bases the tool is adapted to be used with a selected data base. The application stage of the tool will be explained in detail at the following sections. In pursuit of that, a usability questionnaire is conducted. Finally according to the evaluation of the results the tool is rearranged.
The methodology for developing the "material selection tool" and the usability questionnaire are explained in detail at the following.

### 2.1. Developing a "material selection tool"

The methodology used in developing of the "material selection tool" starts with researching and examining the existing material selection methods and design supporting tools. During this step there were methods examined such as; Sneck’s method (Sneck et al. 1969), Cronberg’s method (Özkan 1976), Lohaus and Steinborn’s method (Fouad 2013), Müller’s method (Cziesielski 1990), Ashby’s method (Ashby and Johnson 2002), Japanese method (Japanese 1968) and Balanlı’s method (Balanlı 1997). The methods were applied on some example cases and their usability was compared through pilot studies. All the strong and weak attributes of each method were evaluated.

Briefly, Sneck's method and Cronberg's method only deals with the definition process of the material properties and does not define a decision process. Sneck defines the material properties from a performance based model (Sneck et al. 1969), on the other hand, Cronberg defines them from a user based model (Özkan 1976). Lohaus and Steinborn's method describes the material selection as an "iterative" process and defines the factors that are effective and expected to be taken into consideration during the material selection (Fouad 2013). Müller's method is based on defining the requirements affecting the selection process (Cziesielski 1990).
All the methods explained so far are developed to be used in architectural design. Different from those, Ashby's method is a practical and visual method from an industrial designer point of view (Ashby and Johnson 2002).
One of the examined methods was the research of the Japanese Research Group in 1968, which could be considered the most comprehensive and systematic method for selecting building materials and therefore the main inspiration for the developed "material selection tool". The method comprises the whole material selection process, from defining the material properties to their comparison and selection (Japanese Research Group 1968).
There are several later works that have used the Japanese method and developed further; such as, Ayşe Balanlı's work on the material selection process in a building. The main structure is similar with the Japanese method, but it also investigates the relations of a material and the building element and also states a more strict way for the evaluation and selection of the material (Balanlı 1997).
Regarding to the examination of the existing methods and tools the main structure, the main flow chart of the "material selection tool" is formed. The struggle here was to create a tool that is simple enough to be used by a designer with minimum material knowledge but still leading the designer to the "right" choice in the most practical way. In order to achieve that goal, there arises the necessity to use of a data base which has to be compatible with the main system of the "material selection tool". However, none of the existing material selection methods includes a data base or suggests the use of any data base. An exception is Ashby's method which is related to industrial design. So, after a research of existing data bases and testing their compatibility with pilot studies, the steps of the developed "material selection tool" is adapted to be used with a selected data base, in this case, Material Connexion. This data base has been chosen because of the possibility of different ways of searching and filtering and because of its wide material pond which is close to 70.000. It's accessibility via the library of Bilgi University from free of charge was also a motivation. From the examined other data bases; Yapı Kataloğu and Materia were also free of charge and compatible to be used with the tool, however they were found either not sufficient for their filtering options or their material pound. Therefore the usage of Material Connexion within the material selection process was encouraged through the application.

**2.2. Developing a usability questionnaire**

When approaches of data collection are examined, questionnaires are the fastest technique at gathering information from large groups (Naoum 1999). For that

reason questionnaires were preferred in order to gather information on the usability of the "material selection tool".
On the other hand, monitoring the design process is a problematic task, since the design process of every individual is different from each other. According to David Yeomans commonly the design process of a building could be in four stages as; briefing, sketch design, development, detailing and construction (Yeomans 1982).
The material selection tool is explained to the students and they were asked to use the tool in their architectural detail design processes. An artificial problem is created and briefed to the students, and asked them to make their designs following the defined steps; the given problem and steps are explained in detail at the following sections. As all students were working on the same design problem and with pre-defined design steps, the usability of the material selection tool could be measured in a controlled environment.
The whole design process of the students was observed. During the designing stage some face to face interviews were conducted randomly and some initial feedbacks were taken. The usability questionnaire conducted afterwards is to gain feedbacks about the experiences of the students while making their material selections. With respect to the obtained results of the conducted pilot questionnaires and interviews, the questions took their final form.
The developed questionnaire has two purposes; obtaining data about the material selection process of the students in general and using the developed "material selection tool" with a data base. Therefore the questionnaire has two parts. The first part is applied to all students of the course and the second part was answered by students who used the proposed data base.

