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1 SHADE OF GREY; SIMPLIFY TO EXCEL IN SKETCHING FOR INDUSTRIAL DESIGN ENGINEERS

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ABSTRACT
Sketching is a fast way to explore or communicate ideas and can be done instantly with almost no planning. Sketches are quick, dynamic and iterative. They can be made in many ways but are traditionally created by using pen and paper. This is one of the most efficient tools to trigger the creative process and keep it going. In the educational context where sketching and artistic skills are a compromise between traditional engineering and traditional Design education some problems can be identified. At the Industrial Design engineering program at Lulea University of Technology (LTU) the students are accepted on their grades only, and students attending sketch classes at LTU come from a wide range of backgrounds. As a result of this the sketching education must be tailored for students ranging from experienced level to inexperienced. When there are a lot of students and time is limited, learning activities must be implemented according to this reality. A way to speed up the learning process is to reduce the cognitive load. Too many possibilities and factors confuse students that are inexperienced in the field. The activities should also help keeping the rate of practice up and eliminate things that are not part of the intended learning outcome. This paper shows how a simple change of tools in the sketching class makes huge impact on the progress and discusses the mechanisms behind the effect.

Keywords: Mechanical, engineer, creativity, sketching, design

1 INTRODUCTION

The role of the sketch in creative activities is well established. Designers and architects have accepted that sketching facilitates creativity and have strong communicative qualities for representing thoughts and ideas. Catching the ambiguity in the design process [1], creating freedom of interpretation to stimulate creativity [2] and facilitating the design process in design groups [3] are some of the important qualities of sketching activities. Most important: Along with counting and speaking, sketching is a primary form of cognition and fundamental to human action [4].

This is important in all Industrial Design Engineering programs, just as for the Industrial Design Engineering program at LTU. What is typical for the sketching education at this program is that the individual prerequisites and talent among students varies within a wide range, and the education must be adapted to this situation. Courses with this mixture must start at a very low level to secure that everyone understands and have chance to improve their skills. As courses are relatively short this is a contradiction since starting from the very beginning is time consuming. Making good progress when time is short is a big challenge.

The experience from teachers is that inexperienced students are afraid of sketching. They want to draw perfect lines from the very beginning, which is difficult. This can be an effect of what Constable [5] calls the “pretty picture syndrome”, meaning that sketches are regarded as a final outcome instead of a tool for design thinking. This put focus on the performance of a sketch instead of the message.

Because of this anxiety it’s common that students draw a line, erase it and then draw the same line again. This eternal drawing-rubbing-drawing process can go on for hours with very little result to show when class is finished. They also spend a lot of time on soft shading and rubbing in the gradients on their precious drawings and sketches. Since they spend so much time on each sketch the progress is slow, and number of iterations is low. This flattens the improvement curve in relation to the duration of a course.

According to Buxton [6] a good sketch is quick, inexpensive, disposable, plentiful, has a clear vocabulary, minimal detail, appropriate degree of refinement, it suggests and explores rather than confirms and contains some degree of ambiguity. The stigmatizing notion that every line must be perfect doesn't fit into this description. It's the combination of more or less perfect lines that is interesting, the message. The intended learning outcome of the courses is not that the students will become artists, they are supposed to learn the language of sketching, improve their skills and use it as a tool for creativity. Just getting the lines right could be categorized into the lower orders of the SOLO-taxonomy (Structure of the Observed Learning Outcome, defined by Biggs & Collins [7]), but a Good sketch, because of its nature, is a result of the extended abstract level. So the sketch, as it is described by Buxton, is a simple structure, but the administration of it requires a high level of abstraction. To get there, the need to reduce the extraneous cognitive load [8] to facilitate learning is obvious. Not only in the presentation of the tasks, but also in the affordances of the materials that the students are confronted with.
The problems raised a question: Is the possibilities of the pencil actually hindering the progress in learning for inexperienced sketchers?
This paper reports the results of tests that was performed to see if providing tools that are permanent and only had one value could lead to a faster learning process, compared to using versatile and erasable tools like pencils. A group of engineering students and non-students for reference was to perform a simple still life tasks in two different setups. Half of them were equipped with pencils and the other one with black markers. The time to satisfaction was measured.
The study addresses two main assumptions about how to speed up the process and put focus on the essence of activities in sketching education: Beginners should have as few variables as possible to handle to reduce the cognitive load. By spending less time on each sketch there will be time to increase the rate of iteration and generate a steeper improvement curve.

