Universidad Zaragoza
1542

Trabajo Fin de Grado

Desarrollo de recursos gráficos para la docencia de
design sketching
Development of graphic resources for design
sketching teaching

Autor/es

Irene Hinojosa Deler

Director/es
Markus Kretschmer
Anna Maria Biedermann

Escuela de Ingeniería y Arquitectura
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ANNEX I: RESEARCH

1. INTRODUCTION

1.1. Abstract

Design sketching is used in all the stages of the design process in order to explore formal and functional aspects of the product. This discipline involves analyzing, synthesizing and evaluating information. Thus, this research argues the need to study sketching in the design engineering field. Furthermore, due to the COVID-19 pandemic educators have had to adapt to this new situation by using new technologies to teach from home. Consequently, this research aims to explore new ways of teaching and find an effective approach to distance teaching free-hand sketching.

1.2. Motivation

The COVID-19 pandemic has drastically changed many aspects of our lives. One of these aspects is the educational one. During this situation, teaching methods have had to adapt to online distance learning. This can be complicated in the case of subjects such as design sketching, which requires giving feedback to the students of their sketches and in this situation, lecturers are not able to supervise the students' drawings.

One solution could be the use of graphic tablets but not everyone has access to them so this option has to be discarded. The lack of tools to teach these discipline is an actual concern that has to be solved since the aim is to provide an effective system which everyone can have access to, since access to a quality education is a basic right and one of the 17 goals of the 2030 agenda.

Therefore, it is important to study design sketches, the current methodology utilized and the implementation of new sketch design tools.

1.3. Research question & hypothesis

Given the current pandemic situation the following question comes to mind:
How can we implement a better solution to distance teaching design sketching?

The following hypothesis is formulated; the situation would improve by making the lectures more appealing not only for industrial design students but also for professors making it more interactive and fostering the active participation of the pupils.

Moreover, the more personalised feedback students get, the more satisfied they will be since with this online situation the proximity with the professor and peers with whom they can share ideas and different points of view is lost. Different online platforms could be used to give support when giving a lecture or giving feedback. Furthermore, feedback could be given in a different way than the one used currently.

1.4. Methodology

The methodology followed is the one learned during the product design and product development engineering degree. It will be divided into five phases: research, product design specifications, concept development, final concept development and presentation and documentation of the results.

Phase 1: Research

The first step consists of different strategies to answer the following question: *"How can we implement a better solution to distance teaching design sketching?"*. The aim is to gather information about sketching and the importance of it in the educational field through a series of papers and specific literature which will be quoted in the bibliography section.

The second step will be to interview different professors from different universities of Europe (the University of Zaragoza, the Middle East Technical University, the University of Applied Sciences of Upper Austria and the University of the Arts of Poznan) in order to know how they have been teaching the design sketching discipline during the pandemic and make a comparison of the different aspects involved in this subject. Also, teaching guides will be compared to see which competences will acquire the students once the course is finished.

Next, the contents of different online courses and autodidactic books will be compared in order to know if they follow the same structure as the courses taught at university.

Phase 2: Product design specifications

After that, conclusions will be made. These conclusions will be the foundation to apply a new methodology of teaching design sketching.

1. INTRODUCTION

Phase 3 & 4: Concept development and final concept development

With this information, a rubric to evaluate students' sketches will be designed as well as a demonstration class about formal exploration which will apply this new methodology.

Phase 5: Presentation and documentation

The results will be examined to extract conclusions about aspects of the experience which can be improved or that have worked according to expectations.

2. DESIGN SKETCHING

2.1. Definition

Design sketching is an ubiquitous tool for designers to conceptualise, develop, externalize, record and communicate their ideas through the utilisation of graphical illustrations. [1]

Sketching is not an attempt to represent a solution as such. On the one side, it is a device that helps to reason with complex and changeable mental structures and on the other side, plays the role of communicating and discussing ideas. [2]

According to Tang [3], the act of sketching is a means of communication and attracting attention, as well as providing a medium for storing information as it may facilitate archiving and retrieval of information generated earlier in the problem solving process.

Furthermore, in the practice of engineering, engineers use sketching strategies not only to translate mental design ideas into graphical displays but also to create new ideas which may not exist prior to drawing.

2.2. Why is sketching important?

Sketching is of paramount importance along all the design process, from the earlier stages with more primitive sketches, to the development stages where we can find high fidelity representations of the product. Despite this fact, little research has been conducted in the sketching field.

As it is a relatively unexplored topic, the first step to answer the question "Why is design sketching important?" was to find and establish some of the most significant advantages that sketching offers:

Research has shown that sketching is essential in order to stimulate creativity, especially in the immediate individual idea generation process, by providing new directions for idea generation in an individual generate-interpret cycle [4].

Sketches can provide a more integrated process, by providing better access to the earlier ideas and enhancing the use of information in previously generated ideas, facilitating the access to them [5].

Through sketching, the designer is in a better position to explore potential solutions given a developing understanding of the design problem [6] and facilitates the transition from general descriptive knowledge into specific depiction [7].

Sketching provides visual context and may facilitate archiving and retrieval of information generated earlier in the problem solving process [8]. It also may enhance the use of information in previously generated ideas by enhancing the access to earlier design ideas [9].

Therefore, it becomes apparent that it is necessary to educate engineering design students in free-hand sketching as it provides the creator with useful resources and tools to carry out this task.

2.3. Taxonomy of sketches

Sketching allows information to be represented in various forms, as well as working in various levels of abstraction, used to start analysing a design problem to o refine ideas, previous to detailed design stage.

Ferguson [10] identifies three kinds of sketches, which may be useful for identifying the role of sketches in creative design groups: the thinking sketch, the talking sketch, and the prescriptive sketch.

The thinking sketch is used to support individual thinking processes.

The prescriptive sketch is used to communicate with others.

The talking sketch is produced during exchanges between technical people in order to clarify complex and possibly confusing parts of the drawing.

In the same context, four levels of complexity, based on the levels of detail, fidelity and stage have being identified for engineering concept sketches: the explorative sketch, the persuasive sketch, the explanatory sketch and the prescriptive sketch [11].

2. DESIGN SKETCHING
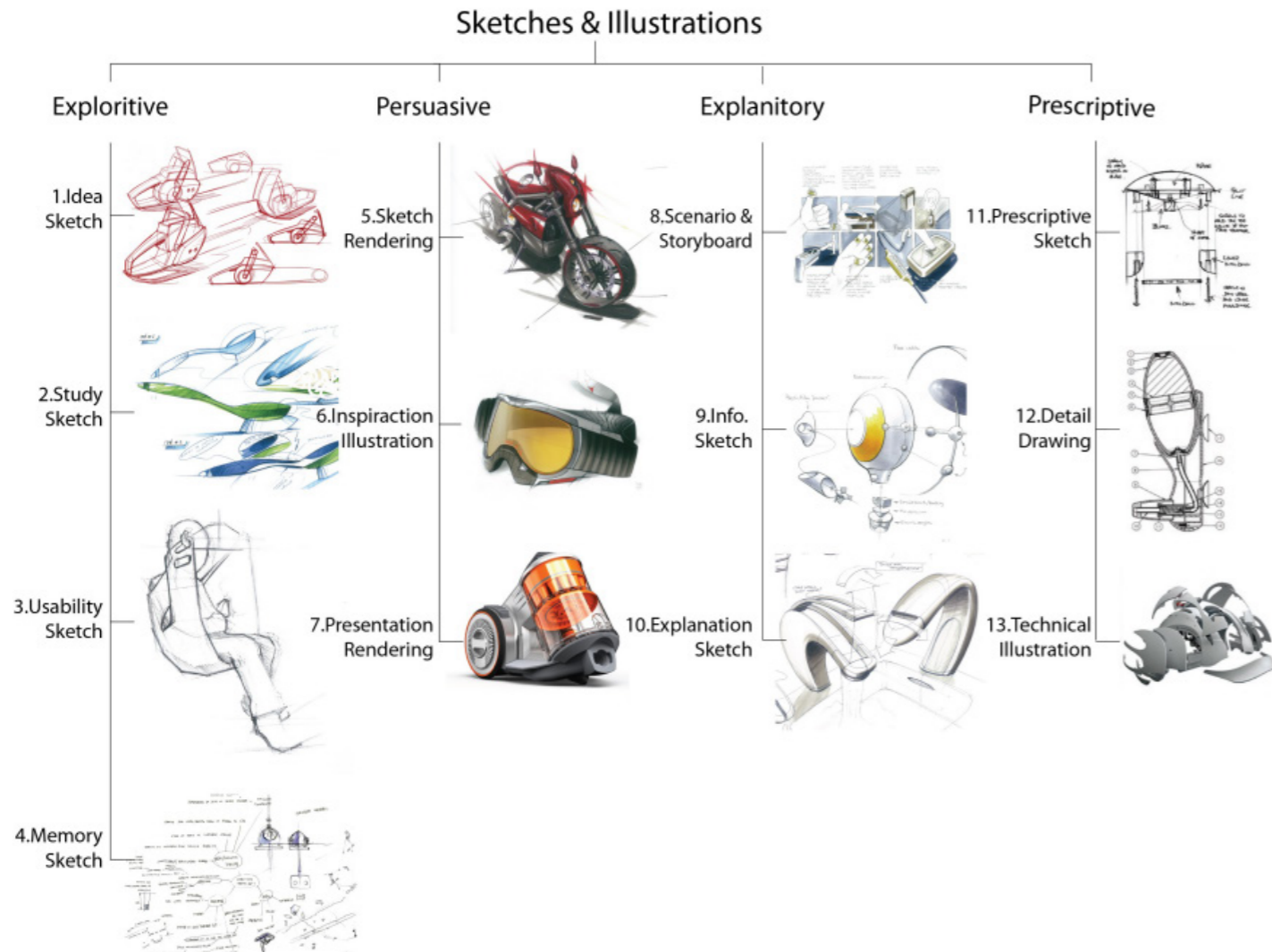
Picture 1: Taxonomy of design sketches, drawings and illustrations (derived from Pei et al)

Looking at the kinds of illustrations presented above, it becomes apparent that ambiguous and casual sketches are most prolific during the explorative phase of conceptual design ideation.

Persuasive sketches are more detailed and with a finished appearance. Their function is to convey design intention and the emotional reasoning to other stakeholders and clients.

Explanatory and prescriptive sketches are created to explain function, structure and form. They communicate a design in a clear and neutral manner, focusing more on explaining the idea rather than selling it.

2.4. Sketching in the educational field

As stated before, few research has being conducted in this area. As sketching is basic for engineering design, as it is involved on several stages (problem definition, concept solutions, analysis and evaluation and communication), it must be a skill required for future engineers and so to be taught.

According to the Engineering Design Graphics Division of the American Society for Engineering Education (ASEE), freehand sketch engineering objects is the second more important skill for graphical communication to be learnt for engineering students. [12]

Yang [13] says that engineering students traditionally are assessed on their mathematical and verbal abilities and less by their visualization skills. In addition to this, if we take a look at the curricula of the industrial design engineering degree in Spain, it becomes apparent that sketching is being replaced by CAD tools to the point that in some cases, that sketching lessons are not even offered in the curricula.

As a consequence of that, engineering graduates limits their capacity to analyze design solutions [14], as well that a negative effect on spatial abilities, visual spatial reasoning and then visual thinking problem-solving skills [15].

3. COMPARISON OF TEACHING METHODS

3.1. Comparative table

In collaboration with the University of Zaragoza, the Middle East Technical University, the University of Applied Sciences of Upper Austria and the University of the Arts of Poznan, an overview of the current curriculum of each university was made in order to analyse how are educators teaching the design sketching subject during this pandemic. The table allows to have a clear vision of the main characteristics of the design sketching lectures in each university.

	year	ECTS	number of students per group	hours per week	materials	software	evaluation method	number of handings	theoretiical and practical topics
University of Zaragoza	1st year of bachelor	6	20 - 21	3 h of practice 2 h of theorical content	Pencils, paper, markers	Illustrator	theoretical exam and practical exam	weekly assignments	1.Fitting and proportion 2.Chiaroscuro and stand out backgrounds 3.Presentation panels and formal exploration of the product
Middle East Technical Univesity	1st year of bachelor	4	20 - 25	2h of practice 2h of theorical content	Pencils, paper, markers	-	practical exams and portfolios	weekly assignments	1. Perception 2. Lines, planes and grids 3. Proportion 4. Composition
University of applied sciences of Upper Austria	1st year of bachelor	3	15 - 20	-	Pencils, paper, markers	-	practical exam	weekly assignments	1. Design methodology 2. Representation techniques 3. Perspective
University of the Arts Poznan	1st year of bachelor	4	15 - 20	4h structured in workshops	Pencils, paper, markers	photoshop, sketchbook	-	weekly assignments	1. Basic sketching 2. Perspective and perception 3. Presentation

Table 1: Comparative table of general aspects of the design sketching subjects in different European universtities

3. COMPARISON OF TEACHING METHODS

3.2. Teaching guides comparison

Subsequently, the teaching guides of Spanish universities, in which the industrial design and product development engineering degree is taught, were reviewed and compared. The main aim was to analyse the subjects related to design sketching taught in the first year of bachelor. The relationship between specific and transversal competences was examined. In addition, the coincidences, complementarity and integration degree from the contents established in each one of them were assessed.

The transversal competences assessed were extracted from the White Book of engineering degrees [16].

GC01: Ability of analysis and synthesis
GC02: Ability of time management and planning
GC03: Oral and written communication
GC04: Computing knowledge relative to the study field
GC05: Information management
GC06: Problem solving
GC07: Decision taking
GC08: Team work
GC09: Critic reasoning
GC10: Autonomous learning
GC11: Creativity
GC12: Leadership
GC13: Initiative and entrepreneurship
GC14: Motivation for quality
GC15: Sensitivity towards sustainability issues
GC16: Basic knowledge of the profession
GC17: Ability to apply the knowledge in the professional practice
GC18: Ability to communicate with non-experts in the field

A comparative table has been elaborated in order to have a clear visual overview of what competences are being met in the main Spanish universities.

3.2.1. Findings

One of the most obvious findings was that there were some universities that did not offer design sketching courses (mostly called artistic expression courses), but they do all offer CAD courses.

As showed in the table below, we can notice that the University of Zaragoza is the one that meets the largest number of competences (14 out of 18), thus we can state that their teaching guide for the Artistic Expression subject is the most complete. The University of Sevilla would be the next on the list (9 out of 18 competences met) and then the rest of the assessed universities (with 7 out of 18 competences met).

As we can observe, oral and written communication are present in every teaching guide. Creativity and problem solving are common competences in many of these guides as sketching is a creative tool not only used to copy objects from real life but to create new ones that solve a detected problem for users.

On the other hand, sustainability is barely regarded maybe because sketching is mostly used in the firsts stages of product design where materials and product lifecycle are not clearly defined. Also decision taking is something in which should be taken into consideration thus, as designers, students should be able to decide on wether a design is valid or not.

It is a bit worrying that the basic knowledge of the profession and the ability to apply the knowledge in the professional practise are only considered in two of the documents as we should take advantage of the practical contents of design sketching to orient them to the professional field.

Another transversal (general) competences were common to all the teaching guides but they were not deemed in the White Book of engineering degrees:

The generation of innovative and competitive proposals: it is important to take the initiative and generate new opportunities and solutions.

Graphic communication: it is as important as oral and written communication as students should be able to communicate effectively through their sketches and designs.

	University of Zaragoza	Polytechnic University of Madrid	Polytechnic University of Cataluña	University of Sevilla	University of Valladolid
GC01	X	X		X	
GC02	X		X		X
GC03	X	X	X	X	X
GC04	X				
GC05	X		X		
GC06	X	X		X	X
GC07					
GC08	X		X	X	X
GC09	X			X	X
GC10	X		X		
GC11	X	X		X	X
GC12					
GC13			X	X	
GC14	X				X
GC15			X		
GC16	X	X			
GC17	X	X			
GC18	X	X		X	

Table 2: Basic and transversal competences in the design sketching subjects

Irene Hinojosa Deler | Industrial Design and Product Development Engineering | Bachelor's Degree Final Project

For the specific competences (SC), we find that every university has different criteria. A list of specific competences will be displayed ordered by university.

University of Zaragoza:

SC01: Ability to make effective and professional presentations through sketching and digital technologies using visual abilities that communicate ideas and concepts in an agile and effective way, choosing the right format and contents.

Polytechnic University of Madrid:

SC01: Knowledge and ability to apply artistic expression techniques.

Polytechnic University of Barcelona:

SC01: Knowledge about design topology, products and their presentation.

SC02: Ability to apply methods, techniques and specific tools for each graphic representation.

SC03: Decision-taking ability related to the graphic representation of concepts.

SC04: Ability of designing and projecting in different environments of effective and efficient communication along with the different agents that intervene in the design process and industrial development.

University of Sevilla:

SC01:Ability to make formal product design proposals with conventional artistic expression techniques (chiaroscuro, charcoal, pastel, watercolour, colour pencils, markers, gouache) and CAD.

SC02: Ability to communicate the product through illustration, styling and investigative, explorative, explanatory and seductive sketches.

SC03: Ability to make analysis and synthesis proposals, from the knowledge of morphologic variables: composition, harmony, rhythm, shape, colour, lighting, textures of products and their semantic and perceptual aspects.

University of Valladolid:

SC01:Ability for the analysis and application of aesthetic values in a determined product as implicated factor in the demands, aspirations and identification steps of the society for which the student designs

SC02: Ability to extract the aesthetics, humanistic knowledge and design histor, sensible and creative material for the design of new products.

SC03: Ability of communication through graphic and symbolic languages.

SC04: Understanding and applying artistic expression's knowledge

SC05: Fulfillment of design projects and industrial development .

SC06: Ability of projecting, visualizing and communicating ideas.

SC07: Understanding the three dimensional space, the basic elements in it and the relationship among them.

To sum up, the specific competences focus on communicating ideas in an effective way, synthesising the knowledge acquired through the utilisation of tools learned in the subject, considering proportion and fitting, lines, lights and shadows, colours and textures.

3. COMPARISON OF TEACHING METHODS

3.3. Design Sketching online workshops

For the comparison of online workshops, as series of courses will be examined:

The first course is the Form & Space course from Skillshare [17]. It is divided in several workshops that cover different sketching principles.

The second course is the Domestika's Introduction to Product Design Sketching course [18].

The third course is Product Design Sketching : How to Sketch using Pen and Paper from Udemy [19].

The fourth course is Sketching for Product Design and AEC from Linkedin [20].

The last course is Fast Track to Design Sketching [21].

The parameters used to assess if these courses are at the same level as the design sketching courses at the different universities from the contents point of view are:

1. Perspective: how to draw cubes, spheres, cylinders, compound and organic forms.
2. Fitting and proportion
3. Lines as communication elements
4. Shading
5. Presentation panels
6. Formal exploration

In the following page, a comparative table has been elaborated in order to have a clear visual overview of what can be learnt in different online courses and detect its strengthes and weaknesses.

3.3.1. Findings

The findings are based in the comparative table found below.

The methodology is similar to the courses taught at university. All the courses have a common structure: they begin explaining perspective principles and drawing simple structures like cubes, cylinders and ellipses. Then fitting and proportion are taught. Then complex forms (prisms+cylinders and organic forms) are explained. After this, most of them explain how to use lines as a communication element.