## 3. A MATERIAL SELECTION TOOL AND DATA BASE

In architectural design process first of all, some basic decisions are made at the building scale; about the structural system, organization of space and mass setup of the building. Generally due to some structural and aesthetic reasons some ideas of material use begins to arise in the designers mind. However, the material ideas in this step should not be directly affecting the material selection process. Designer has to be objectively examining the performance requirements of the building elements and making his selection of material due to satisfy these requirements. Aesthetics would be an inevitable parameter during the process, but should not be the leading one. Relations of the aesthetics and the material selection process are shown in the main flow chart of the tool [Figure1].
Performance requirements of the building elements are determined with respect to the using scenario of the building, therefore the user requirements and environmental factors affecting the building, like climatic conditions. After the performance requirements are determined for the building element, these transform into expected requirements from one layer of the building element. For instance, the transformation of the requirements of a floor system into the requirements of the coating layer of the floor. At this point from a “generic layering” each performance requirement of the building element are assigned to a layer. One requirement could be satisfied by two or more layers at once or one layer could

satisfy two or more requirements. Therefore the assigning should be carefully made with the consideration of the whole element.
When the performance requirements of the layers are determined there has to be another transformation to the expected properties of material that will be used in that layer. For instance from the coating layer example, it has some fire related requirements which could be satisfied by using a material having non combustible property.

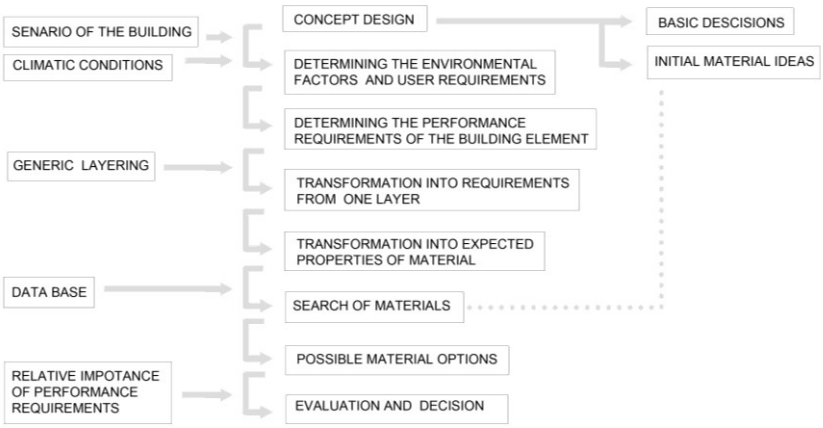



Figure 1. Main flow chart for the "material selection tool", developed based on Japanese's and Balanlı's methods.

From this point, the search for materials with the expected properties begins. Since the students have minimum material knowledge in this step the use of a data base is crucial. How the search would be conducted through the data base is optional, but the main usage is projected as searching from a key word or from the origin of material or from material properties. Designers are expected to find several possible materials and narrow down the material options.
As the final step, there has to be a decision process. The listed requirements from the layer are arranged according to their "relative" importance. Starting from the most relatively important requirement, all the possible material options are examined and by using an elimination technique the most suitable material, the one that satisfies the most relatively important requirements, is envisioned to be chosen. In order not to limit the designers, the decision steps have not been dictated with strict rules. Designers let to choose freely according to their different perspectives, as long as the chosen material satisfies the performance requirements.

## 4. USABILITY OF THE "MATERIAL SELECTION TOOL"

The developed "material selection tool" was explained to the 2nd year architecture students in İstanbul Bilgi University and they were encouraged to use the tool in

their architectural detail design processes as a part of the "Building Materials and Technologies" course. For the course, students were obliged to design a "housing+" for one or two person to live, on an island that they previously designated the environmental conditions. The building has to include areas for living, sleeping, dining, cooking, bathing and a plus function, such as an activity area for photograph, design, art, music, dance...etc. As a part of their design process, they were to choose the floor covering material of one of the floor systems in their "housing+" design by using the explained material selection tool.
Designing typical area details of the buildings elements was a mandatory task of the course. Students have to determine the performance requirements of the building element and appoint a function to each layer. Therefore, they were investigating the relations of the element and its layers. From that point they were to;

- transform the performance requirements of the layers to the expected properties of material,
- search for materials (Material Connexion was advised to be used as a data base, but it was not mandatory),
- list possible material options,
- evaluate them with respect to the relative importance of the performance requirements,
- decide on a material.

