Think-Sketch-Create: Improving Creative Expression Through Sketching

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Abstract. Sketching skills are fundamental for engineers, especially in the field of design. However, developing this skill is not straightforward; most first-year students only have technical drawing training and the attempt to achieve hyperrealism finishes usually blocks them. Based on multidisciplinary work, this study presents a teaching intervention: the 'Think-Sketch-Create' (TSC) workshops aimed to help students improve their skills to express their thoughts and ideas through sketching. These workshops consist of two blocks: warm-up and experimentation. The TSC workshops are applied and assessed through qualitative and quantitative methods in a subject with 84 university students. The assessment of the TSC workshops shows its positive integration into the curriculum, its utility to establish a satisfactory climate to avoid blockage without fear of making mistakes, and its ability to broaden knowledge. In short, this paper evidences the interest of training future engineers in sketching and the need to support teachers with new methods that aid them to foster creative expression in their students.

Keywords: Design education · Teaching skills · Sketching · Workshop design · Creativity

1 Introduction

The need for professionals with boundary-crossing skills in different work sectors of today's world requires training students through competency-based learning [1, 2]. Indeed, the concept of 'skill' is understood as the dynamic combination of knowledge, understanding, and abilities that prepare students for their future employment and role in society [3]. Thus, in the engineering context, and especially in the design and Design Thinking (DT) fields, one of the most relevant skills to be developed by the students is the expression of thoughts and ideas with sketches [4–6].

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DT is based on formulating and solving complex problems through an analytical and creative human-centred process [7–12]. This process generally consists of three main phases: inspiration, ideation, and implementation [13]. Sketches have an essential role during specific moments of these DT phases, such as ideation, conceptualisation, and presentation. Sketching allows designers to develop, externalise, record, and communicate the ideas they have in mind and to generate new ones [14]. Therefore, there is a strong relationship between sketching and DT.

Likewise, sketching is related to creativity [15], one of the most important 21st-century thinking skills, understood as the ability to connect learned knowledge to solve problems and create new things [16, 17]. Expression through sketching favours creative problem solving through methods such as Visual Thinking (VT), which provides the analogies needed to develop new structures [18]. Therefore, most creative processes extensively use visual thinking, and thus, sketching is considered a means of stimulating and supporting creative thinking.

However, teaching and developing the ability to express thoughts with sketches is not straightforward. Children draw without caring whether they do it right or wrong; nevertheless, this language and spontaneity are lost when they are instructed. Most academic environments generally consider drawing and creativity a pastime in practice [19]. In this sense, most first-year engineering students have not used drawing as a means of communication for years, and their previous training is primarily technical. Likewise, their drawings' attempt to achieve perfection or hyperrealism leads to a blockage that prevents them from developing this sketching skill. As a result, many students often use only verbal language to communicate their ideas during ideation and 3D modelling and rendering software to conceptualise and present solutions.

This effect is partly because, according to Norp and Van Hoek [20], many times during the training programs, students spend hours creating 'perfect' colour gradients or getting the right lines to produce the most excellent final drawing they can achieve. Nevertheless, this is not aligned with professional practice; it is more helpful for their future to express themselves through sketching quickly and collaboratively, fostering communication between group participants through a common ground for discussion: the sketches.

In engineering training, some studies propose tools for teaching sketching skills. However, there are few interventions focused on reducing the blockage to develop this skill [4]: Worinkeng, Summers, and Joshi [21] proposed a pre-sketching activity to foster concept generation and Booth et al. [4] raised 'freehand sketching' and 'sketch inhibition' modules to reduce inhibition. Meanwhile, in the field of artistic education, activities to teach sketching and address the blockage are more common; these activities seek to use the right side of the brain, enhancing creativity [22]. Thus, practical solutions are needed to help teachers popularise creative expression through sketching in future engineers as a universal language, aligning better the relationship between training and professional practice of design sketching.

To address this situation, in the following sections of this paper, we present a workshop called Think-Create-Sketch (TCS). Section 2 shows the rationale, the application, and the assessment of the TCS workshop. Section 3 collects the results and discussion of the TCS assessment, conducted in a real educational environment with end users

(engineering students), by qualitative and quantitative methods. From this experimentation, the TCS's utility, the advantages, difficulties, and limitations derived from its implementation, and the feedback necessary for its improvement are discussed.