None of them teach how to make presentation panels and only two of them scouts formal exploration, so we can assert that the courses cover the basics of sketching but they do not dive into the exploratory and creative fields of sketching.

At the end of each course we can find a few exercises to practise.

To sum up, what we can learn with these courses are the basic principles of perspective through observation by breaking any form down into its basic volumes.

We can also learn how to use different types of lines as communication elements to produce quality sketch lines. Moreover, we can go deeper and learn how to use markers for simple shading and rendering the product to simulate materials and textures. Furthermore, the use of lights and shadows to make more realistic sketches is present in all these books which is an essential step before and while rendering the product.

Another thing that we are provided with these courses is how to make good photos of your sketches which could be interesting during this pandemic situation in order to present the work done over the course.

What we cannot learn through these courses is how to make presentation panels with stand out backgrounds and form exploration of the product. These courses are only meant to learn to draw the same product in different perspectives.

	Perspective	Fitting and proportion	Lines	Shading	Presentation panels	Formal exploration
Form & Space course	✓	✓	✓	✓		
Introduction to Product Design Sketching course	✓	✓	✓	✓		
Design Sketching : How to Sketch using Pen and Paper course	✓	✓				✓
Sketching for Product Design and AEC course	✓	✓	✓	✓		✓
Fast Track to Design Sketching	✓	✓	✓			

Table 3: Comparison of design sketching online workshops

3. COMPARISON OF TEACHING METHODS

3.4. Design sketching books

The following design sketching books will be examined in terms of content:

Sketching the basics by Koos Eissen and Roselien Steur (2011)

Sketching - Drawing Techniques for Product Designers by Koos Eissen and Roselien Steur (2013)

Basic sketching techniques for the industrial designer by Thomas Valcke

Creative sketching in product design by SendPoints (2018)

The parameters used to assess if these courses are at the same level as the design sketching courses at the different universities from the contents point of view are:

1. Perspective: how to draw cubes, spheres, cylinders, compound and organic forms.
2. Fitting and proportion
3. Lines as communication elements
4. Shading
5. Presentation panels
6. Formal exploration

In the following page, a comparative table has been elaborated in order to have a clear visual overview of what can be learnt in different sketching books and detect its strengthes and weaknesses.

3.4.1. Findings

The findings are based in the comparative table found below.

As observed, books seem to be a more incomplete way to learn design sketching since almost none of them considers the topics of lines as communication elements and presentation panels. Formal exploration is also a topic that must be reinforced in sketching books.

On the other hand, they explain scale and distortion and include techniques to colour sketches and imitate materials and some exercises.

To sum up, what we can learn with these books are the basic principles of perspective through observation by breaking any form down into its basic volumes.

We can also learn how to use different types of lines as communication elements to produce quality sketch lines. Moreover, we can go deeper and learn how to use markers for simple shading and rendering the product to simulate materials and textures. Furthermore, the use of lights and shadows to make more realistic sketches is present in all these books which is an essential step before and while rendering the product.

What we cannot learn through these courses is how to make presentation panels with stand out backgrounds, formal exploration of the product. (The courses are only meant to learn to draw the same product in different perspectives) and sketching with different types of lines and its use as communication elements.

	Perspective	Fitting and proportion	Lines	Shading	Presentation panels	Formal exploration
Sketching the basics	■	■		■	■	■
Sketching - Drawing Techniques for Product Designers	■	■		■		■
Basic sketching techniques for the industrial designer	■	■	■	■		
Creative sketching in product design	■	■		■		

Table 4: Comparison of design sketching books

3.5. Conclusions

All the courses follow a common structure: they begin explaining perspective principles and drawing simple structures like cubes, cylinders and ellipses. Then fitting and proportion are taught. Then complex forms (prisms+cylinders and organic forms) are explained. After this, most of them explain how to use lines as a communication element.

Based on the research made, the best way to learn design sketching is by attending classes since there is teacher-student interaction, so all the doubts concerning sketching can be solved and also students have granted to acquire a series of competences by having taken this course. In addition, a complete study program is offered.

The next option would be online design sketching courses. Here the interaction between teacher and student disappears. But still, they are interactive to some extent, as the student can follow step by step what the teacher is doing. The program is less complete than the one offered at universities since almost none of the online courses teach how to make presentation panels with stand out backgrounds and they do not stimulate creativity through formal exploration.

The least optimal learning method would be sketching books which are not interactive and their program is more incomplete than the ones from other methods.

4. DIGITAL VS. TRADITIONAL SKETCHING

Research has been conducted to check if traditional sketchbooks can be replaced by new technologies. Since the invention of graphic tablets and sketching applications digital drawing has become a promising technique. Digital drawing applications provide the designer with different brushes (which can be customizable), a wide range of colours, zooming, working with layers, portfolio creation, online sharing options, etc. In a world where technologies such as laptops or mobile phones have become an extension of our bodies, how can we integrate sketching in this digital era? Is it worth it for students? Does digital sketching improve or diminish creativity?

Previous research on sketching activity and designers' cognitive processes has proven that freehand sketching has advantages over digital media, such as supporting the perception of visual–spatial features, and organizational relations of the design, production of alternative solutions and better conception of the design problem. [22]

They have become quite handy for creative works; including drawing, painting, image editing, designing, sketching and animating, than before [23].

It can be felt freehand sketch drawing is losing its importance with today's increasing computer aided design technology environment. However, although it seems as if sketching losing its importance in design education, freehand sketching shown as a traditional method should not lose its value, it should be aimed to gain sketch habit to the student in all of the design courses.

4.1. Survey results

The integration of drawing apps to design education is a challenging concern, as digital methods are taking over. However, results show that conventional sketching media are still the most preferred in design education (see survey).

Students are aware of the many advantages of digital sketching such as layering, the wide range of colours offered, paper and other materials savings and the easiness to erase and re-do sketches (see survey). However, the emotional component of traditional sketching is a big game changer.

The survey also reveals a lack of feedback given during the lessons. Students are eager to know their mistakes and share opinions with their classmates, something that could not be done during online sessions. Thus, the effort will be focused on desig-

ning a class that gives somehow feedback to each one of the students and that fosters the continuous contact between student and educator.

Another thing about students complain about is the lack of time to experiment and explore the new techniques learnt during the lessons. There should be more time left for formal exploration so pupils can rely more on their creativity rather than just copy a product.

One positive aspect of studying at home detected is that ou have any object on hand so students can sketch the products which results more of their interest. This can be a factor to foster creativity.

4.2. Conclusions

Sketching and drawing in the first year sre essential as they lay the foundations for product design. Sketches are a tool which pupils will use during all the degree as well as their professional career no matter if they are digital or traditional.

Although traditional sketching is preferred over digital sketching, many students think about starting to learn how to use a graphic tablet in their sophomore year. It seems digital sketching is a step further in the line of progression. This can give a hint to introduce graphic tablets later on in the degree or maybe begin to teach hybrid methods (combining digital and traditional sketching). This can be challenging as 38% of the pupils who do not own a graphic tablet cannot afford one.

Nevertheless, the most important thing revealed is the lack of feedback during the sessions due to the online situation. This is crucial for students so they can improve their technique. If they do not show an improvement in their sketches, the lessons will end up being useless.

The majority of the students have found the lessons easy to follow or with a medium difficulty, so the dynamics of the class will have to be revised to enhance the learning of those who have found the classes a bit difficult to follow up.

As a final highlight, students would like more time dedicated to form exploration.

All these aspects will be detailed in depth in the *Annex II: Design Specifications*.

5. SURVEY

A survey has been carried out to obtain feedback and get some important data from the bachelor students who are attending this year design sketching lectures. What was meant to be detected with these surveys were the negative and positive aspects of the subject during this online situation period. This way, focus can be put on the most important aspects in order to improve them on later phases.

Have you taken the subject Artistic expression I?

- Yes
- No

100%
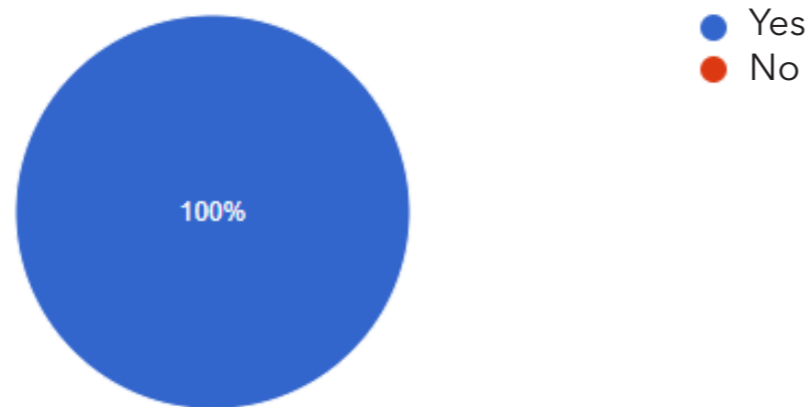
During the pandemic, the classes have been online, how easy has been following Artistic Expression I lessons?

Very difficult — Very easy
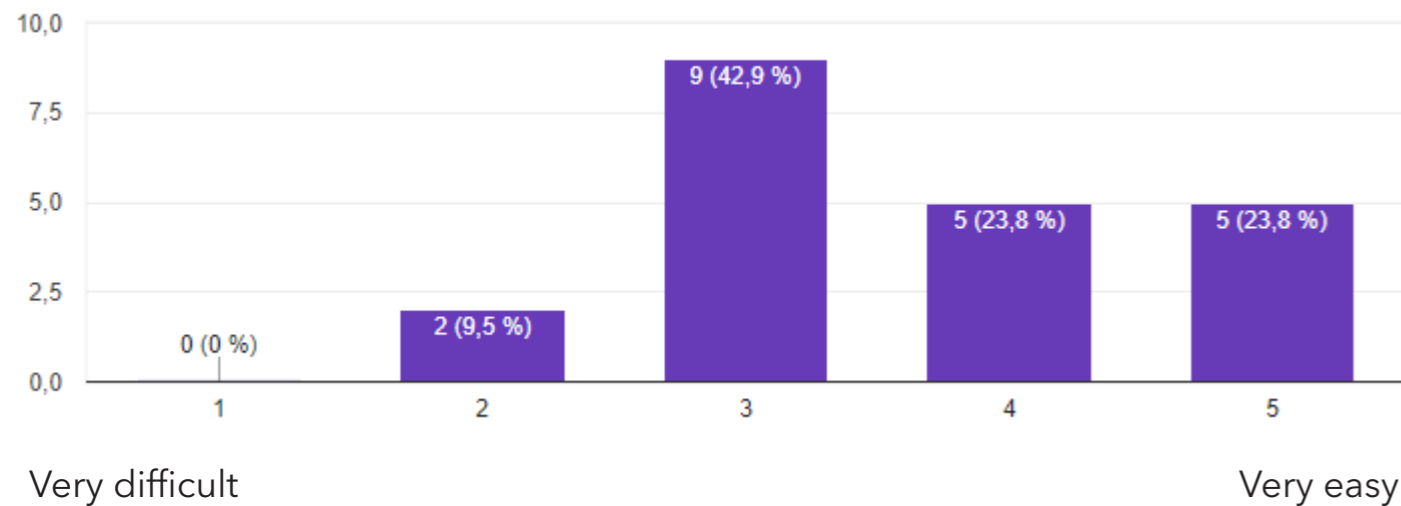
Which negative or improvable aspects did you notice?

1. Something that could help improve the lessons is that the teacher used paint or any other image editing program to open the photos sent and thus, point out the mistakes or things to improve in the sketch. It would also be useful that she taught herself how to draw with some kind of tutorials which served as a guide before the students began sketching the axis and lines by themselves. In other words, she could bring herself to draw the object to show us her technique apart from showing Youtube tutorials.

2. The teacher can't correct your mistakes and show you how to make the sketches.

3. More instructions when drawing.

4. You don't learn anything

5. The fact of not being in person makes impossible that the teacher can see your work and help you with some aspects of your drawings.

6. The classes in presence are fundamental to keep improving our sketching techniques.

7. It is complicated to get feedback from the professor, since in many occasions she didn't see your work before handing it to her, so you could not modify your mistakes.

8. It is more difficult to learn the techniques. Also you lose that teacher-student contact.

9. I think the practical lessons could have been in presence to have a better communication with the teacher and in order to better comment our sketches.

10. There is no time left to try more in depth the techniques or experimenting. In my opinion, the theoretical lessons adds nothing new. The subject could have been only practical. Also being online we lack of feedback.

11. The theoretical lessons could have been more practical and teach the theory by using examples.

12. I think that what lacks in these online classes is the possibility to learn from the others, seeing the work of your classmates, sharing ideas and information. Also I would have liked to see more examples and different ways of working. I think these classes could have been in presence.

13. I think that being in the classroom with the other classmates we could have learned more, watching each others' mistakes and the things they have done right to apply them to our sketches.

14. There is almost no time to revise your sketches.

15. In this kind of subjects it seems important to me to work at class in presence so we could all learn from each other.

And positive aspects?

1. We could practise with objects that we had at home and see the object from all the perspectives.

2. Online classes are more comfortable and calmed.

3. At home I have all the materials on hand.

4. The teacher asked for the participation of every student.

5. The teachers were really attentive.

6. The theoretical classes were very dynamic.

7. The teachers assisted you and motivated you to participate.

8. The teachers have been able to adapt to this difficult situation by using new technologies and made interactive classes through google meet.

9. I liked being at home since I find that a more appropriate environment to sketch rather than being in the classroom. Also, I liked trying out different sketching techniques.

10. The subject is very well organised and complete.

11. The classes were dynamic and interactive. Very easy to follow.

12. It is an interesting subject, the teachers made it possible to follow it easily. We didn't have an exm and other aspects have been taken into account such as the information shared in the 'wiki' and the individual search work, that has been really interesting. Plus, the Pinterest web was really useful.

13. It was very well organised taking into consideration the current situation of pandemic. The classes were enjoyable and even if you started with a low level of knowledge sketching, a couple of weeks later you could notice your improvement.

14. The ability of receiving feedback immediately and see the mistakes of your classmates. Also, sketching in my room enhances my concentration.

Do you own a graphic tablet?

- Yes
- No

57,1%

42,9%
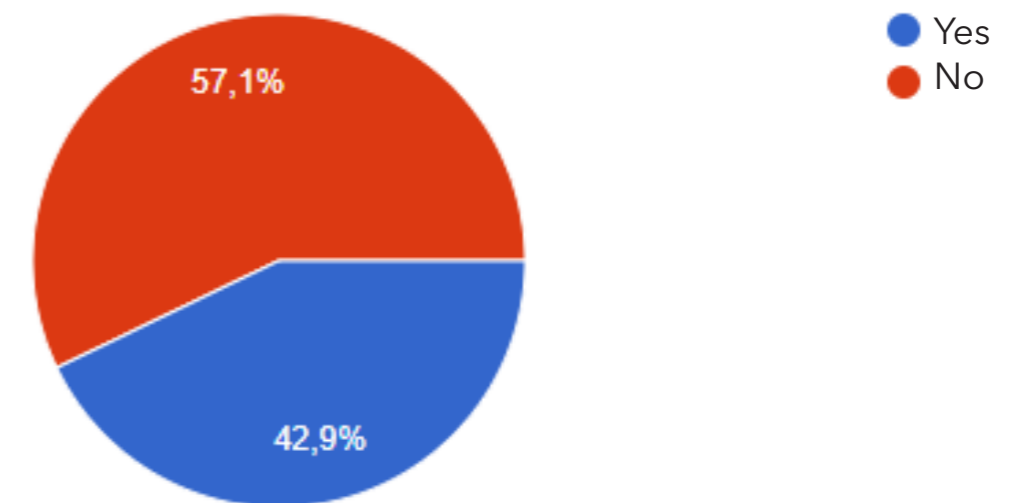
5. SURVEY

In case of not owning one, could you afford one?

- ● Yes
- ● No

36,4%

63,6%
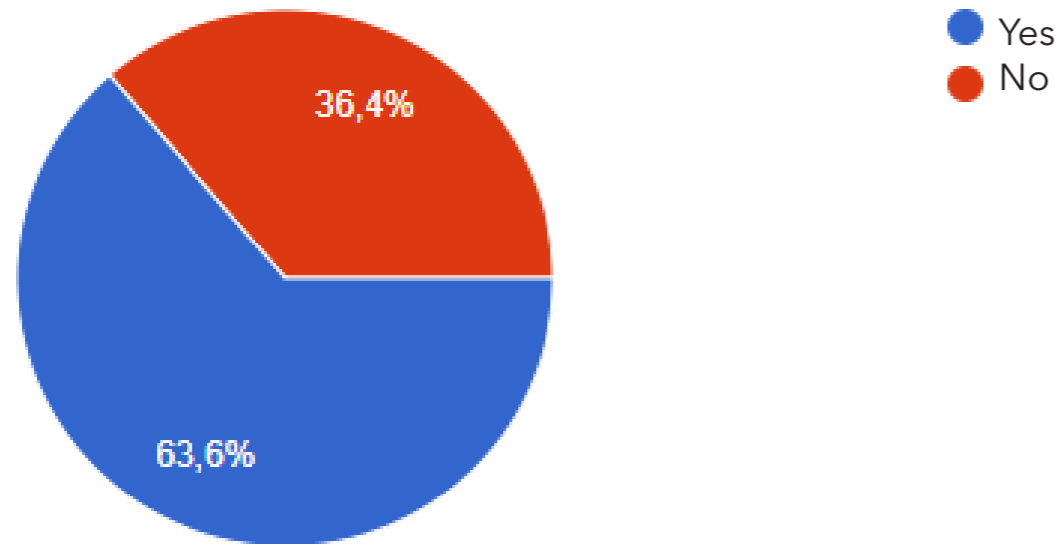
Do you prefer sketching the traditional way or digitally (with graphic tablet)?

- ● Traditional
- ● With graphic tablet

38,1%

61,9%
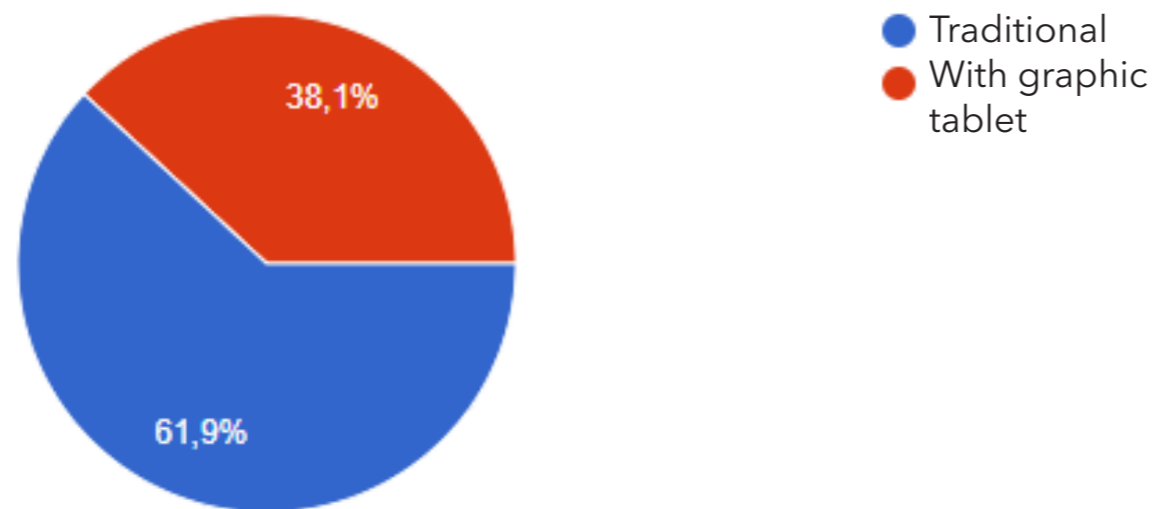
Why traditional?