## 5. RESULTS

During the whole process the usage of the developed "material selection tool" as a part of building element design is observed. The initial feedbacks from the random face to face interviews shows that since this is probably the first time that the students uses such a methodic tool, they have been skeptical and showed propensity to skip steps. The usability questionnaire conducted at the end of the process has two parts, evaluation of the material selection process in general and material selection process by using the Material Connexion data base within the developed material selection tool. The obtained results are presented and discussed at the following.

### 5.1. Material selection process in architectural detailing

94 students answered the questionnaire about the material selection process as a part of building element design.

When asked as follows; *which of the following(s) explains the way you use in your material selection process as a part of building element design? (Multiple options can be marked)* The distribution of the answers is given in the following [Figure2]. According to obtained results; 28% of the students *investigate materials that would satisfy the performance requirements*, 20 % tend to make their material selections by *examining the materials used in the similar projects* and another 20 % *consult to friends or professors who assumed to have knowledge on the subject.* 14 % of

the students *tend to choose the materials that they already know* and only a few of them consider the material being environmentally friendly or economic.
Results obtained from this question is crucial, because even thought the whole material selection process planned to be shaped with the aim of satisfying the performance requirements two out of three percent of the students does not even consider them.

When asked as follows; *which of the following(s) you use as a tool in your material selection process as a part of building element design? (Multiple options can be marked)* The distribution of the answers is given in the following [Figure3]. According to obtained results; 26 % percent of the students prefer *using reference projects* as a tool in their material selection processes and 25 % prefer *searching over internet (using search engines, like Google..etc.).* 18 % mentions *using data bases, like Material Connexion, Yapı Kataloğu..etc.*

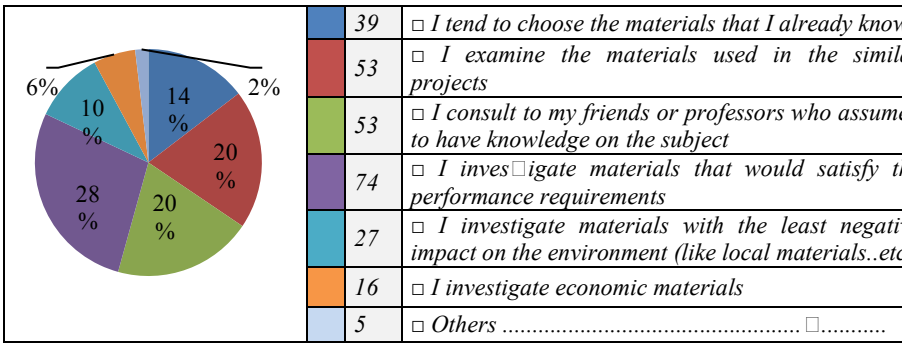



Figure2. Answers of the 1st question, shows the number of students who marked each option and their percentage distributions.

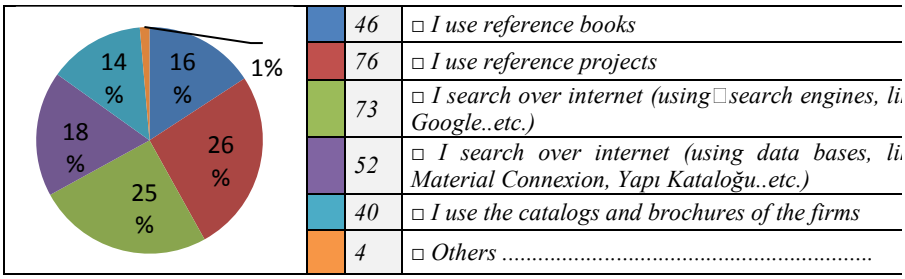



Figure3. Answers of the 2nd question, shows the number of students who marked each option and their percentage distributions.

When asked as follows; *if you use internet as a tool in your material selection process as a part of building element design please explain your steps briefly. Which search engine or data base you used? How did you make your research?*

*(over materials area of use, origin, properties related to performance, visual properties..etc.) What key words you used?* The distribution of the answers is given in the following [Figure4]. According to obtained results; the majority of the students, 57% percent, uses Google search engine as a tool in their material selection processes. Material Connexion, Detail, Yapı kataloğu, Arch Daily ve Archi Expo could be listed as the most used data bases in order.
With respect to the students' explanations about their material selection processes, it could be said that the majority of the students prefer making research by using keywords like the *name of the material* and/or material's *area of use*. Some prefer searching over the material *properties related to performance* and some over the *visual properties* of the material. Also most of the students look for *reference projects* and search over the *dimensions* of the material. Very few prefer to look for the *origin* of material, material's type of production, material's price or material's environmental impacts.