2 Materials and Methods

2.1 Workshop Rationale and Definition

A high level of x-disciplinarity is required to design and incorporate a new method in the educational environment. X-disciplinarity is a term assigned to the set of possibilities of collaborative work: multi-, cros-, inter-, trans- [23]. Thus, in this research, a multidisciplinary team comprised of specialists in design, art, architecture, creativity, and technology was created. From the beginning, the five members of the team (manuscript authors) worked together during several sessions, considering the visions and experiences of each discipline. The sessions were focused on modifying the methodology based on hyperrealism or perfect finishes by activities that lead students to experiment and open new doors of discovery. Some verbatims about the team's intention were collected during the sessions: 'Sketching and not rendering', 'We want them to experiment', 'Dynamics to free them from the blockage', 'Foster creativity'.

From the collaboration between disciplines, we propose workshops called 'Think-Sketch-Create' (TSC), which aims to help students improve their skill of expression through sketching, reducing the blockage. These workshops consist of 3-h sessions structured into two blocks: warm-up and experimentation. The activities in the first block aim to get students to 'let their hands loose' through activities that lead them to sketch their thoughts directly, regardless of perspective, detail, or quality, just flowing. The activities in the second block seek to make the students experiment with different sketching techniques without fear of making mistakes, thinking and reflecting about the process and not just about the final result, and knowing that if one sketch does not achieve the desired result, they can do more.

2.2 Context and Participants

The TSC workshop was applied and assessed by the multidisciplinary team in an educational environment with end-users. Specifically, in the 'Artistic Expression' subject of the Engineering in Industrial Design and Product Development degree from the School of Engineering and Architecture (EINA) of the University of Zaragoza, taught in the first year and compulsory for all students. The subject deals with different representation techniques of industrial products. A course participated in the study; a total of 84 participants aged 18–22 years applied the TSC workshops to develop their sketching skills.

2.3 TSC Application

TSC was applied during the chiaroscuro practices on three sessions of three hours each. To guide the students during the workshop properly, the 84 students were divided into

four groups of 21 members. Each of these sessions (twelve in total) were guided by two multidisciplinary team members and were accomplished following the two general blocks mentioned. The first block is called warm-up-block; it lasts 90 min and consists of the following phases:

- Unblock activity: It is a straightforward and short workflow whose objective is students to disconnect from the previous class and immerse themselves in the context of sketching.
- Presentation: The aim is to present and explain some theoretical aspects of the chiaroscuro drawing technique to be used.
- Warm-up activity: It is an activity whose objective is to begin to experiment and test with the drawing technique.
- Initial sketch: It is aimed to fit the shape of the industrial product chosen by the student making initial sketches.

This is followed by a break for the students, while the teachers photocopy the initial sketches developed by the students. Then, the second block, called experimentation-block, begins. This block lasts 90 min and consists of the following phases:

- Ctrl-Z: It is an activity whose aim is that students can experiment without fear, trying and 'dirtying' the paper, having the possibility of 'undoing' the actions. For this, they use the photocopies of their initial sketches.
- Inspiration presentation: The aim is to show some examples of sketches with the explained drawing technique, highlighting that 'less is more' and that they should not look for hyperrealism.
- Final sketch: During this time, students develop their final sketch from the initial sketch, synthesizing all the knowledge and experiences learned during the session. Meanwhile, the teacher provides feedback to help students reflect and discover themselves.

Table 1 shows the application of TSC in the three chiaroscuro sessions:

Table 1. Application of think-create-sketch (TCS).

TSC	First session	Second session	Third session
Unblock activity (10 min)	Thirty circle challenge: Convert as many circles as possible into recognizable objects. Draw what you have in mind, regardless of perspective, or quality, flowing	To warm the fingertips, the back as a canvas: Draw with the finger on the back of a classmate while capturing what he/she perceives. Mute!	Start smudging to colour a sketch quickly (can draw outside lines). Then apply layers of markers and pencils to create shadows. Use pastels for the lights
Presentation (15 min)	Explanation, tips, and short exercises. Chiaroscuro drawing technique: pencils	Explanation, tips, and short exercises. Chiaroscuro drawing technique: pastels	Explanation, tips, and short exercises. Chiaroscuro drawing technique: markers