1. I have never used a graphic tablet and I don't have a steady hand.

2. Because I don't have a graphic tablet.

3. It seems more real to me and also it has an emotional component.

4. You can control more the strokes and the lines you draw.

5. I think that using a brush in a tablet is not the same as drawing in a sheet of paper.

6. I have a better control drawing traditionally than with a graphic tablet.

7. The results are better.

8. It is more comfortable for me.

9. Because it is what I know. I have never drawn with a graphic tablet.

10. I like better the results using the traditional way.

11. I think it's interesting the results obtained with the traditional way, experimenting with the materials.

12. It is easier for me, I can control the strokes but using a graphic tablet you get cleaner results.

13. I have more liberty to control the strokes and that gives my personal touch to the sketches.

5. SURVEY

Why graphic tablet?

1. I have access to more colours and brushes.

2. They look better and there are tools that make sketching easier.

3. You can work with layers and also correcting your mistakes is much easier. Also, it is easier to obtain better results.

4. The digital method is much more pragmatic when you make mistakes.

5. Sketching with a graphic tablet is easier.

6. The grphic tablet is more versatile and you can erase things the times you want. Also, the results are better than the traditional way.

7. I control better the proportions, I can work with layers and re-sketch as many times as I like and the paper doesn't get dirty. The bad thing about using a graphic tablet is that you cannot use it outside unless you carry a laptop with you.

8. I consider that it offers more possibilities than drawing the traditional way, even though I think it is important to learn first the traditional way.

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ANNEX II: DESIGN SPECIFICATIONS

1. DESIGN SPECIFICATIONS

Technological	User	Structure and methodology
It has to allow instant educator-student feedback. It has to adapt to the current situation of pandemic but also it has to be useful in other situations where online learning is required. It has to be inclusive for all the users, so graphic tablets are out off topic.	Users have to be comfortable using the tools created for the class. It has to allow all users to participate.	It has to allow to teach how to draw. The structure and the activities of the class has to be easy to follow.
It has to be interactive. It does not have to entail a workload for the student or the teacher. It has to allow student-student feedback.	It has to have a motivating component for the student.	It has to allow to learn from other students. It has to allow to create a collaborative environment. It has to allow students to explore different techniques

Table 5: Desirable and critical design specifications

● Critical design specifications

● Desirable design specifications

ANNEX III: CONCEPT DEVELOPMENT

1.1. Types of feedback

Meaningful online feedback is necessary in an online learning environment because it provides a constructive work reflection to the students. Instructors who provide online learners with constructive feedback help learning participants process new ideas and information while improving self-efficacy.

Students can obtain feedback from their educator, their peers or external feedback.

Instructor feedback: instructor feedback is of paramount importance for students as instructors who provide thoughtful online feedback provide learners with explicit expectations for the performance outcomes for their work and an opportunity to understand areas where academic improvement is needed.

Learner-learner feedback: peer feedback is also essential. Sharing ideas and compare your work with others can help analyzing review and synthesise your own work. Therefore it is important to provide a collaborative milieu for students. Rubrics can be developed to encourage and guide peer feedback.

External feedback: external feedback from non-expert people in the field can be also useful to see things from a different perspective. That ensures your work is going to be understood by all kinds of public.

1.2. Online video call platforms

The most used video call platforms used to teach online courses at universities are going to be evaluated in order to decide which one offers more advantages when it comes to online education.

A comparative table has been elaborated in order to detect its strengthes and weaknesses of online learning platforms and decide which one fits the best for this purpose on design sketching learning.

	Microphone and camera	Hand raise button	Screen sharing	Whiteboard	Chat	Others
Google meet Picture 2: Google Meet logo	✓	✓	✓	✓	✓	Creation of a meeting for a specific date and link it to google calendar.
MS Teams Picture 3: MS Teams logo	✓	✓	✓		✓	It allows to create break-up groups
Zoom Picture 4: Zoom logo	✓	✓	✓	✓	✓	It allows to create break-up groups Creation of a meeting for a specific date.

Table 6: Comparison of online videocall platforms

1.3. Platforms which enable to create a digital portfolio

A portfolio is a must for anyone who is involved in the design or creative industry. When student work is housed in an online space for others to see, the importance for the learning naturally increases. Peers, family, friends and even the world can be a potential audience. And when there is an authentic audience, there is the opportunity for feedback.

Hence, creating a portfolio is a magnificent way to reflect and showcase the progress made over time. It serves as a true example of what you are capable of and what abilities you have to offer. The evolution of the sketches, the creativity and the acquisition of the student's own style becomes evident when the audience scans through the portfolio.

Because portfolios include a collection of performances that demonstrate growth and include student reflections, they provide additional assessment information beyond what can be gleaned from a traditional grade.

A student's digital portfolio also provides a vehicle for regular feedback and dialogue with their teachers. As students consistently gather and reflect on their work, instructors develop a clear picture of the learning that is taking place and are better able to identify areas that need attention.

Nowadays, there are online platforms that allow everyone to create and share their own digital portfolios. Next, a series of online platforms to make a portfolio will be assessed.

Among these platforms we can find the following (most used ones):

Behance
Instagram
Issuu
Dribbble
Domestika

All these platforms are free so neither the student nor the teacher has to pay to create an account or portfolio.

Variables analyzed:

Portfolio creation: the site allows you to create your portfolio *in situ*.
Portfolio sharing: the site allows to share our portfolio with other users.
Templates: the platform provides templates to create your portfolio.
Follow designers: find and follow the designers that are of the students' interest. Also the teacher can follow students which is useful to give them feedback.
Intuitive: easy to use.
Feedback: section of comments open to everyone.

	Portfolio creation	Portfolio sharing	Templates	Follow designers	Intuitive	Feedback
Behance	✓	✓	✓	✓	✓	✓
Instagram		✓		✓		
Issuu	✓	✓	✓			
Dribbble	✓	✓		✓		
Domestika	✓	✓		✓		✓

Table 7: Comparison of online platforms for portfolio creation

In addition, all these platforms give the chance to get hired so they might be useful for the students' future career.

1.4. Conclusions

Among all the video call platforms investigated, the most effective to learn online is Zoom. Both the professor and the pupils can share their screens to show their ideas and allows instant feedback. Another important feature of Zoom is the break-up groups which can be effective to obtain feedback from peers in an organized way (small groups are less chaotic) as well as for co-evaluating them and share ideas.

The professor can join any small group whenever he or she wants to provide individual feedback, which students have been missing during online classes.

A good complement for this tool would be an online portfolio. Otherwise students would have to show their paper sketches through the webcam, which is translated into low effectiveness.

The pupil would upload a photo to his or her portfolio, share the screen and ask for feedback. Also, for evaluating the pupils' work, the educator could follow their students so he or she would be able to see the progress made.

In addition, sharing their work online, allows even more feedback from a broader audience but it is important that this audience is specialised so feedback can be given in a more constructive way from which students can leverage.

For all these reasons, Behance is the best tool among the ones analyzed.

To sum up, educators and students would make use of two tools: Zoom and Behance. These tools do not require much effort to be used, they are user friendly. Zoom allows feedback from classmates and from the teacher and Behance allows feedback from peers and specialised audience. Behance is also a useful tool for the students' future career.

2. FORM EXPLORATION

2.1. What is form exploration?

An important step in design is the form exploration of the product. Products communicate features such as functionality with shape, colour and texture. Sketching does not only consist on copying objects that already exist but to explore and modify them in order to get an aesthetical or functional improvement out of them.

Thus, form exploration allows to examine and scout hypotheses, assumptions and preconceptions about our designs by experimenting with variations of an idea. It is also a useful tool to detect and explore potential solutions through an iterative process.

Form exploration can serve for multiple purposes such as searching for empathy and emotional bonds or new ways of consuming or using a product.
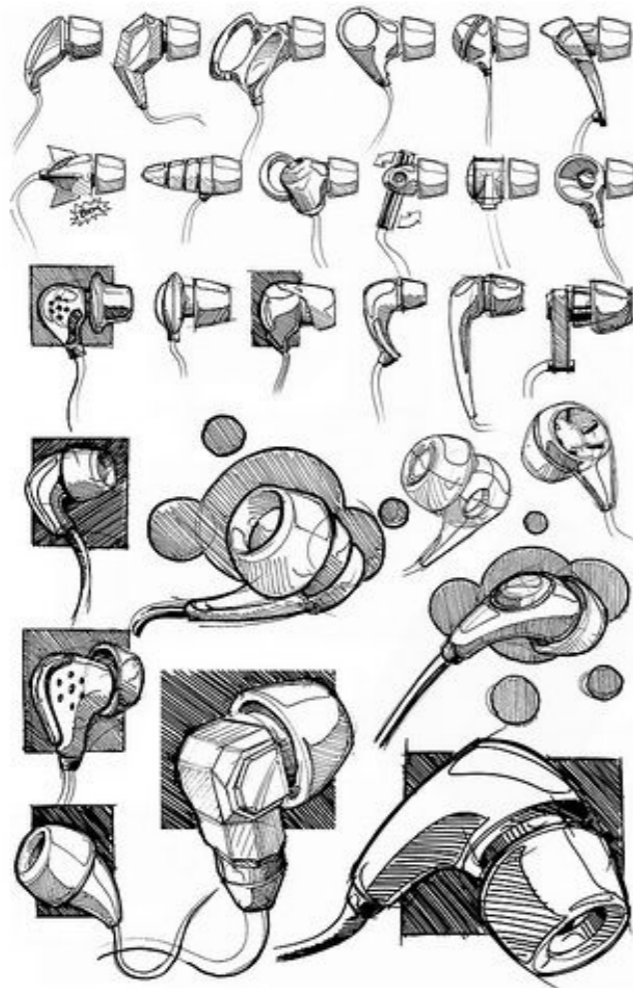
Picture 5: Ear buds form exploration sketches

2.2. How can form exploration be carried out?

There are different techniques that can be used to obtain new shapes and results. Some of them are: [1]

Addition: the product presents a sum of similar elements.
Subtraction: The product's overall shape is perceived as the absence of other shape.
Fusion: a union between different shapes is produced resulting in an hybrid form.
Torsion, bending, tension, expansion and transformation: a variation is produced and the form changes modifying its initial structure.

Picture 6: Addition and subtraction

Other way of carrying out form exploration is through imposing restrictions. Some of the restrictions that can be applied are:

Time: sketching within a limited amount of time will affect the lines and the details shown in the sketch.
Drawing support: by changing the size and the texture of the paper, results will be different.
Tools: by changing the sketching tools (e.g. pen, pencil) for others (e.g. brush) parameters such as the strokes, the thickness and quality of the lines will vary.
Others: sketching without any references, sketching the product upside-down, sketching with non-dominant hand, working only with straight lines, etc.

2.3. Current structure of a form exploration lesson (University of Zaragoza)

Professors have had to restructure the lessons to adjust to the current situation and thus, change the way they teach them. Leaving behind the traditional way of teaching design sketching is, undoubtedly a challenge. Online learning is completely new for most of the educators and students and requires intensive work to prepare and adapt the lessons to this format.

As for now, the lessons follow this structure:

Planning: The professor explains the different parts in which the practice will be divided into.

Theoretical input: first, the teacher gives a brief explanation about what the practice is going to be about and explains some theoretical contents related to the topic.

Composition: students have time to think about how their composition (perspectives, number of sketches, details...) is going to be, which format (vertical, horizontal, A3, A4, A5...) will bring the best results.

Sketching: Pupils sketch based on the theoretical input and examples shown before. When time is finished, they take photos and upload them to moodle.

Feedback: the professor downloads the images from moodle, opens them into illustrator and sharing his or her screen, gives feedback, points out the mistakes and corrects them by painting over them.

This structure might seem correct but feedback should not be a phase but should be an element present in every phase. If feedback is only given at the end of the lesson, students do not have the opportunity to correct their mistakes while sketching. This is shown as a clear disadvantage for pupils in order to improve their sketches before being evaluated.

Also, the professor cannot give individualised feedback to everyone due to the great number of students.That is why it is needed to think about other ways of giving feedback. Next, a couple of ideas for giving feedback will be commented and developed.

2.4. Ideas for giving more feedback

2.4.1. Break-up rooms

Platforms such as Zoom and MS Teams (in this case we will work with Zoom) have the option to create smaller rooms to perform tasks in smaller groups. The theoretical part would be taught in the main room whilst the sketching part could be taking place in smaller rooms with the purpose that students can exchange ideas and opinions and give feedback to each other. The instructor can enter these rooms whenever he or she wants to provide feedback.

Zoom also has a button called "ask for help" which notifies the teacher if there is a group which has any doubt and go assist them.

2.4.2. Rubrics

As said before, it is impossible for teachers to give individualised feedback. Thus, rubrics can be a useful tool to give feedback yet they are often underutilized in the learning process. Rubrics are a way to efficiently give guidelines, go through the criteria of a project and assess where the student met the criteria and with what quality.

Students can see the rubric and check their level of achievement objectively. After this, they identify by themselves the categories that scored the lowest. These categories may be the best areas to focus on, as they provide the greatest opportunity for improvement.

Rubrics not only allow the student to assess his or her own work but to assess others' work. So co-evaluations among peers can be implemented following these rubrics.

2. FORM EXPLORATION

A set of criteria for grading assignments has been designed which can be used by teachers when marking, and by students when planning their work. It is an attempt to communicate expectations of quality around a task. In other words, it is expected to serve as a way of giving indirect feedback. The criteria selected are fitting and proportion, line, shading, stand out backgrounds, form exploration and presentation panels.

	Excellent	Advanced	Developing	Needs improvement
Fitting and proportion	Correct use of planes, lines and grids to fit the product. Everything is proportional. All elements in the composition are correctly proportioned and work together within the frame to communicate unity and a visual equilibrium.	Correct use of planes, lines and grids to fit the product. Everything is proportional. Some elements are not well represented.	Proportions of the sketch somewhat resemble the size and shape of the sketched object. Minimal use of lines, planes and grids.	Lack of understanding or skills in applying correct proportion measurements. The use of pkanes and grids is not evident.
Line	Variations in line weight (heavy, light, thin, dark, etc.) and appropriately used and well controlled in all areas of the sketch.	Variations in line weight but there is a lack of emphasis in certain areas with minor importance.	Little variations in line weight with a lack of emphasis in important areas of the sketch.	There is little or no variation in line weight, which results in many lines "expressing" the same. Lines may communicate a lack of an intentional process.
Shading	Correct application of lights and shadows, very close to reality.	The sketch has strong, well-done shading but additional shading is needed to create a more realistic three-dimensional appearence.	Little or no variation of shading techniques. Inconsistent or poorly t applied shading.	No evidence of shading in the sketch.
Stand out backgrounds	The background is appropriate and stands out but without being the main focus of the work.	The background is appropriate and stands out but there is room for improvement.	The background does not totally match the product represented, colours are too flashy or divert the attention from the product.	The student does not apply any stand out background or it is inappropriate.
Form exploration	Considers shape, materials, ergonomics, shows details and the design is original and easy to interpret. There is a variety of sketches.	Considers shape, materials, ergonomics, shows details but the design requires effort to understand. There is a variety of sketches.	Considers shape, materials, ergonomics, but there is a lack of details and the design requires effort to understand. Two or three sketches.	Limited consideration of shape, materials, ergonomics, there is a lack of details and the design requires effort to understand. One or two sketches.
Presentation panels	Neat, clean work with no wrinkles or stains. The composition of the reticle is optimal.	Neat, clean work. The composition of the reticle is good but can be improved.	Poor , messy appearence. The composition of the panel is good but can be improved.	Broken, wrinkled, stained or smudged panel. Not using the correct physic support for the panel (foam board or similar). Messy composition of the reticle.

Table 8: Design sketching rubric

3. PROPOSAL OF EXERCISES

3.1. Participants

To make classes more dynamic, a series of exercises will be proposed. To report the efficacy of these exercises, a sample of undergraduate industrial design students has been selected. An online session was arranged in order to carry out these exercises.

The criteria for the participant selection were the following:
• Successfully completed design fundamental courses and sketching courses.
• Enrolled as a full-time student in the degree program (Industrial Design Engineering and product development).

Each of the students selected have different profiles; one part of the sample has a more technical background while the other part has a more artistic background.

Students with an artistic background are said to find easier to create new designs and variations whilst students with a technical background are said to be stagnated during this explorative process.

3.2. Purpose

One of the main ideas is to help these technical background students to comprehend the creative process and encourage them to explore different alternatives. The thresholds typical from their background can hinder the creative process and thus, these exercises are thought to foster creativity among the students.

Another point to achieve with these exercises is to guide students through the process of form exploration as many of them do not know how to take the first step with this procedure.

3.3. Task environment

To check if the methodology used would be effective for online courses, the experiment took place online. Each participant was at home with their computers and webcams turned on. The subjects were provided with plain drawing paper, pens, pencils, coloured markers and other analog tools commonly used as media during sketching activities.

3.4. Procedure

The participants were given an introduction related to the aims and objectives of this research, their rights and obligations as a participant and the task procedure. After this, a brief explanation about what is form exploration was made. Then, a summary of what are restrictions when drawing was made.
The way to proceed was the following:
The lesson consisted on series of 7 exercises were proposed to 11 participants. Due to limitations of time, each exercise had a restriction of time (5 or 10 minutes). All the participants would do the same exercise at the same time and were controlled to avoid them cheating by looking up images on the internet.

The product selected for participants to draw was a salt cellar. The starting product was the one shown below:

Picture 7: salt cellar

When finished, all students were told to answer a short survey in order to have feedback about the exercises proposed in order to make imrpovements. After collection of data, every participants' results were matched and compared.