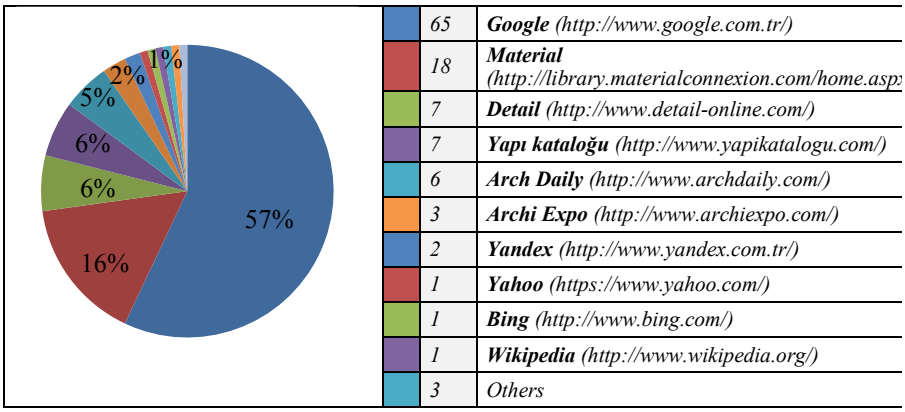



Figure4. Answers of the 3rd question, shows the number of students who marked each option and their percentage distributions.

When asked as follows; *which of the following(s) are effective in the decision step of your material selection process as a part of building element design? (Multiple options can be marked)* The distribution of the answers is given in the following [Figure5]. According to obtained results; 35 % of the students stated that *satisfying the performance requirements* is the most effective factor in their decision step, whereas 34 % of the students marked *aesthetics, visual properties* as the most effective factor. 15 % considers materials *having the least negative impact on the environment* while they are making decision. For only a few the origin or the price of the material is an important factor.
The results show that some of the students are tend to ignore the performance requirements if the material satisfies their visual parameters.,

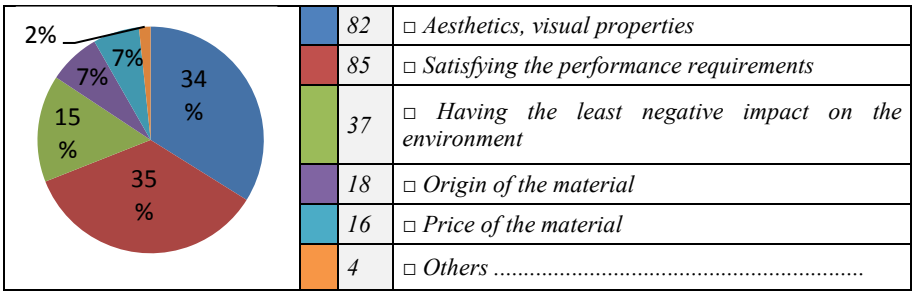



Figure5. Answers of the 4th question, shows the number of students who marked each option and their percentage distributions.

To sum up, according to obtained results it could be said that students tend to investigate materials that would satisfy the performance requirements, but they also tend to make their material decisions according to appearance. Being economic or environmentally friendly seems to be a secondary parameter in their material selection processes for the majority of the students. The results draw a general framework on how the students are making their material choices. Though there is a material selection tool which was explained step by step still most of the students base their selection on aesthetic reasons. It shows that, for the students who answered the questionnaire, appearance is an essential parameter for the evaluation of materials, as well as the performance requirements.
Most of the students use internet sources to make material searches. The most common keywords used to make a research are the name of the material and/or material's area of use. Therefore, the data base that is to be used as part of a tool in the material selection process should have some searching or filtering options on these areas.

**5.2. Usability of the Material Connexion data base.**
33 students who used Material Connexion data base as a part of their material selection process answered the questionnaire.