(*continued*)

Table 1. (*continued*)

TSC	First session	Second session	Third session
Warm-up activity (25 min)	Templates and canvas to make gradients, colour palettes, and pencil patterns	Templates and canvas to make spheres and cubes in gloss and matte finish; scratch and smudge with pastels	Group sketching: Redesign a water bottle, salt shaker, vase, or air freshener in groups. Use drawings, titles, and callouts, being mandatory not to speak
Initial sketch (25 min)	Composition and shape sketches with pencils		
Ctrl Z activity (20 min)	Experimentation of chiaroscuro with pencils on photocopies	Experimentation of chiaroscuro with pastels on photocopies	Experimentation of chiaroscuro with markers on photocopies
Inspiration presentation (10 min)	Examples of chiaroscuro sketches using pencils	Examples of chiaroscuro sketches using pastels	Examples of chiaroscuro sketches using markers
Final sketch (60 min)	From the initial sketch and experimentation applying the corresponding technique		

Finally, a short closing session was conducted, in which a self-assessment, a survey, and an exercise of 'internalise and simplify' were developed. In the self-assessment, each student reflected and assessed her/his work and the work of another classmate. The survey was distributed among the students to find out their perceptions. During the exercise of internalise and simplify, students were challenged with the following task: Imagine you are in a meeting, and you have to show the rest of the team a product in 10 min. How would you do it? In this manner, the students reflected on the product sketches made in the previous weeks and the techniques and knowledge they had learned (Think). They synthesised and simplified this learning to make a sketch in just 10 min (Sketch). Thus, they developed a 'solution' to the challenge (Create).

2.4 Assessment

During the application, the multidisciplinary team acted as evaluators in the field (specifically three members who acted as lecturers). They assessed the use of TSC by students through a survey, as well as observation, field notes, and periodic internal discussions [24]. In this manner, Xassess is the general framework used for the assessment; Xassess is an evaluation methodology that merges qualitative and quantitative approaches and is centred in multidisciplinary teams [25].

Survey: Individual surveys were conducted, using questionnaires with open and closed questions in the Google Forms platform. The purpose of this survey was to collect scores and feedback about the TSC from students. The survey was divided into five sections. The first 'control questions', which included questions about what previous drawing training had the participants or what blocked them before drawing. The second section, 'development of the TSC workshops', which had questions related to the utility of establishing the classes in phases and the usefulness of these phases. The third 'workshops contributions' contained questions about the contributions of each phase, the drawing techniques, and skills developed. The fourth section, 'workshops improvements', included questions to discover improvements proposed by the participants. Finally, the

fifth section, 'sketching training', had questions to know the participants' interest in sketching training.

The resulting data were exported to MS Excel. The closed questions (quantitative) were examined using descriptive statistics and visual graphics. These graphics were made with the Python 3.8 language and the Pandas, Matplotlip, and Seaborn libraries. The open questions (qualitative) were manually coded and grouped according to similarities in the reflections made by the students. Thus, Sect. 3 presents quantitative graphs as well as verbatim quotations that support the assessment.

Observation, field notes, and periodic internal discussions: During the observation, the professors collected field notes which were shared in periodic internal discussions of 25 min at the end of each session (twelve in total). These annotations allowed discovering the key features and contributions of the TSC workshops, collected in the Discussion Section.

Thus, the assessment allows checking to what extent the TSC workshops are integrated into the curriculum (1), to what extent the workshop process is suitable for the students (2), and how it broadens their knowledge for their future (3). In this manner, the results and the main contributions of this study follow this three items structure.

3 Results and Discussion

This section discusses the results obtained on the assessment and the lessons learned to apply TSC workshops to improve students' skill of expression through sketching.

3.1 Incorporation and Adaptation to the Curriculum

According to Calavia et al. [16], incorporation and adaptation to the curriculum are the first premises to consider when developing a material to ensure its viability in the classroom. TSC is adapted to the subject in timing and scope for two reasons. The first and straightforward reason is that, in line with Blanco et al. [23], creating a multidisciplinary team from the beginning make it easier to adapt TSC to the environment.