The lesson objectives were to communicate different design ideas effectively. to check how different constraints can affect design and to review the different strategies used by students when it comes to form exploration

List of participants:

P1: Artistic background   P7: Technical background
P2: Artistic background   P8: Technical background
P3: Artistic background   P9: Technical background
P4: Artistic background   P10: Technical background
P5: Artistic background   P11: Artistic background
P6: Technical background

3. PROPOSAL OF EXERCISES

1. Draw the upside-down salt cellar in a normal position. (10 min)
Restrictions: position of the product (perspective), time.
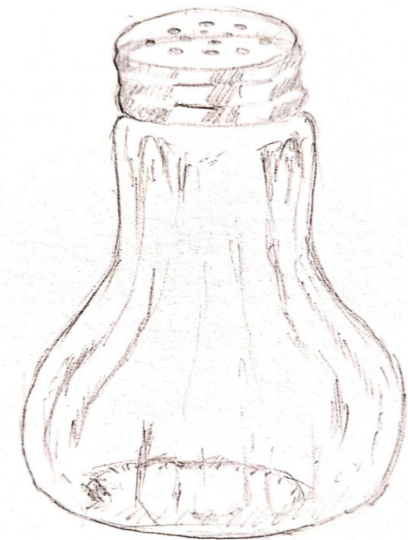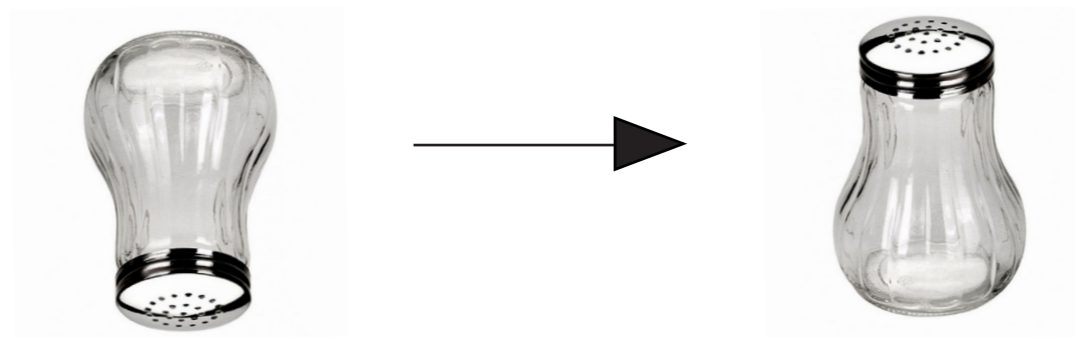
Picture 8: salt cellar by participant 1

Picture 9: salt cellar by participant 1

Picture 10: salt cellar by participant 3

Picture 11: salt cellar by participant 4

Picture 12: salt cellar by participant 5
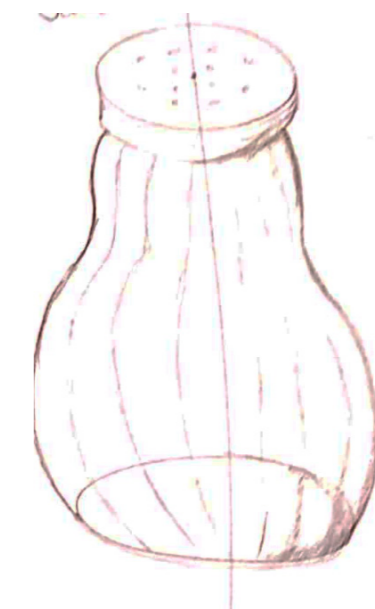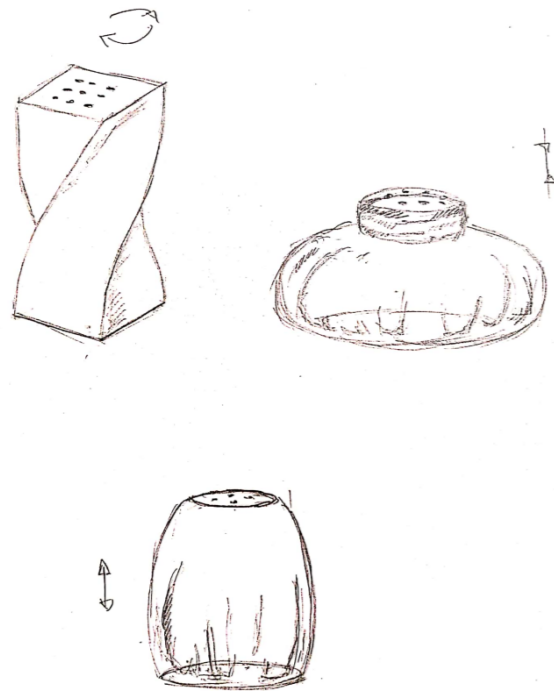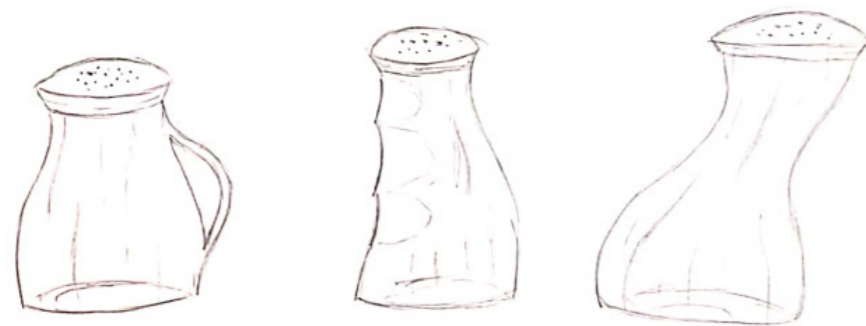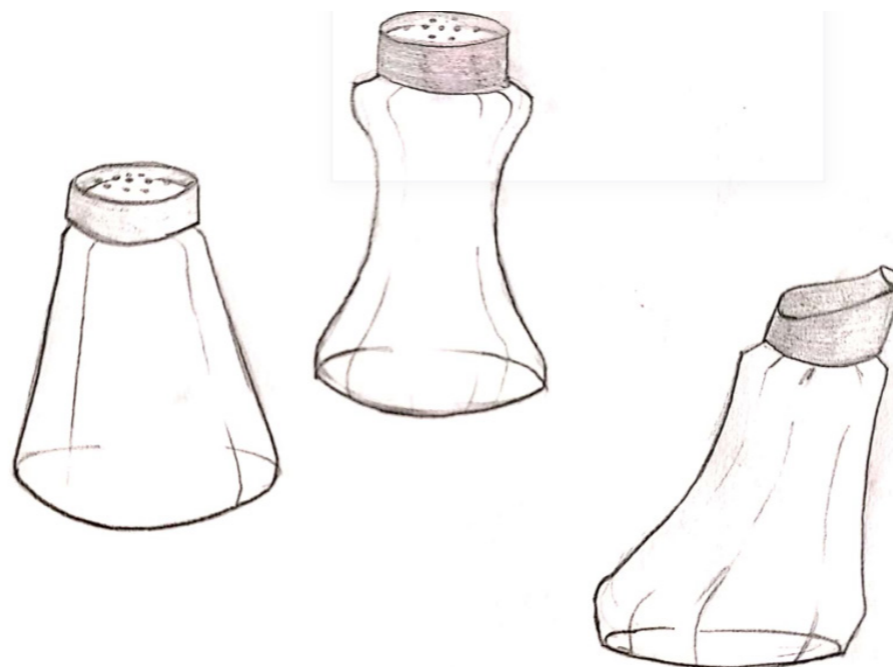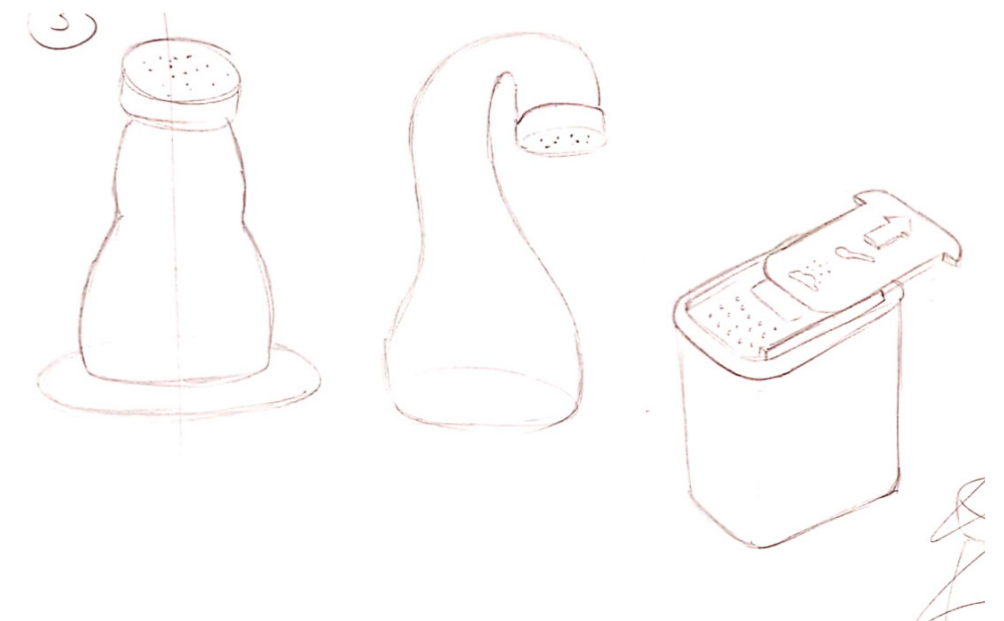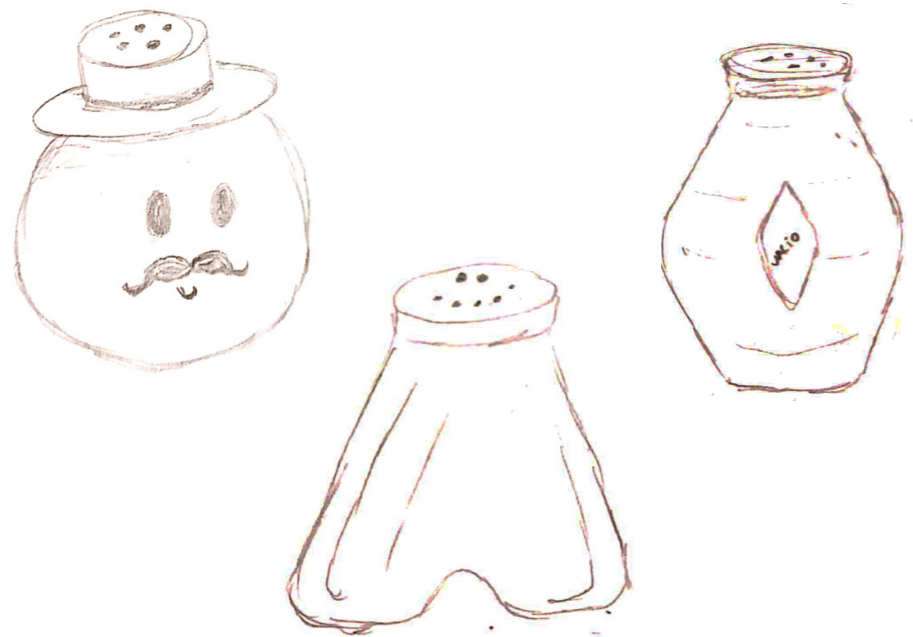
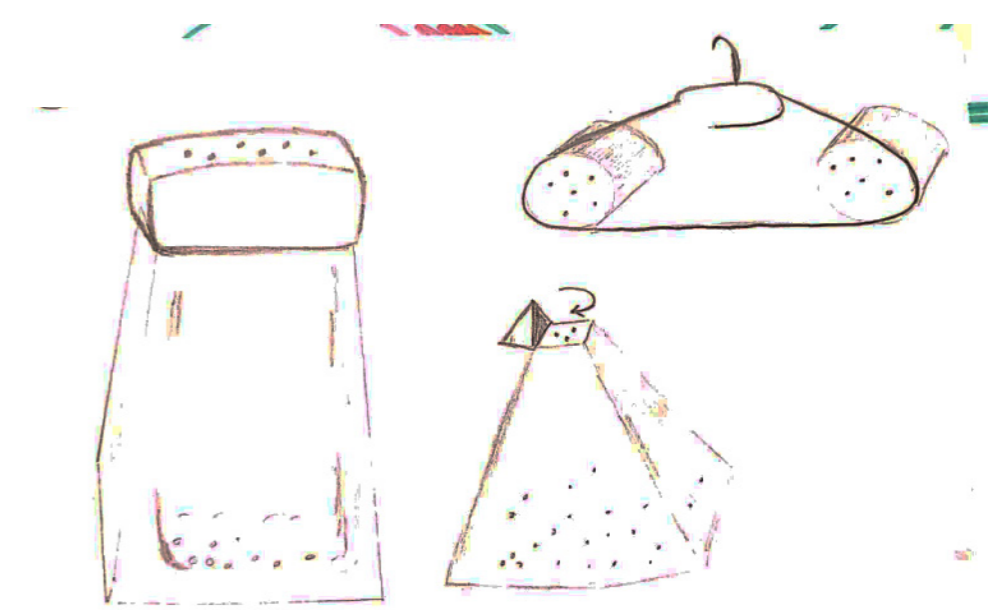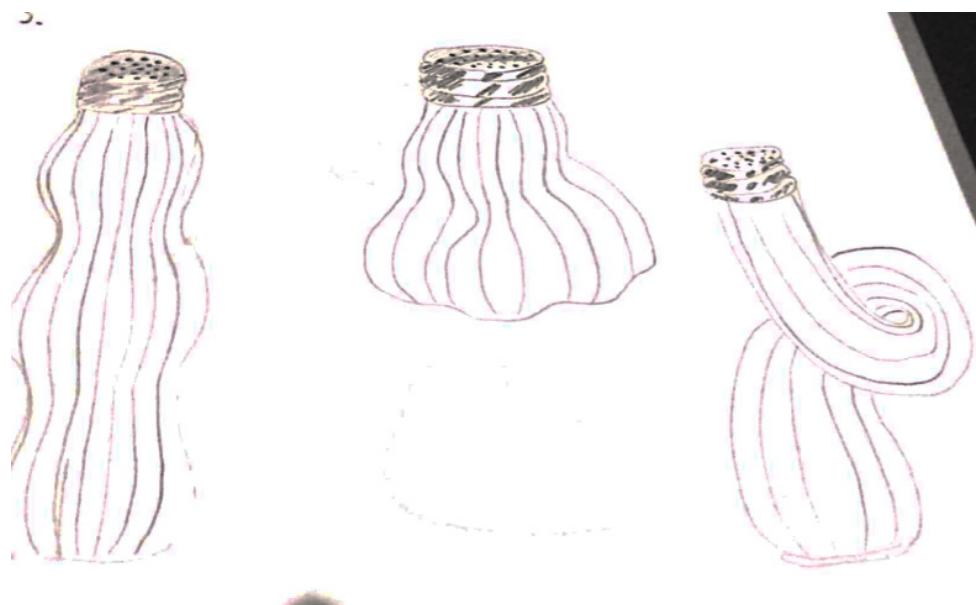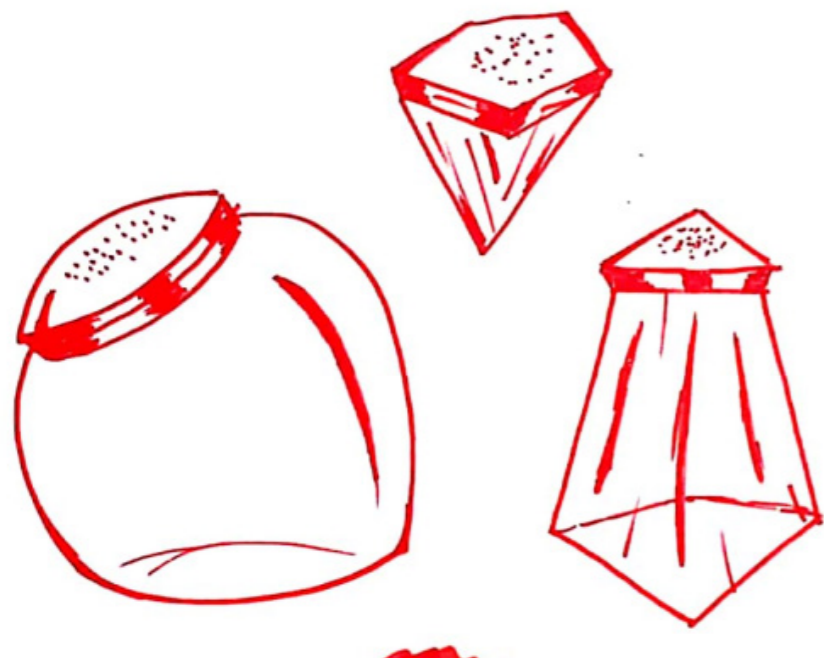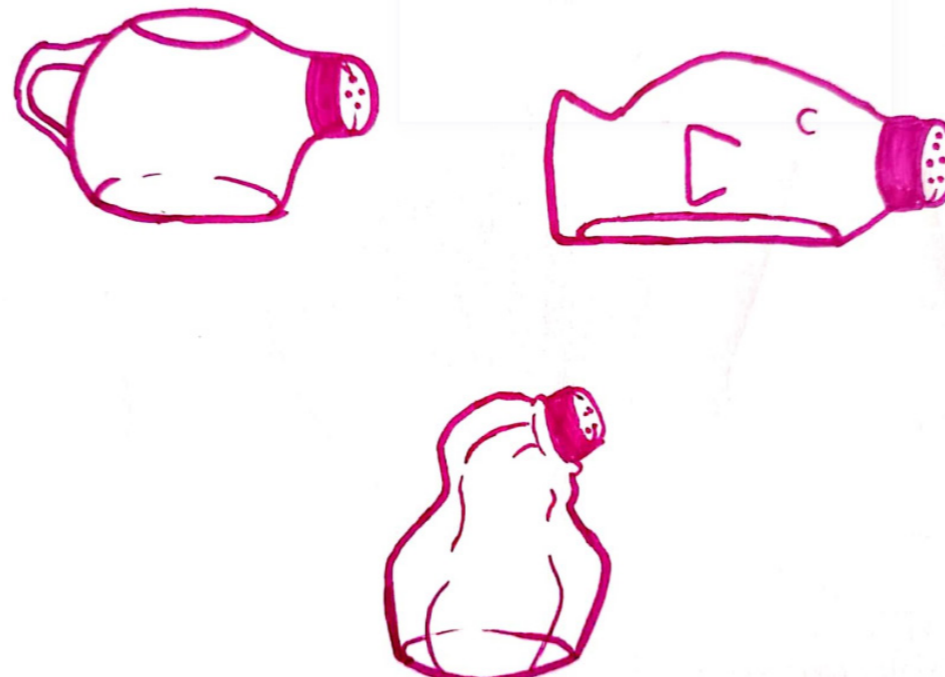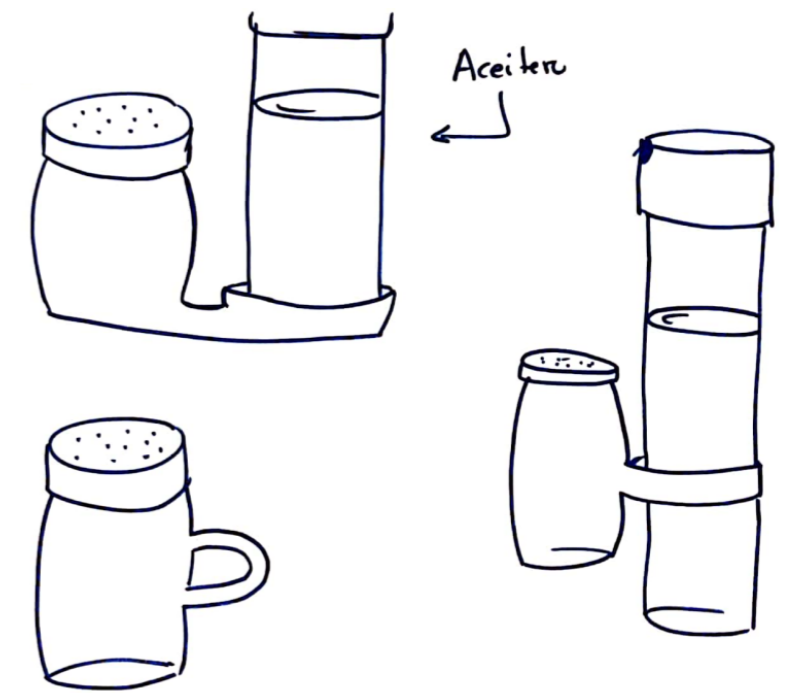Picture 13: salt cellar by participant 6
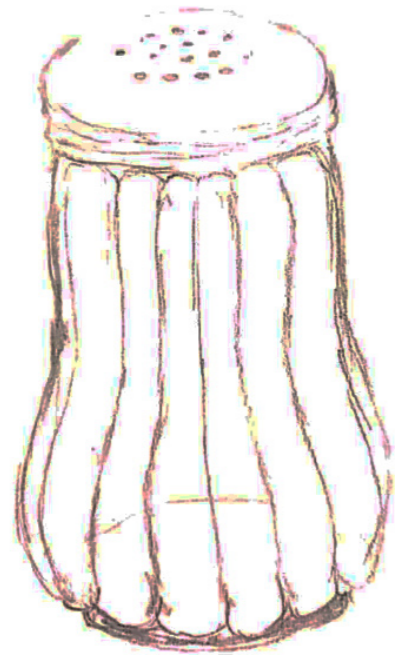
Picture 14: salt cellar by participant 7