2 METHOD

This section contains the background for the studies and a description of them, and ends with the results.

2.1 Background

In the program IDE (Industrial Design Engineering) at LTU there is a long tradition of teaching students sketching skills to strengthen the creative process in project assignments, creative workshops and presentations. In these program courses students come from varying backgrounds and with varying skills. The students apply for the programs on their grades and there is no demand on artistic skills to be accepted. This means that the level of talent and experience of drawing varies, and the learning activities must meet the needs of the most inexperienced. Taking an ordinary program sketching course means students have 30 hours of scheduled sketching and 170 hours to sketch on their own. This is not much time for learning activities when you have to start from a very basic level.
One thing that teachers have noticed is that inexperienced students are afraid of making inexact lines when sketching, and they worry about the artistic qualities of their work. Their focus is not on understanding how to represent the objects they draw and the signs they make, they are mostly focused on not drawing wrong. This idea of perfection, the pretty picture syndrome, slows the pace of the production down, and lowers the number of exercises and iterations that a student performs during a course.
To see the effect that the affordances of the tools used had on the performances of tasks and the learning process, experiments was conducted with students from different programs and also with staff employees of the University. Two tests were made; one intervention study where the performance was monitored during an ordinary class and one user study where the subjects were tested individually to verify the findings from the first test.

2.2 Test 1

The first test was an intervention study that was performed in larger groups with 20-25 students each. These students worked with an assignment that has been used for many years both at the courses at LTU and also at art schools in the region. This early-in-the-course-assignment is a measuring assignment to present basic knowledge about drawing by using measuring to depict real life objects, in this case a typical cardboard box about 50x40x80 cm of size. Students form a circle around the object

and teachers introduce the measuring technique. While student work with the assignment they can ask for help and teachers also offer guidance when students have got the instruction all wrong.
The same test was done with four parallel groups. Students in this case were freshmen at two different programs, Industrial Design Engineering and Engineering Architecture. For each class, one group used pencils and the other group markers. Time was measured from the point when everyone said they understood the instructions until the whole group had fulfilled the assignment. The teacher made sure that all drawings had acceptable perspective, lighting and shadowing.
To see if there could be a difference doing the same test with LTU staff members, two groups from the administration were formed with 6 subjects in each group. Compared to the student groups the staff members consisted of people with more diverse backgrounds, ages and interests.

2.3 Test 2

In this user study 20 students was instructed to draw two objects on a round table with light and shadow. Their task was to draw the objects until they were satisfied with the result. Different from the first test there were no quality check from the teachers since the focus was on the time subjects spent on the assignment on their own, the time a task was awarded without outer restrictions. This addresses the assumption that a higher rate of iteration will generate a steeper improvement curve.
Time was taken individually from when they started and until they claimed to be finished, and no guidance was allowed during the test. This was repeated with students from different programs with varying experience and interest of drawing. Half of the students used markers to draw the objects and the other half used pencils and erasers.
A time limit, that the subjects wasn't informed about in advance, was set to 60 minutes for two reasons: First of all to adapt it to a class situation where more time than this can't be allocated for a single task, secondly because it's 3 times the calculated time a task like this is supposed to take. This decision could affect the results if the time limit proves to be too short.

2.4 Result

Test 1:
The results from the first test setup (Table 1.) showed that test groups using pencils used a lot more time to produce an acceptable assignment. They needed 45-60 minutes to fulfil the assignment, and the groups using markers needed not more than 30-35 minutes to do the same job. A few subjects in the marker groups were faster than this but no one in the pencil groups finished their assignments faster than 40 minutes. Some subjects in the pencil group needed more than 60 minutes. The difference between the groups of students compared to the staff members was negligibly.