The second reason is that these workshops are justified in the general subject structure. The course begins with the first block of understanding reality (proportions, scales, etc.), then the chiaroscuro block is found, and finally, it moves towards the third block of formal exploration, i.e. the subject moves from 'what is' to 'what can be'. There is a pathway to move students from something tangible that can be represented towards divergent thinking that leads them to create and develop new forms. Thus, the second block of chiaroscuro, where the TSC workshops are framed, is in the middle and serves as a link between the two blocks. Therefore, applying the approach of the TSC workshops in this block allows students to obtain small knowledge pills that 'open' their minds and aid them to assimilate new resources for action, facilitating the transition between the three blocks of the subject.

Additionally, starting with a more convergent block and ending with a more divergent one makes sense because more than 90% of the students who participated in this study had only technical drawing training. This implies that most of them indicated that what they found most difficult when starting to draw freehand was 'not using ruler and compass'.

It is important to note that these are students who start from convergent thinking, using the left brain to achieve the solution. They need to develop divergent thinking, using the right brain to foster creativity and generate many solutions, since this models them as designers [26]. As novice designers, students need to be trained with methods such as TSC workshops that lead them to develop their own design patterns, accompanying them in this transition.

3.2 Valuation of the TSC Workshops

The students assessed and reflected on the contributions of each of the phases of the TSC workshops (Fig. 1).

- Students noted that the unblock activities helped them 'to break the ice and relax', 'to gain confidence to face the following activities', and 'to stimulate their minds and feel more creative'.
- The presentations were appreciated for the 'to know and understand the techniques', as well as 'to be able to see other examples for inspiration'.
- The warm-up activities are seen as 'direct application of theory' that allow 'discovering and experimenting with the new technique to gain fluency'.
- The experimental activities allowed them 'to discover what works and what does not', 'to try freely and without fear of damaging the end', 'to discover by trial and error'.
- Finally, the making of the final sketch was 'the manner of reflecting all the previous phases' while receiving 'feedback and advice to open the mind and improve the work'.

Regarding the survey item about what phases were the most useful (Fig. 1), it can be seen that the experimental activities were the most highly valued. This is understandable because the students relaxed and openly experimented without fear of failure, under the slogan of 'learning by doing and failing' [27]. In contrast, the presentations were the least chosen by students. This is reasonable since, although the presentations were very visual, they are a typical resource in the classroom, and the student does not participate directly as in the other activities.

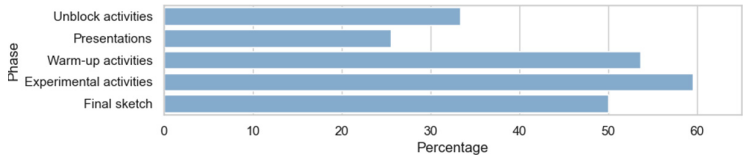


Fig. 1. Phases selected as the most useful by students on percentage (multiple choice question).

Similarly, in response to the question of 'Is it useful to establish the 3 h of class in phases?' they answered positively almost unanimous (97.6%). Students indicated that it was useful following and understanding the process 'it is more enjoyable and interesting, if not it is tiring and monotonous', 'without this distribution, I might have completed the tasks faster, but I would not have known the purpose of the practices'.

However, some students indicated that they would have liked to have more time to complete their final sketch 'because it is what counts towards our grade' 'so we do not have to finish this at home'. These reflections have to do with traditional systems based on extrinsic motivators because they perceived as insufficient the time given for the final sketch, which is assessed with a quantitative mark, sensing the evaluation separate from learning. This is a tough matter, but we align with Sternberg and Lubart [28] about the necessity of devaluing the importance of final marks. We believe that the adoption of workshops such as the proposed could mitigate this phenomenon.