Picture 15: salt cellar by participant 8
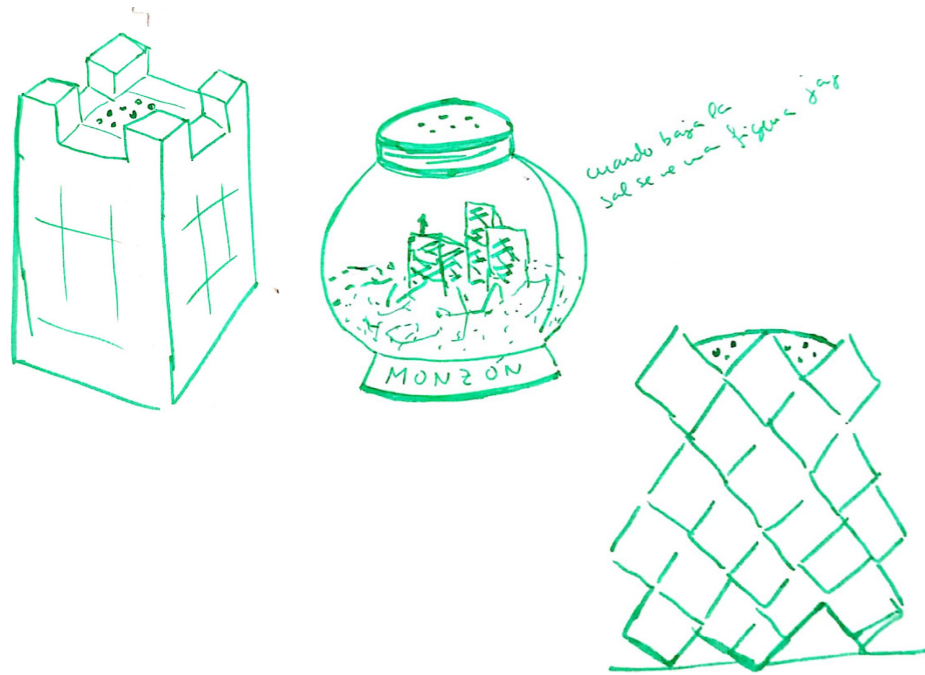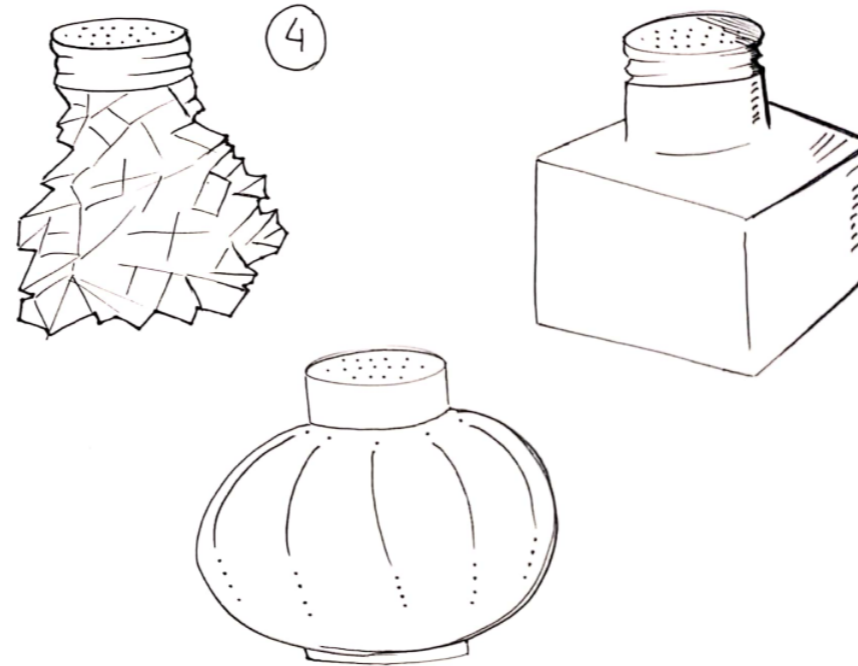

Picture 16: salt cellar by participant 9

Picture 17: salt cellar by participant 10
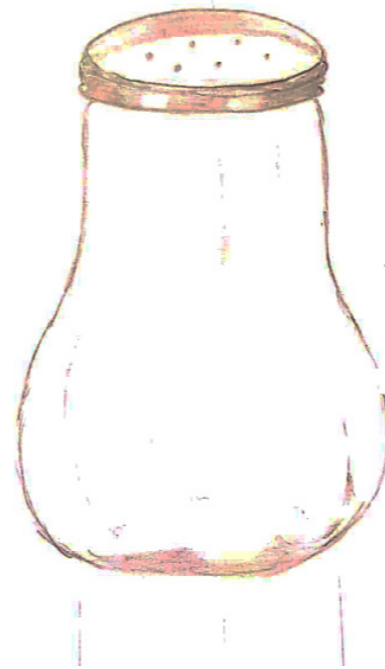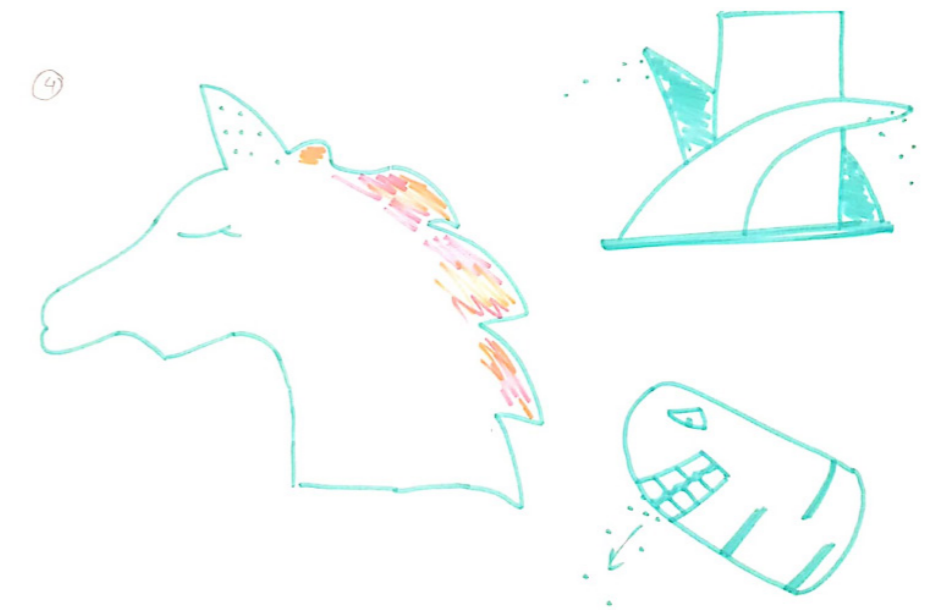

Picture 18: salt cellar by participant 11

The exercise resulted in a subtile but yet notorious difference in the forms, even though they all had the same object as reference. The greater difference observed is in the curve lines and lower part of the product. Shading also makes the product look better.

Another aspect is the strokes. In general, the thickness of the line is better controlled by those students who have an artistic profile.

2. Draw 3 salt cellars using torsion, addition, substraction, etc. Each salt cellar has to have at least one of these transformations. (10 min)
Restrictions: transformation, time.

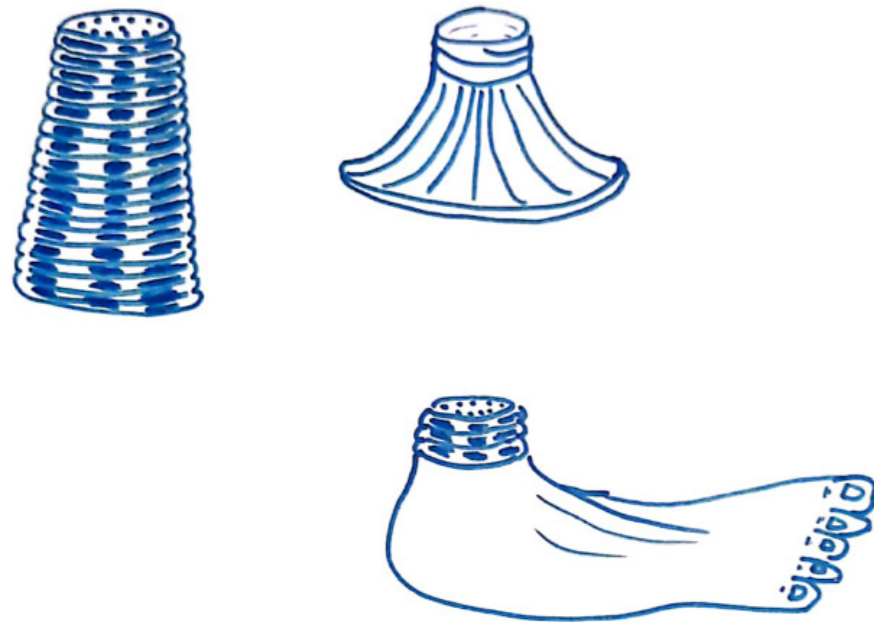Picture 19: salt cellar by participant 1
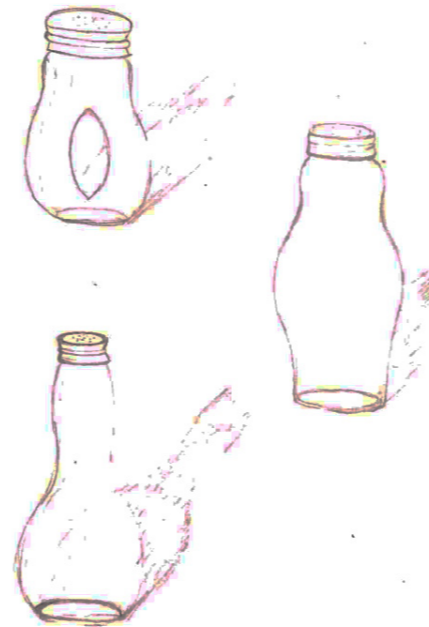
Picture 20: salt cellar by participant 2

Picture 21: salt cellar by participant 3

Picture 22: salt cellar by participant 4

Picture 23: salt cellar by participant 5

Picture 24: salt cellar by participant 6

Picture 25: salt cellar by participant 7

Picture 26: salt cellar by participant 8

Picture 27: salt cellar by participant 9

Students with technical background did not show any problem making this exercise.

It is noticeable that some salt cellars are alike (see participant 7 and participant 11, participant 1 and participant 8, participant 2 and participant 7 and participant 10 and participant 11). As it has been highlighted before, none of the students could see the sketches of their mates as they were in different physical locations.

Picture 28: salt cellar by participant 10

Picture 29: salt cellar by participant 11

**3. Draw 3 different salt cellars using a marker. (5 min)**
Restrictions: tool (marker), time

Picture 30: salt cellar by participant 1
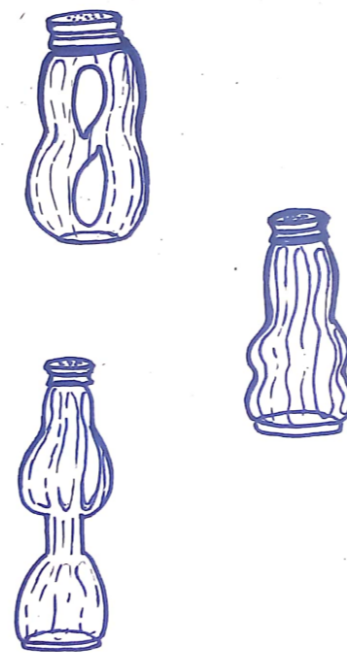
Picture 31: salt cellar by participant 2
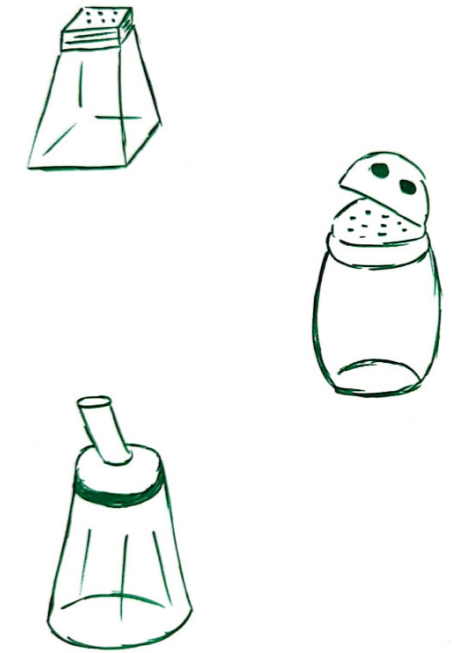
Picture 32: salt cellar by participant 3

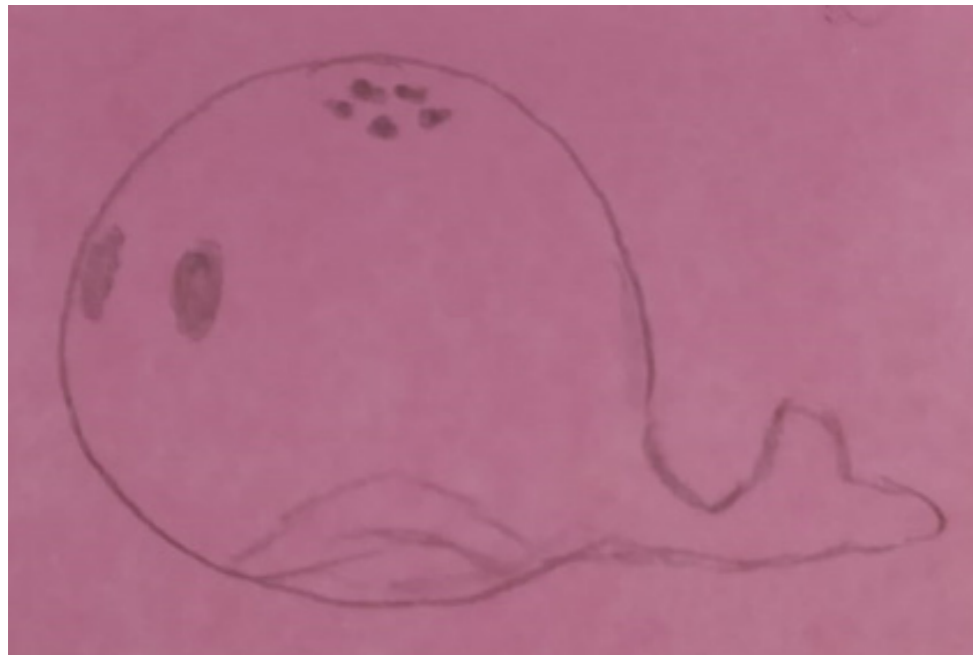Picture 33: salt cellar by participant 4
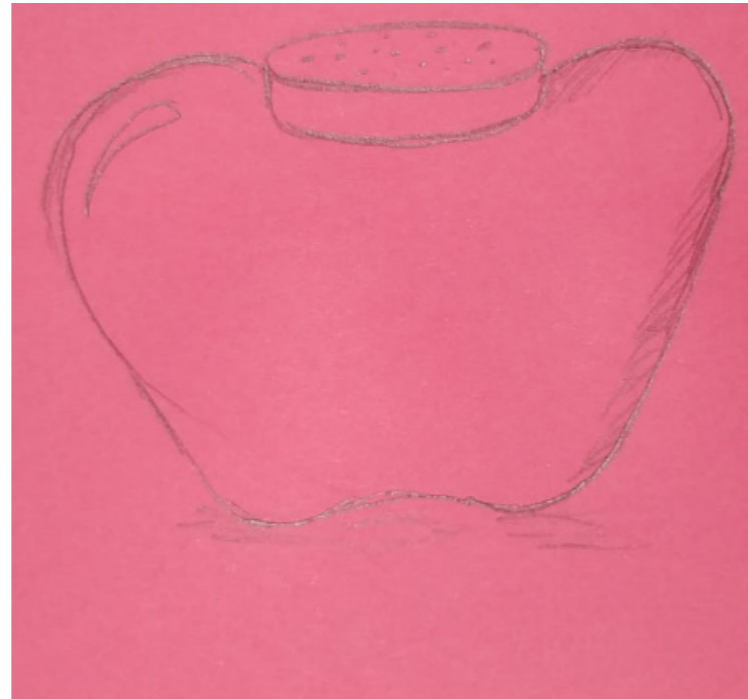
Picture 34: salt cellar by participant 5

Aceitera

Picture 35: salt cellar by participant 6

3. PROPOSAL OF EXERCISES

Picture 36: salt cellar by participant 7

Picture 37: salt cellar by participant 8

Picture 38: salt cellar by participant 9

Picture 39: salt cellar by participant 10

Picture 40: salt cellar by participant 11

The main purpose of this exercise was to make the students to keep on sketching regardless of the mistakes they could have made. The added difficulty of time restriction fostered the quick flow of ideas.

In this exercise, technical profile students began to present some difficulties as they had already drawn 4 salt cellars and they began to run out of ideas.

Some of them began to copy objects around them and translate them into brand new salt cellars.