When asked as follows; *which of the following(s) search options in Material Connexion data base you used? (Multiple options can be marked)* The distribution of the answers is given in the following [Figure6]. According to obtained results; although the data base offers different ways of searching with 33% the majority of the students prefer to *search with a key word.* The preference order for the other options are as, *search from the usage title, the physical properties title, the origin of material.* Only 8% of students use the other searching options like *the processing title* and *the sustainability title.*

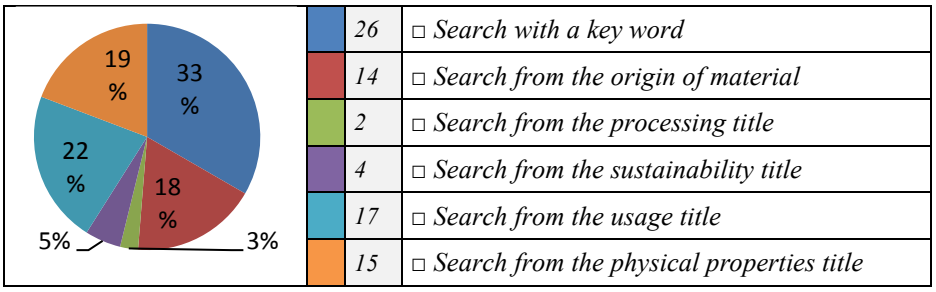



Figure6. Answers of the 5th question, shows the number of students who marked each option and their percentage distributions.

When asked as follows; *evaluate the adequateness of the filtering options in Material Connexion data base. (1 – least adequate / 5 – highly adequate) Briefly explain your reasons.* The distribution of the answers is given in the following [Figure7]. According to obtained results; more than half of the students found the filtering options *adequate or highly adequate.* The ones who were not sure about the adequateness of the data base mentioned some problems caused by too many sub-parameters under the titles and lack of filtering over the materials' area of use.

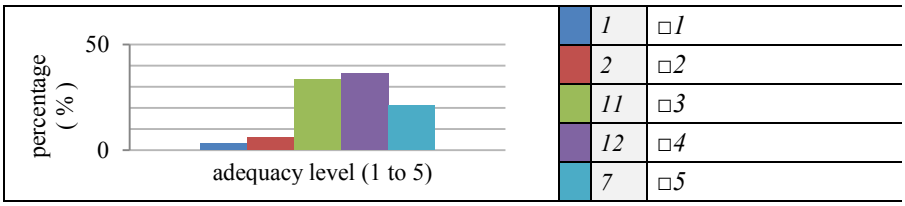
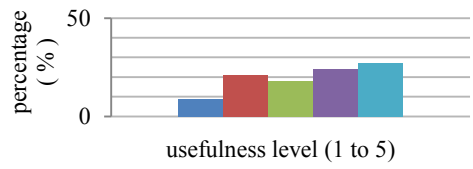



Figure7. Answers of the 6th question, shows the number of students who marked each option and the percentage distribution of the adequacy level of the filtering options. (1 – least adequate / 5 – highly adequate)

When asked as follows; *evaluate the usefulness of the Material Connexion data base in following terms. (1 – least useful / 5 – highly useful) Briefly explain your reasons.* The distribution of the answers is given in the following [Figure8-9]. According to obtained results; the data base is found useful for *seeing different material options* and also it makes it easier at *accessing and comparing material options* according to the majority of the students. However, students who used the data base have different opinions about its being *quick at getting results* and m*aking the "right" material choice.* Some mentions about accessibly and language problems, which made it difficult for them to complete their material selection through the data base.

*Accessing material options*

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| | 7 | □2 |
| | 6 | □3 |
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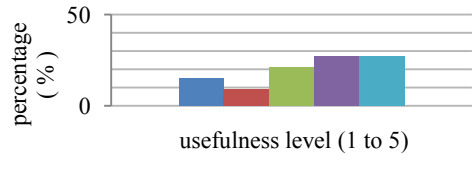
| | 9 | □5 |

*Getting result quickly*




| | | |
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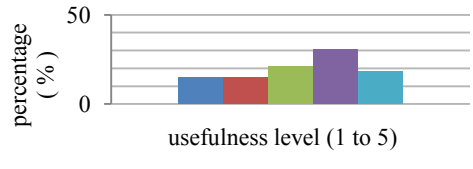
| | 7 | □3 |
| | 9 | □4 |
| | 9 | □5 |

*Figure8. Answers of the 7th question, shows the number of students who marked each option and the percentage distribution of the usefulness of the data base. (1 – least useful / 5 – highly useful)*