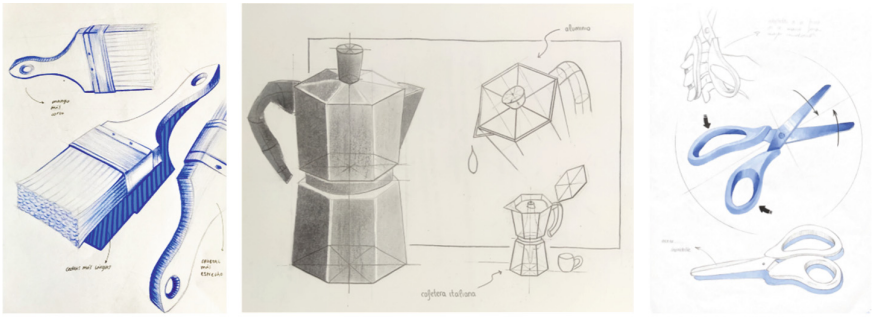
We focus on students assimilating the concept of thinking about the process and not only about the final result, in line with Kleon [29], and supporting them with continuous feedback. This concept match with the type of drawing that is expected in the subject; they should not achieve hyperrealism finishes but process sketches that include what is necessary for their interpretation (indications of use, materials, arrows, calls, cuts, dimensions, etc.). In this manner, they can develop, externalise, record, and communicate their thoughts and ideas during the Design Thinking process, in accordance with Gryaditskaya et al. [14].

It is proposed that to enhance this approach in future applications, in the next course, students document the entire process up to the final sketch (versions, experimentations, initial sketches, etc.), together with a reflection on decision making. Likewise, it is proposed to add a mandatory final reflection phase at the end of each session so that students can see and learn from the work of their colleagues.

Valuation of the Drawing Techniques. Regarding the three techniques used to work on chiaroscuro, 100% of the students admitted that they were suitable for 'learning to add volume to our sketches'. Specifically, of the pencil technique they appreciated that 'a lot can be done with a very simple material' and its usefulness to 'modulate the line'. Likewise, this technique implied that most of the students reflected on the importance of 'understanding that not everything should be painted' and 'not to fill the paper'; this is essential to achieve fresh finishes (Fig. 2a).

About the pastel technique, they appreciated that it allowed them 'to give dynamism to my drawings' as well as 'to spot and enjoy' and 'to cover large surfaces in a short time'. However, some students pointed out that 'it did not contribute anything to me' 'I think it is more focused on artistic drawing', and some even commented on the possibility of removing it. Thus, it is necessary to work on getting all students to understand it as a technique to provide volume and colour quickly, emphasizing the use of the least amount of material, and thinking about what is essential and what can be omitted. There is no interest in obtaining a perfect realistic render with pastels (see Fig. 2b). However, consideration could be given to changing the subject's name from 'Artistic Expression' to (for example) 'Expression through sketching' to avoid the association with the art and preconceived ideas.

Finally, regarding the marker technique, they appreciated 'achieving more professional results' as well as 'surprisingly matte and glossy finishes of plastics'. Likewise, this technique implied that most of the students reflected on the importance of 'thinking well before painting because the marker cannot be removed'. This is fundamental because before sketching a product, it is important to think and plan; for example, in this case (Fig. 2c), the direction of the light for highlights and shadows.



(a) (b) (c)

Fig. 2. Examples of sketches using (a) pencils, (b) pastels, and (c) markers.

During the sessions, we insist on 'where you cannot achieve with one technique, apply another'. However, we consider that in future applications, it would be interesting to develop the last practice to combine the three techniques. In addition, the group sketching activity during the third session worked particularly well because they used only the sketch as a means of communication (Fig. 3); so it would be interesting to implement more group activities. Training in sketching quickly and collaboratively is fundamental to their future because it will allow them to express themselves, foster new ways of communication, and promote creative proposals.

Fig. 3. Group sketching activity.

3.3 Broadening Knowledge

All these experiences led students to value the following statements positively, as shown in Fig. 4. These results support our hypothesis about the utility of the TSC workshops in helping students to unblock themselves to communicate through the sketch. In addition, the students perceived that the workshops were useful to achieve the subject contents in relation to chiaroscuro and well-balanced compositions. They also highlighted the improvement in their ability to think more about the process and less about the end result. Therefore, according to the students' view and considering that sketching stimulates creative thinking [15], the workshop contributes to fostering divergent thinking, enabling students to think creatively.

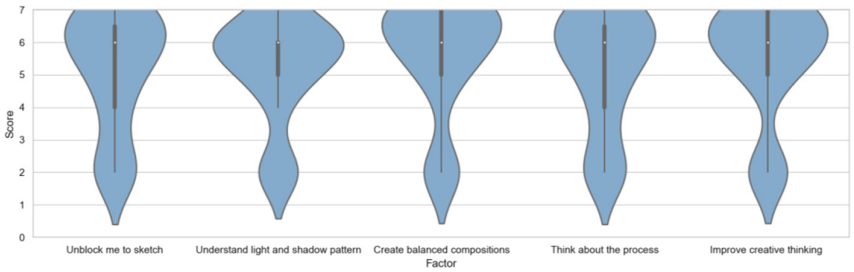


Fig. 4. Assessment of the statements. Likert scores range from 0 (minimum valuation) to 7 (maximum valuation).