4. Draw a salt cellar in a post-it. (5 min)
Restrictions: size, time
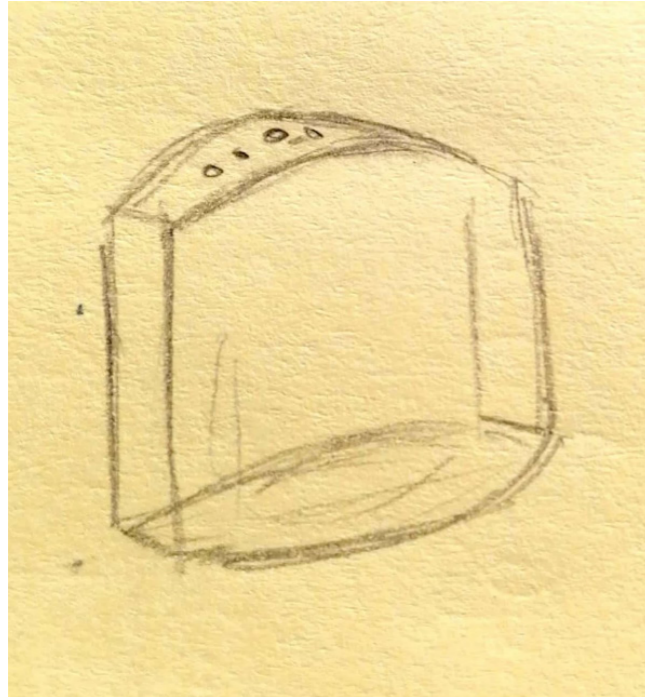
Picture 41: salt cellar by participant 1

Picture 42: salt cellar by participant 2
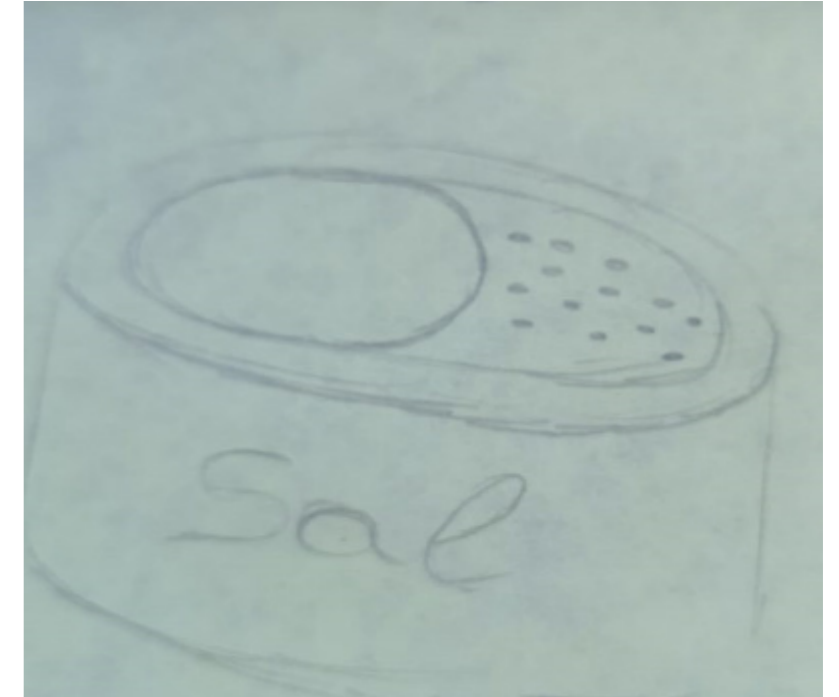
Picture 43: salt cellar by participant 3

Picture 44: salt cellar by participant 4

Picture 45: salt cellar by participant 5

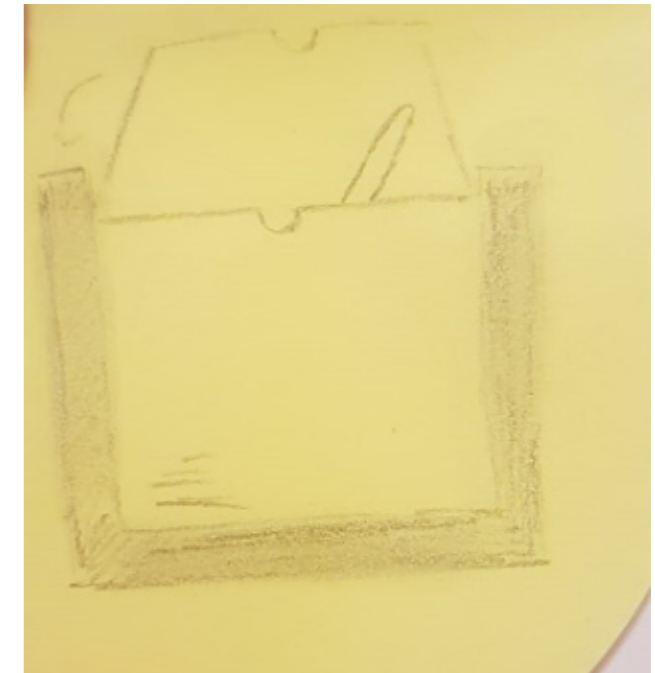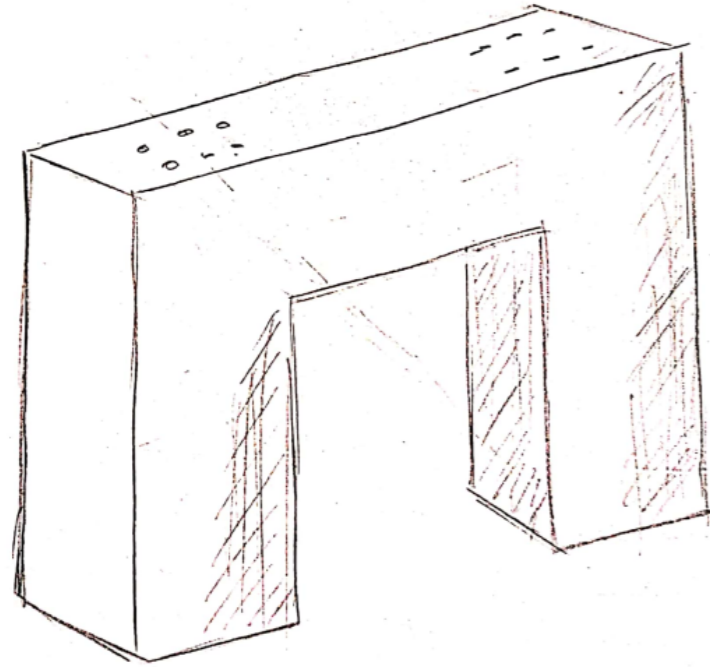Picture 46: salt cellar by participant 6

3. PROPOSAL OF EXERCISES

Picture 47: salt cellar by participant 7

Picture 48: salt cellar by participant 8

Picture 49: salt cellar by participant 9

Picture 50: salt cellar by participant 10

Picture 51: salt cellar by participant 11

Exercise number 4 was less stimulating. None of the students had any impediment sketching in a smaller surface. Yet we can see that most of the designs are simpler and the use of lines and details has been reduced significantly.

Maybe it was not as challenging because since the beginning participants were making small sketches in an A4 format. Changing the paper format to an A3 in order to make the sketches bigger and then changing into a post-it would have been more effective.
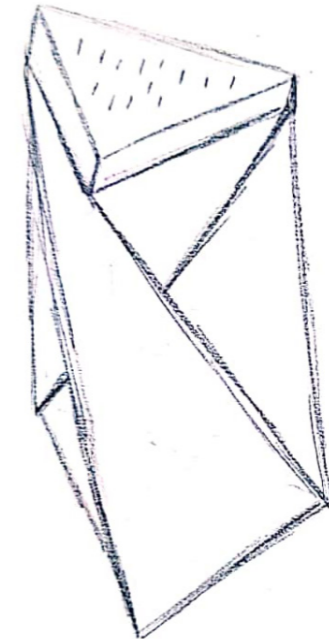
5. Draw a salt cellar using only straight lines (5 min)
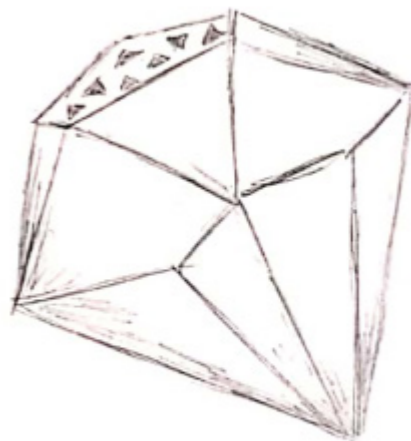**Restricitions: technique (straight lines), time**

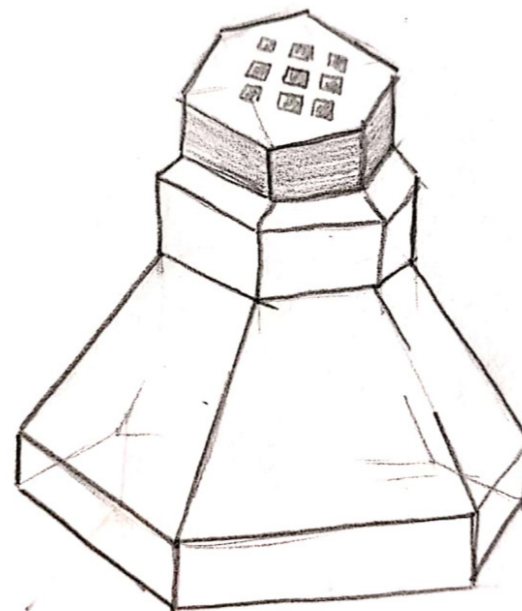Picture 52: salt cellar by participant 1

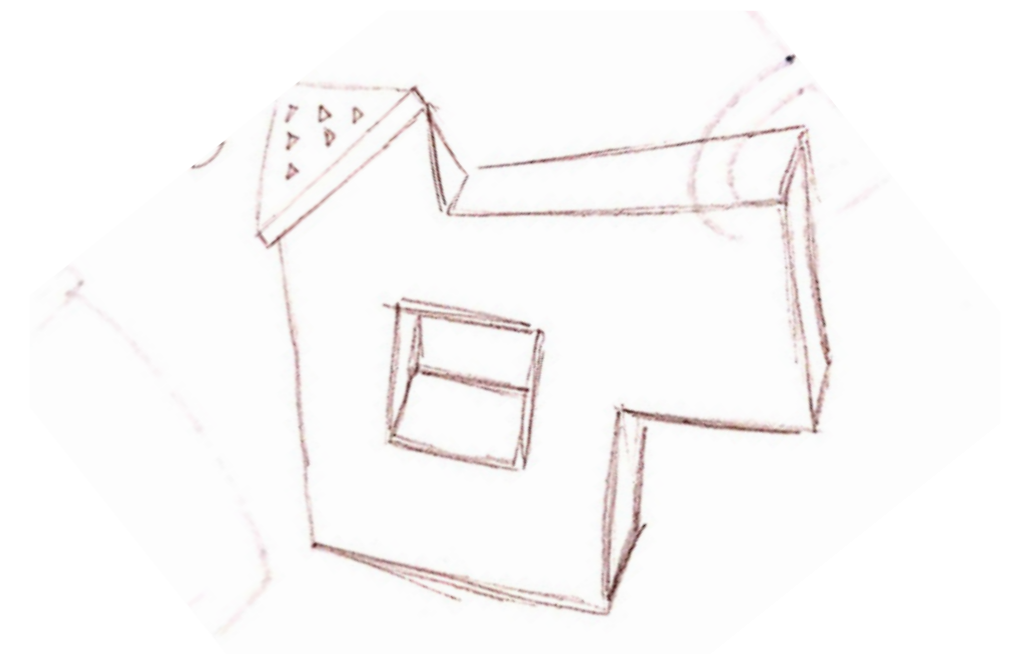Picture 53: salt cellar by participant 2

Picture 54: salt cellar by participant 3
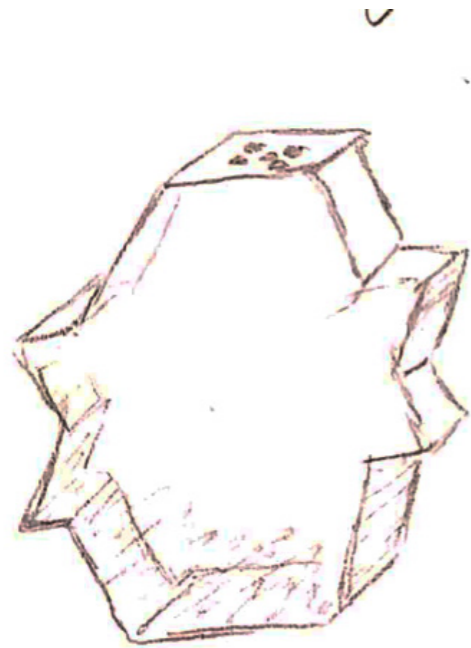

Picture 55: salt cellar by participant 4
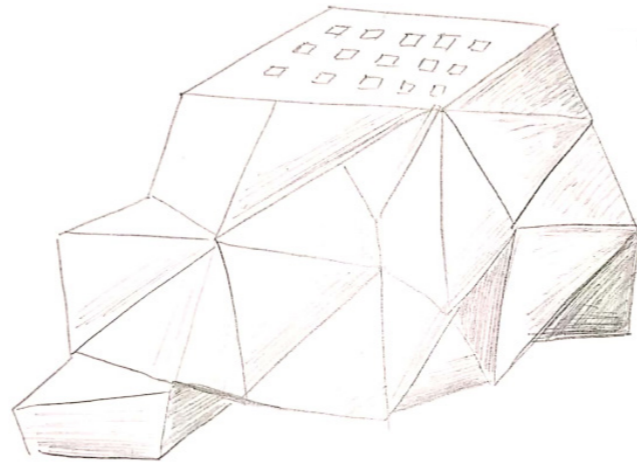

Picture 56: salt cellar by participant 5

Picture 57: salt cellar by participant 6

Picture 58: salt cellar by participant 7

Picture 59: salt cellar by participant 8

Picture 60: salt cellar by participant 9

Picture 61: salt cellar by participant 10

Picture 62: salt cellar by participant 11

Exercise number 5 showed interesting results. The use of geometric shapes such as triangles is quite common. 5 out of the 11 sketches are composed with triangles.

With this restriction, we can see more original results than with any other restriction. This might be because the use of straight lines forced students to change their thinking patterns.

6. Draw a salt cellar without lifting the pencil from the paper. (2 min)
Restrictions: technique (not lifting the pencil from the paper), time

Picture 63: salt cellar by participant 1

Picture 64: salt cellar by participant 2

Picture 65: salt cellar by participant 3

Picture 66: salt cellar by participant 4

Picture 67: salt cellar by participant 5

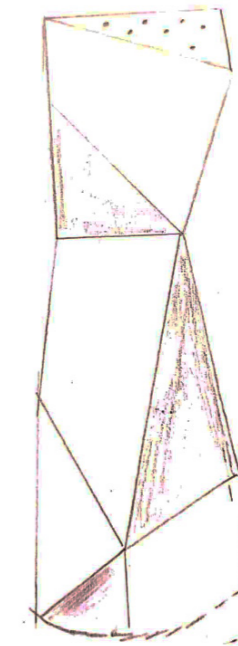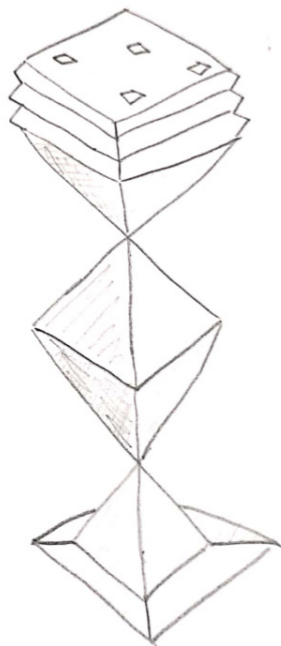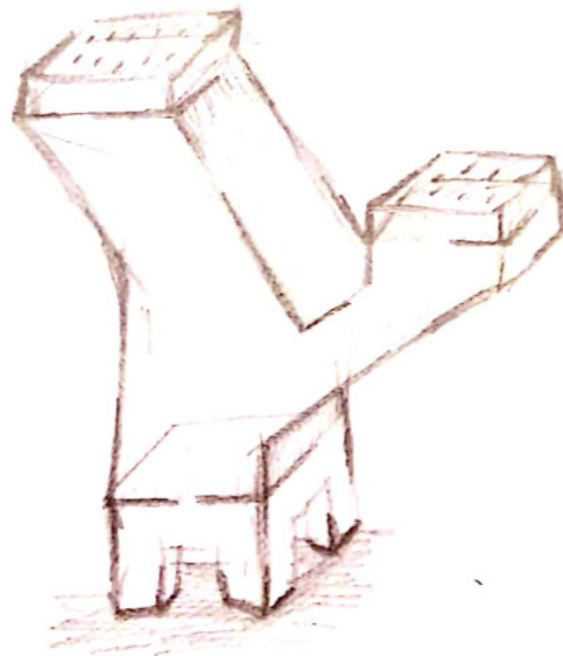Picture 68: salt cellar by participant 6

Picture 69: salt cellar by participant 7

Picture 70: salt cellar by participant 8

Picture 71: salt cellar by participant 9
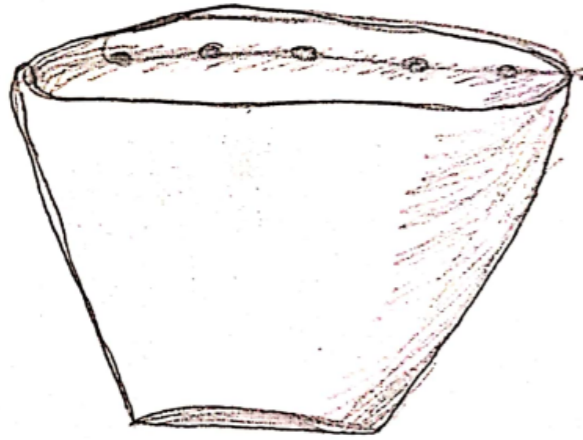
The restrictions imposed made the participants go for simpler curvy designs in its majority.

The thickness of the lines is not that well controlled as they look really homogeneous, maybe due to the lack of time.