*Comparing material options*

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| | 5 | □1 |
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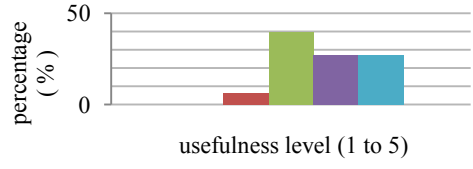
| | 7 | □3 |
| | 10 | □4 |
| | 6 | □5 |

*Seeing different material options*

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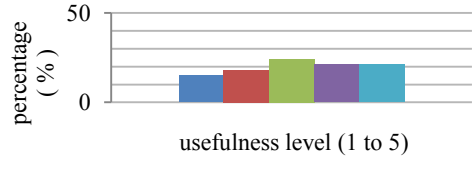
*Making the "right" material choice*

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| | 8 | □3 |
| | 7 | □4 |
| | 7 | □5 |

Figure9. Answers of the 7th question, shows the number of students who marked each option and the percentage distribution of the usefulness of the data base. (1 – least useful / 5 – highly useful

When asked as follows; *do you plan to use Material Connexion data base in your next material selection processes? (1 – definitely no / 5 – definitely yes) Briefly explain your reasons*. The distribution of the answers is given in the following [Figure10]. According to obtained results; the majority of the students are planning to use the data base in their next material selection processes, whereas one of three of the students is indecisive. Overall the data base if found helpful for a material selection via performance requirements perspective.

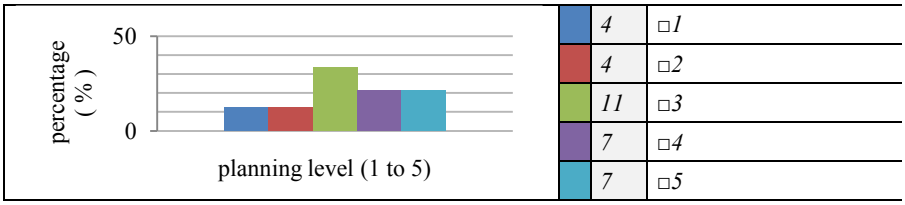


Figure10. Answers of the 8th question, shows the number of students who marked each option and the percentage distribution of the planning level to use the data base in the future. (1 – definitely no / 5 – definitely yes)

In general, the use of Material Database as a part of the material selection process found to be useful by the most of the students. Having a wide material pond and having various filtering options are the strong points of the database. Also the relative comparison of the material properties like; low, medium, high, allows the users to easily compare materials. However lack of filtering over the materials' area of use could be listed as a weakness of the database.

## 6. DISCUSSION AND CONCLUSION

A material selection tool has been developed which is to be used within the building element design process. The usability of the tool is investigated with its application by 2nd year architecture students in İstanbul Bilgi University as a part of the "Building Materials and Technologies" course and with a usability questionnaire, answered by 94 students. Obtained results could be listed as;

- Most of the students investigate materials that would satisfy the performance requirements, but they are leaning to make their material decisions according to aesthetic reasons.
- In the decision process, being economic or environmentally friendly seems to be a secondary parameter for the majority of the students. In general, they tend to make their choices according to appearance but they check if the chosen material satisfies the performance requirements.

For that reason, although it was intentionally left more flexible, the decision process should be more strictly defined. Making a material choice for an aesthetic reason should not lead the users of the tool to a material that would not satisfy the performance requirements.

- Most of the students use the internet sources to make material searches.

The most common keywords used to make a research are name of the material and/or material's area of use.

Since it was the first time that the students used a methodic material selection tool, they were tentative about its usage and they were tending not to follow the steps exactly the way it's explained. The majority of the students were not using any material data base in their previous material selection processes and although it was advised some still choice not to use. According to the feedback of the 33 students who used the Material Connexion data base as a part of the material selection process;

- The data base found useful, because of having a wide material pond, having various filtering options and presentation of material properties in an easily comparable way.
- The deficiency of the data base is not having a searching option over the area of use.

Although there were positive feedbacks about the data base, sometimes the usage of one data base may not be enough at reaching a decision. Therefore the use of multiple data bases in relation with each other could be an alternative solution. Besides, generally firm based data bases are used but some non commercial data bases listing the general characteristics of the material and the standards could also be included to the process.

In the light of the application of the developed "material selection tool" and the evaluation of the results of the usability questionnaire, the development of the tool continues with respect to the preliminary findings.

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