This learning is visible in the internalise and synthesise exercise, in which they applied all the acquired knowledge in a condensed manner in just 10 min. Results are quick and fresh (Fig. 5), including elements learned during the subject such as hidden lines, line thickness, background, traces, arrows, annotations, or dimensions.

Fig. 5. Examples of the internalise and synthesise exercise.

Finally, to ascertain the satisfaction and the degree of interest awakened in the students, we posed the question of whether these types of workshops to foster sketching are interesting for their training and whether they would like to broaden their knowledge or information in the future. As shown in Fig. 6, the assessments are positive; the average is 6.4 ± 0.7 and 6.2 ± 0.9, respectively.

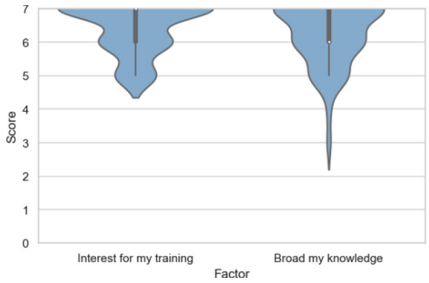


Fig. 6. Assessment of perceived interest and broadening of knowledge. Likert scores range from 0 (minimum valuation) to 7 (maximum valuation).

In order to inquire about the workshop contributions from the teaching perspective, five indicators are identified on the subject's teaching guide related to the learning achievements. First, according to teacher's perspective, the 'agility' of the students was improved thanks to the fluency of the process and the deadlines established in each session. This agility connects with the second item, the increase in 'collaboration'; all groups of students showed an unanimous aptitude to participate in the activities, with an open and fresh initiative that uninhibited them, improving the third indicator, enjoyment. The atmosphere created in the workshops was favourable, and the 'enjoyment' during the activities was tangible among all the actors involved, improving teacher-student and student-student relations. This effect is also reflected in the fourth item, the 'result of the evaluation of the teaching activity', where teachers had a 'positive distinction'. Finally, the academic marks were positive; however, no substantial changes was observed from previous courses. Perhaps this is due to the fact that, as mentioned above, students had less time for the exercise being assessed.

In sum, we can reaffirm that the skill to express oneself through the sketch is fundamental in the training of engineers, especially in the case of design specialists, in line with Hilton et al. [6]. This skill requires further promotion and training throughout the degree to enable future designers to use sketches as a means of communication in their work teams, without the need to use 3D modeling or rendering programs until later or final stages. Thus, using the TSC workshops is not a unique solution but a step towards improving these concepts in future designers' training.

4 Conclusions

This paper proposes the Think-Sketch-Create (TSC) workshops to train future designers in sketching so that they are able to express their thoughts and ideas in work teams. For the workshop development, a multidisciplinary team (formed by specialists in design, art, architecture, creativity, and technology) worked together, focusing on a teaching intervention that leads students to experiment, far from trying to achieve hyperrealism or perfect finishes. As a result, TSC is embodied in practical workshops, in which students experiment with different sketching techniques, thinking and reflecting about the process and not just about the final result. TSC was assessed quantitatively and qualitatively

through its application in a compulsory subject of the Engineering in Industrial Design and Product Development degree, with 84 university students.

The results of the experience allow us to affirm the integration of the TSC workshops in the subject, with it being possible to apply the same scheme in other classes. The previous multidisciplinary work, as well as the structure of the subject (from convergent to divergent thinking) implied that TSC was naturally integrated. Additionally, the assessment evidences the effectiveness of the workshop for the proposed objectives; the students openly experimented, thought about the process, learned chiaroscuro techniques, and understood that they should not achieve hyperrealism finishes. Thus, the TSC workshops are a first step that aids future designers to unblock themselves to use sketching as a means of communication during the design process. Consequently, this study reflects the potential of fostering sketching skills and the need to develop actions for their continuous training.

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