Picture 72: salt cellar by participant 10

Picture 73: salt cellar by participant 11

7. Draw a salt cellar without looking at the paper. (2 min)
Restrictions: technique (not looking at the paper), time
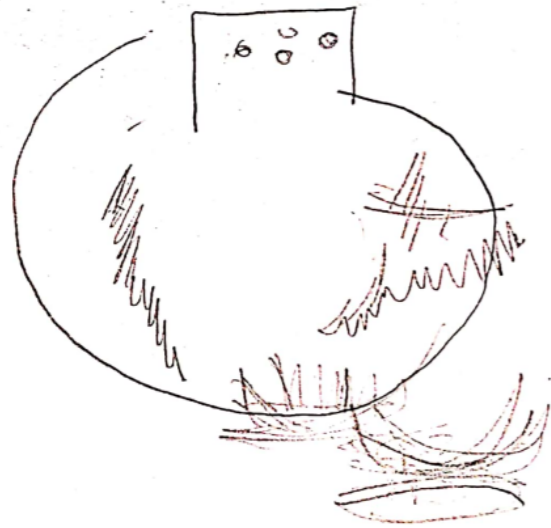
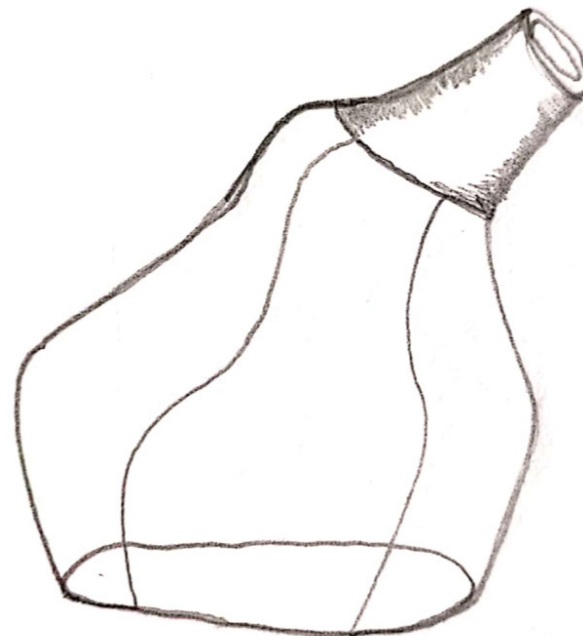Picture 74: salt cellar by participant 1

Picture 75: salt cellar by participant 2

Picture 76: salt cellar by participant 3

Picture 77: salt cellar by participant 4
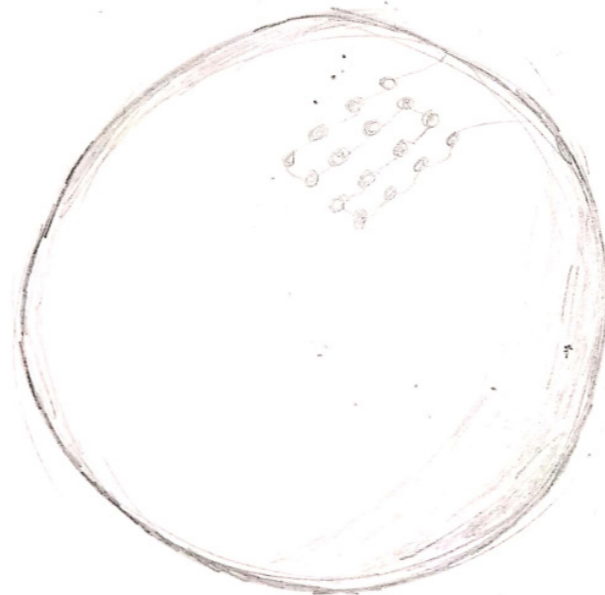

Picture 78: salt cellar by participant 5

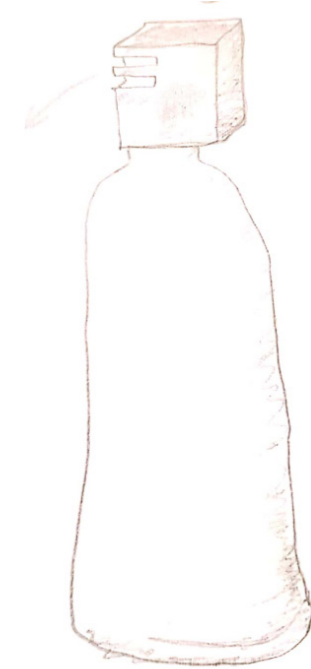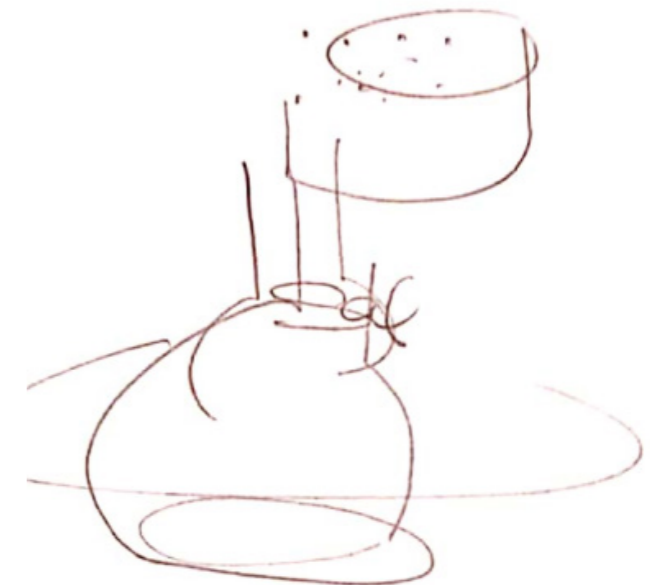Picture 79: salt cellar by participant 6

3. PROPOSAL OF EXERCISES

Picture 80: salt cellar by participant 7

Picture 81: salt cellar by participant 8

Picture 82: salt cellar by participant 9

The purpose of this last exercise was to see if the students could find a new form "by accident". However, it did not result as expected.

Drawing without looking at the paper is such a complex exercise to put into practise that most of the times it end up being a failure.

Picture 83: salt cellar by participant 10

Picture 84: salt cellar by participant 11

3. PROPOSAL OF EXERCISES

3.6. Survey

After finishing the exercises, an online survey was provided to each participant in order to obtain feedback about the exercises that they did just make and improve or discard them if necessary.

The questions and their answers are reflected in the following pages:

What are your thoughts on these exercises?

1. I had fun.

2. Very entertaining.

3. Curious.

4. I had a good time making them.

5. Entertaining and a good product choice considering the time we had.

6. Interesting.

7. Entertaining.

8. They haven't been long and thinking about different salt cellars was really fun.

9. They have been interesting, I had fun and they have allowed me to know other resources when designing a product.

10. Ver interesting and original to carry out form exploration

11. Interesting and different

Do you think they help to foster form exploration?

- Yes
- No

100%
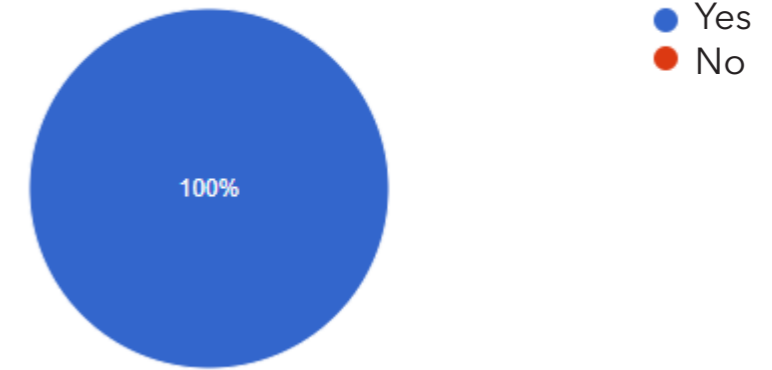
Which was the most useful exercise?

	Ex. 1	Ex.2	Ex. 3	Ex. 4	Ex. 5	Ex.6	Ex. 7
P1		■	■		■		
P2			■				
P3		■					
P4		■					
P5			■				
P6		■					
P7						■	
P8			■				
P9							
P10	■						■
P11			■				

And the least useful?

	Ex. 1	Ex.2	Ex. 3	Ex. 4	Ex. 5	Ex.6	Ex. 7
P1						■	
P2							■
P3							■
P4	■						
P5				■			
P6					■		
P7				■			
P8	■						
P9							■
P10	■						
P11							■

Could you think of more exercises which help to foster form exploration?

1. No.

2. Trying to copy the shape of other objects in the product.

3. No, sorry.

4. Repeating any of them after watching our classmates' results

5. Searching for photos of the product and combine them.
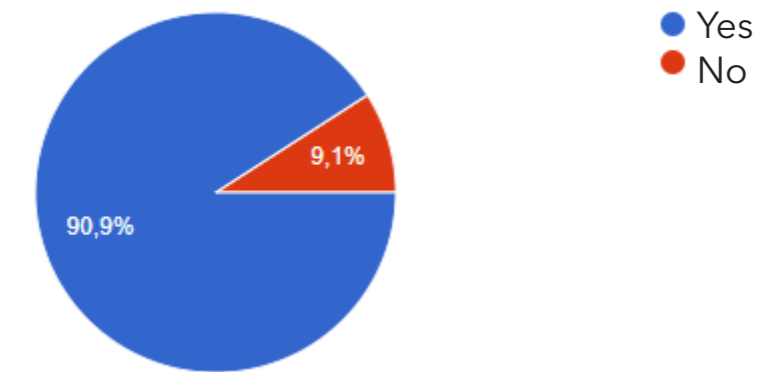
6. Drawing using a brush.

7. No.

8. Using the mash-up technique; mixing different random objects to obtain a new product.

9.Drawing with both hands.

10. Joining different features of different salt cellars and creating a new salt cellar.

11. No, sorry.

Do you think a rubric would be useful in order to assess these kind of exercises?

● Yes
● No

9,1%

90,9%

3.7. Conclusions

The exercises resulted to be entertaining and stimulating for students and at the same time fostered form exploration. However, there have been exercises that worked better than others.

Exercise number 1 was not well rated by participants, probably because they had to copy an object instead of creating something new. Exercise number 4 was not that well rated because, according to participants, it was not a big deal drawing in a small area, so they were not forced to think differently and be creative. Exercise number 7 did not show the results that were expected due to the complexity of the given task.

The exercises that worked the best were 2, 3, 5 and 6 because they forced students to think in totally different ways. Exercise 5 was the least well rated among these exercises. However it showed the most interesting results.

The main difference noticed between participants with artistical and technical background was the amount of time needed. While artistical profile students finished the exercises earlier, technical background students spent more time ideating in their minds what they were going to sketch. Another aspect that has been noticed is that technical profile participants began to lack ideas in the third exercise. Maybe it would be usefulfor them to share their work and see their mates work to get more inspired. Also, we must point out that while going deeper into form exploration, functionality began to fade.

In addition, at the end of the session, students were told to think about other exercises which they thought might be useful to foster form exploration.

One of these exercises was to sketch in the post-it with a brush. This exercise was proposed at the beginning but could not be carried out as not all the members had a brush at home. This could be a way to improve the post-it exercise as there are more restrictions. The only thing to take into account is that the brush must not be that thick.

Another exercise proposed by students was to do a mash-up. In other words, having two reference objects and merge the different features of each one to create a new product.

After that, the utility of a rubric was argued as during the session, there were several doubts about how students should sketch. To support this hypothesis, the survey showed that 10 out of 11 participants considered that a rubric would have been useful. This might be helpful especially students who are less creative to have some guidelines at the time of sketching.

Finally, it must be said that as all the students belonged to the same university, the results could be biased as they all were taught with the same methods. Unfortunately, no other universities were willing to participate in the experiment.

To sum up, exercises 1 and 7 will be disregarded and the rest of the exercises will be kept as a proposal. Moreover, another exercise will be added. So the list of activities will be the following:

1. Draw 3 salt cellars using torsion, addition, substraction, etc. Each salt cellar has to have at least one of these transformations. (10 min)
2. Draw 3 different salt cellars using a marker. (10 min)
3. Draw a salt cellar in a post-it. (5 min)
4. Draw a salt cellar using only straight lines (5 min)
5. Draw a salt cellar without lifting the pencil from the paper. (2 min)
6. Having two reference objects,merge the different features of each one to create a new product. (10 min)

4. FORM EXPLORATION RUBRIC

The survey results showed that a rubric would be useful to guide students when they are doing form exploration. In order to obtain more feedback in a different way, students can assess their own work and their peers' by taking a look at the rubric elaborated below.

	Excellent	Advanced	Developing	Needs improvement
Fitting	Correct use of planes, lines and grids to fit the product.	Correct use of planes, lines and grids to fit the product but some elements are not well represented.	Minimal use of lines, planes and grids to represent the object.	The use of pkanes and grids to fit the product is not evident.
Line	Variations in line weight (heavy, light, thin, dark, etc.) and appropriately used and well controlled in all areas of the sketch.	Variations in line weight but there is a lack of emphasis in certain areas with minor importance.	Little variations in line weight with a lack of emphasis in important areas of the sketch.	There is little or no variation in line weight, which results in many lines "expressing" the same. Lines may communicate a lack of an intentional process.
Shading	Correct application of lights and shadows, very close to reality.	The sketch has strong, well-done shading but additional shading is needed to create a more realistic three-dimensional appearence.	Little or no variation of shading techniques. Inconsistent or poorly t applied shading.	No evidence of shading in the sketch.
Transformations: addition, substraction, torsion, change of proportions, straight lines...	Different transformations shown in the sketches and applied to the whole product.	Wider range of transformations applied in the sketches but only in a part of the product.	Sketches show a little range of transformations in some parts of the products .	Very little or no transformations applied.
Functionality	The product is original in form and completely functional.	The product is original in form but some functions could be improved.	Some functions of the product are difficult to perceived or not perceived at all.	The product is not original nor functional at all. The function of the product is not perceived.
Ergonomics	The product is ergonomic (easy to hold/grab, to use, it has the right proportions and size...).	The product is ergonomic but there are some details that could be improved.	Some ergonomic aspects have not been considered in the design.	The form variation hinders or worsens ergonomics.
Organised layout	Attractive and original layout. Organised sketches. It's easy to locate important elements and the final design.	Attractive and original layout. Organised sketches. It's easy to locate most of the important elements but not which is the final design.	Attractive and original layout. Sketches are a bit messy. It's difficult to locate some of the important elements.	The sketches are cluttered and somehow confusing. It's difficult to locate the important elements and the final design.
Creativity and originality	New and innovative approach to the topic; student has created own design and product.	Student adapts others' ideas to create own design; some originality shown.	Student adapts others' ideas to create own design; very little originality shown	Creativity and originality absent
Information and details about the product	The sketches contain different views, including detailed views of the product and anotations if necessary.	The sketches contain some views, some detailed views of the product and anotations are not relevant.	Some of the detailed views are not relevant or do not show correctly the transformations. No anotations present if they were needed.	Detailed views or information about the product are absent.

Table 9: Form exploration rubric

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Article title: Create memorable learning archives
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Article title: The Power of Form Exploration in Sketching — sw-industrialdesign
URL: https://www.sw-industrialdesign.com/blog/the-power-of-form-exploration-in-sketching
Last consulted: 12th May 2021

[1] Biedermann, A. M., Serrano Tierz, A. (2020). Practice 10 form exploration.

Picture 2: https://upload.wikimedia.org/wikipedia/commons/thumb/9/9b/Google_Meet_icon_(2020).svg/1200px-Google_Meet_icon_(2020).svg.png

Picture 3: https://upload.wikimedia.org/wikipedia/commons/thumb/c/c9/Micro-soft_Office_Teams_%282018%E2%80%93present%29.svg/1200px-Microsoft_Office_Teams_%282018%E2%80%93present%29.svg.png

Picture 4: https://community.pacificoaks.edu/informationtechnology/PublishingImages/Pages/Training-Zoom/zoom-logo.png

Picture 5: https://www.pinterest.es/pin/73887250111199800/

Picture 6: https://es.scribd.com/presentation/239485812/Transformacion-de-la-Forma

Inspiration for the rubric

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URL: http://mavengineering.weebly.com/concept-sketching-rubric.html
Last consulted: 12th May 2021

Website title: Faculty.academyart.edu
URL: http://faculty.academyart.edu/dam/faculty/assets/pdf/rubrics/SketchRubric.pdf
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Sung, E., Kelley, T. R., & Han, J. (2019). Influence of sketching instruction on elementary students' design cognition: a study of three sketching approaches. Journal of Engineering Design.

Salt cellar

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ANNEX IV: FINAL CONCEPT DEVELOPMENT

1. FORM EXPLORATION LECTURE STRUCTURE

1.1. Introduction

Currently, design sketching lessons at the University of Zaragoza last 3 hours and are being held online. According to this time frame and the circumstances, the lesson will be divided into three different parts, with a 10 minute break between each of the parts.

In order to make clear how the organisation of the class will be, a Gantt's diagram has been designed and displayed at the bottom of the page.

The lesson's modules will be:

1. Theoretical input: A brief introductory power point based explanation to form exploration with visual examples. (40 min). This presentation will be elaborated in the following pages as a graphic resource for the class.

Break (10 min).

2. Exercises: the exercises proposed in *Annex III:Concept development (p. 48)* will be made by students (60 min). The product chosen will be a perfume bottle as it is a simple product that can be drawn in less than 10 minutes. Each exercise has its own restrictions in order to foster creativity.
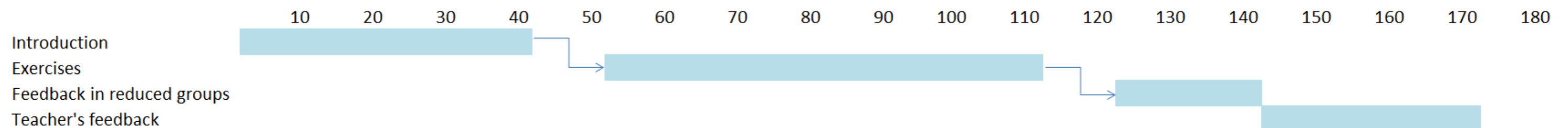
Break (10 min).

3. Feedback: feedback will be divided into two different parts:

3.1. Peer-to-peer feedback (20 min): As the platform used will be Zoom, the educator can create reduced groups of 4-5 people so students can discuss their designs based on the rubric they will have available and share their ideas (4-5 minutes per person). This has been shown to improve students' sketches. The lecturer can also go into the groups, to give more personalised feedback to the students.

3.2. Teacher-student feedback (30 min): pupils willing to have more feedback from the lecturer can display their sketches and show them to the whole class so they can get some brief feedback from the professor.

In the following pages, the content shown during the lesson will be developed.

Diagram 1: Gantt's diagram showing the structure of the lesson

1. FORM EXPLORATION LECTURE STRUCTURE

1.2. Before the lecture

Before the lesson starts, students would be asked to créate a Behance account in order to upload their sketches and send their username to the lecturer so he or she can follow them in order to check their work. The sketches done during the lessons would be uploaded to this platform so students can get feedback not only from the lecturer but also from their classmates, career colleagues and more specialised public.

They would also be asked to download Zoom since this would be the platform selected to carry out the design sketching practical lessons.

1.3. Theoretical input

A series of slides with the basic concepts and examples of form exploration will be displayed during the first part of the class. These slides will be shown in the following pages:

Block III - Practise #10
DESIGN SKETCHING - FORM EXPLORATION
EXPLORATORY SKETCHING

Semester I

Artistic Expression I

Industrial Design and Product
Development Engineering

PRACTISE #10 OBJECTIVES

- Describing a clear evolutive secuence in the product's form exploration

- Utilising a narrative and message tone suitable to the product's characteristics

02 PLANNING

18:00 -18:40 Theoretical input

18:50 - 19:50 Exercises

20:00- 20:20 Feedback round in reduced groups

20:20-20:50 Feedback from professor to the whole class

# MATERIALS

- A3 paper
- Pencil, rubber, markers
- Post-its

Design is an activity that involves exploration and development of **design alternatives**. This involves transformation of overall outline shape and parts of shapes.

Once we have proceeded through the problem definition phase of our design process, we have a top-level description of the problem we are trying to solve and a list of **user needs**.

We now proceed from what is fundamentally a problem of defining the what, into the challenge of the how. What are the **various solutions** that might address the gap in the user experience?
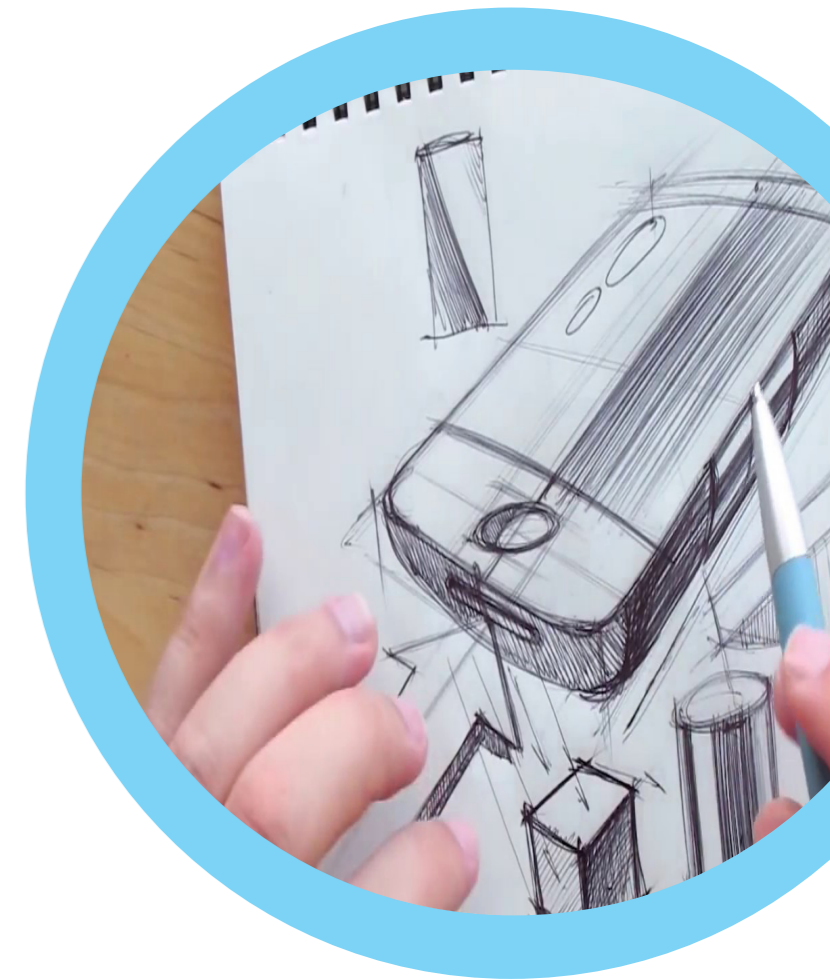
04 WHAT IS EXPLORATORY SKETCHING?

Exploratory sketching is a **simple drawing process** to obtain in a quick way possible variations or small changes in the product's form/shape without the need of presenting an elaborated result. The exploration phase of our design process is going to result in a set of design **concepts or alternative solutions**. This process is generally, is **highly iterative.**

WHAT IS EXPLORATORY SKETCHING?

Concept generation, exploration, is really hard, and it takes much more effort than most people appreciate. To make a successful form exploration we need to be open to ideas that come from anywhere and everywhere.

Form exploration consist on **reinterpretating** our cognitive patterns in order to generate something new.

The form/ shape is an important aspect for any visual appealing product. A **good designed** product will always have good outer shape with **unique form.**

Form exploration is a method of **communicating** the outer form through a product which invites to its use.

THE AIM OF FORM EXPLORATION

Emotional component/empathy. Shape is a key determinant in design as it is the principal means in which people experience functional and emotional aspects of products.

THE AIM OF FORM EXPLORATION

Marketing. It allows for this product to distinguish itself from the other competing alternatives that the user is faced with when making a purchase decision.

Aesthetics. As designers, we should strive to create things that are beautiful and that are elegant.

THE AIM OF FORM EXPLORATION

Functionality. To address the user's needs.

FORM TRANSFORMATIONS

Addition. The product presents the sum of similar elements.

06 FORM TRANSFORMATIONS

Substraction. The product is perceived as the absence of a form.

FORM TRANSFORMATIONS

Fusion. It is produced by the union of different shapes resulting in a hybrid form.

E.g. The bottle is formed by a cylinder (upper part) and a prism (lower part).

06 FORM TRANSFORMATIONS

Torsion, bending, tension, expansion and transformation: a variation is produced and the form changes modifying its initial structure.
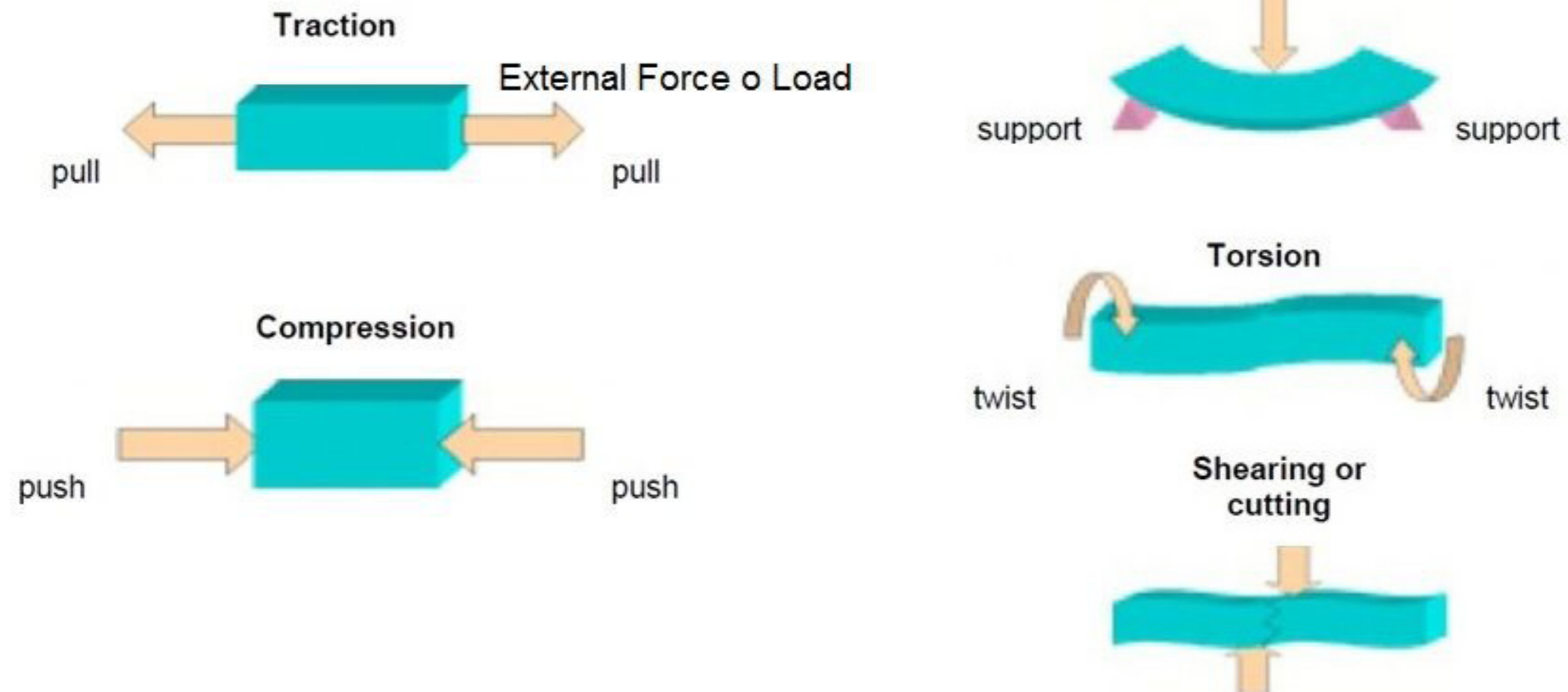
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Let's think of a sequence of external forces that deform the initial structure of the product until it acquires another dimension, as if it was a solid body which has the possibility of **experimenting form variations.**

TYPES OF EFFORTS OR STRESSES

Traction

External Force o Load

pull · pull

Compression

push · push

load

support · support

Torsion

twist · twist

Shearing or cutting

Sequence to facilitate the comprehension of the process:

1. Deciding in which area of the product are we going to apply the trnsformations.

2. Indicate this area and the type of concept (3-5 steps).

3. Planning an ordered form exploration sequence (line, column, other types of distributions...)

4. Indicate which is the final selected design ustilising an adequate resource (making it bigger, colouring it, applying shades, etc.).

5. Including the exploratory process in the final panel.
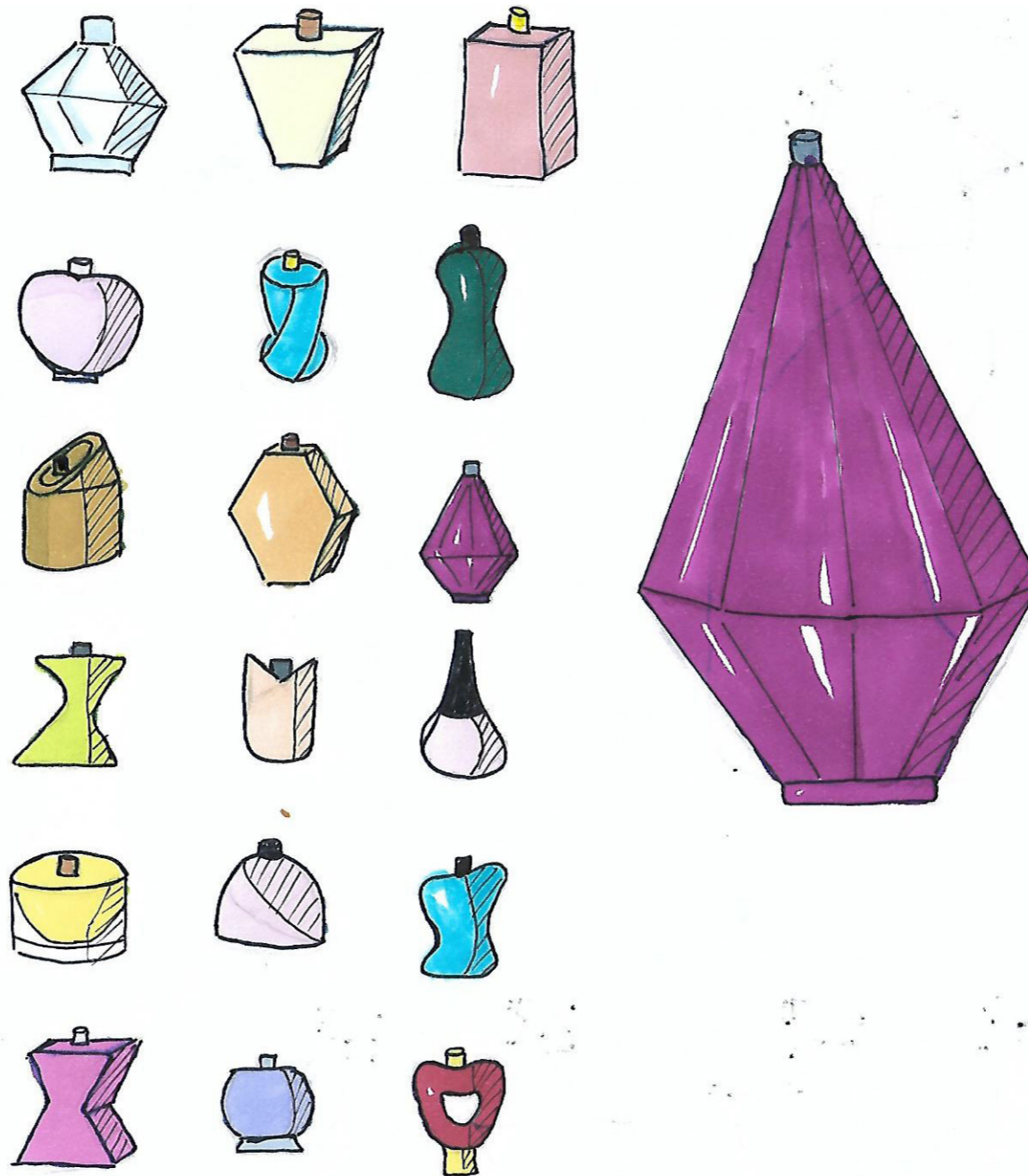
Note: All the exploratory sketching examples are drawn by Irene Hinojosa

EXPLORATORY SKETCHING EXAMPLES

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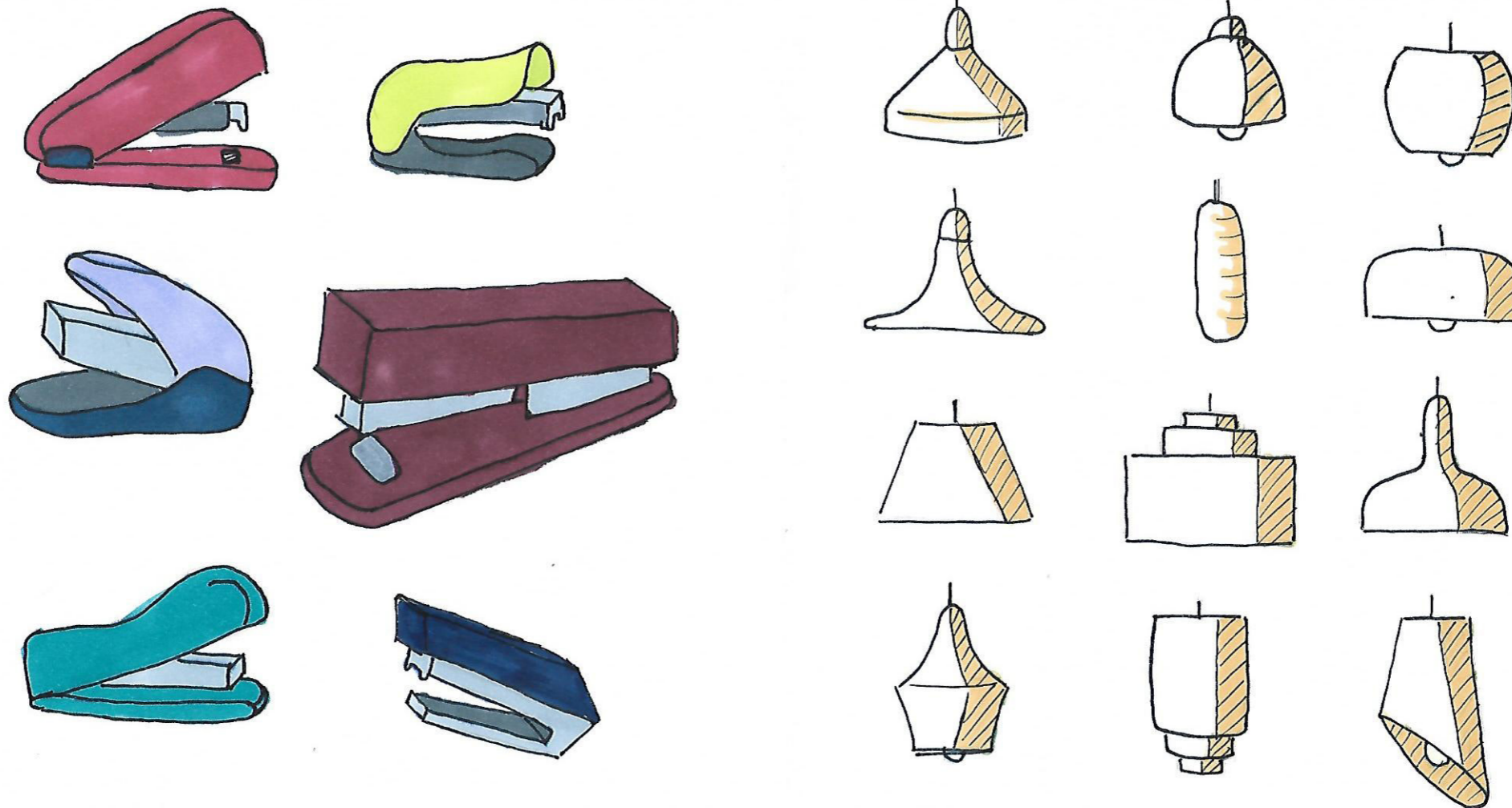Note: All the exploratory sketching examples are drawn by Irene Hinojosa

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1.4. Set of exercises

The following set of exercises will be proposed to students to make them within the second hour of the class.

1. Draw 3 perfume bottles using torsion, addition, substraction, etc. Each salt cellar has to have at least one of these transformations. (10 min)

2. Draw 3 different perfume bottles using a marker. (10 min)

3. Draw a perfume bottles in a post-it. (5 min)

4. Draw a perfume bottle using only straight lines (5 min)

5. Draw a perfume bottle without lifting the pencil from the paper. (2 min)

6. Having hair dryer and a salt cellar,merge the different features of each one to create a new perfume bottle. (10 min)

1.5. Feedback round

The session would be carried out via Zoom. This platform allows the creation of reduced groups in which students can work and collaborate. They would individually assess their own work with the help of the form exploration rubric elaborated and then, in groups of 4-5 people (4-5 minutes per person), they can show their concepts, previously uploaded to Behance and by sharing their screen, and do a peer-to-peer evaluation of their group mates (they can also rely on the rubric to do this). The lecturer can go into these smaller groups in order to give more personalised feedback.

When the 20 minutes of peer-to-peer evaluation are finished, all the students would return to the main room where the lecturer can give more feedback to those who are willing to get it during 30 minutes. The lecturer would download the sketches from Behance and with the help of a tool such as Sketchbook, Photoshop or Illustrator, he or she can draw over the drawing and point out the mistakes made by the students.

1.6. After the lecture

Students will be told to upload their final designs to their virtual portfolio in Behance so the professor can have a closer look and evaluate them.

2. FINAL CONCLUSION

I am very satisfied with the results of this project. When I was in my first year of bachelor, I enjoyed design sketching lectures a lot. They allowed me to communicate my ideas and to develop graphic resources that have been useful throughout my bachelor years. Thus, I was really motivated to make this project. I wanted to give the students the same experience that I had or at least improve the current experience they are having with online design sketching lectures.

The aim of this project was to improve design sketching courses in this pandemic situation. Thus, I wanted to ensure interactivity, idea sharing, consistent feedback and a better way to introduce students to form exploration.

I also was very glad to count on different universities as partners to help for this project, even though they could have participated more. It has been a very enriching experience to get deeper into different design sketching teaching methods.

Design sketching is considered an essential skill for industrial designers. Through this work, different ways of teaching design sketching have been shown and it has been demonstrated that despite the pandemic situation, we can get support from online platforms to continue teaching this discipline.

Feedback is something that was absent during the online-lectures situation. Thus, the importance of an online portfolio to get external feedback and peer-to-peer feedback has to be highlighted.

The exercises proposed turned up to have very interesting results; they made students think in a different way and fostered form exploration. However, the results may be biased as the students belonged to the same university and they have been taught with the same methodology. I could not get the other universities to participate in this experiment which would have made it more enriching and complete.

Finally, it can be said that all the critical design specifications and many of the desirable ones have been met but to make sure of it, the lecture must be put into practise to check which aspects of the project are functioning well and which ones do not work.

3. BIBLIOGRAPHY AND REFERENCES

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