Table 1. Result Test 1. Time for assignment in minutes

	1st group	2nd group	Staff	Mean
Pencil	44	60	51	51,7
Marker	32	29	33	31,3

The results indicated that there were obvious differences in performance between the groups, but the data is too limited and uncertain to draw any direct conclusions from. Studying groups of 20-25 people and also having to help students by answering questions makes it hard to control the study. Some students might keep on drawing even though the result is satisfying, and it is also somewhat complicated to measure an accurate time with that amount of students. Since no regard was taken regarding outliers the measurement was a bit rough, but still it gave good enough indications to continue with the second test.

Test 2:
The result of the second test setup is visualized in Figure 1. On average, participants using marker ($M=17.1$ min, $SE=3.69$ min) completed the task faster than participants using pencil ($M=43.1$ min, $SE=16.9$ min). As the variances for the two groups differed, a t-test not assuming equal variances was used to test if the difference in completion time was statistically significant ($p<.05$). The difference was significant, $t(9.85)=4.73$, $p=.001$.

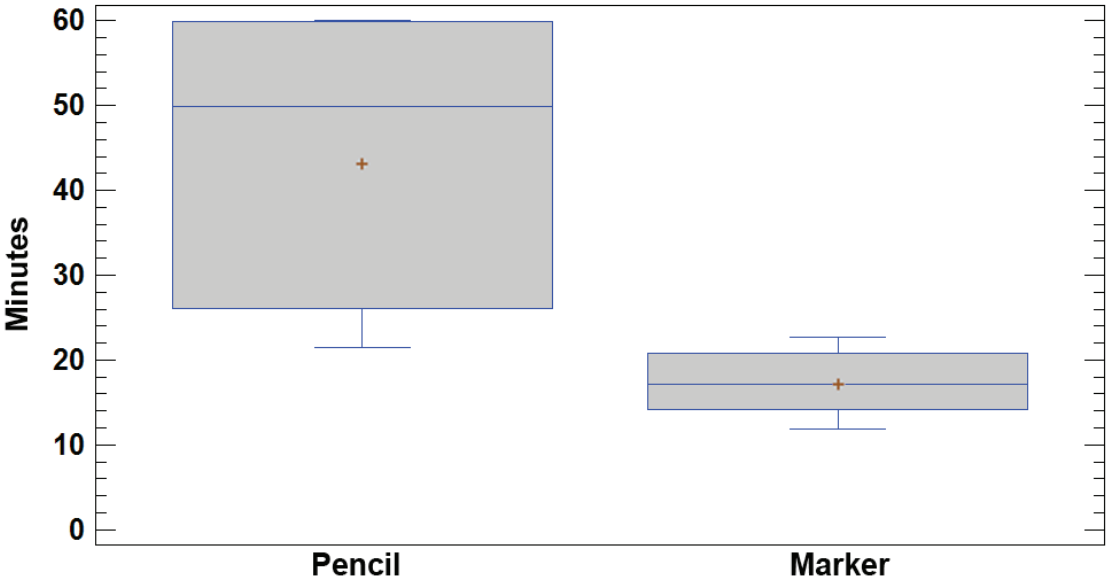

Figure 1. Box-and-Whisker Plot of results from Test 2. The median is marked as a horizontal line within the box, the box shows the sample interquartile range and the whiskers show max and min values. The average value is shown as a plus sign. No outliers (deviating more than 1.5 times the interquartile range from the median) were observed

In the pencil group two subjects could not finish their assignments within 60 minutes. The cut-off caps the result for the pencil group slightly, but if the full range had been measured it would have increased the difference.
In the marker group most subjects ended up in a very short span between 15-20 minutes while the pencil group is much more spread between 25-60 minutes.

3 DISCUSSION

The results, especially from Test 2, are very convincing: The study shows that a change of tools in classes with inexperienced students is a way forward when it comes to speeding up the learning activities. Speeding up the process will free up time, which is of great importance, especially when the time available is limited. Inexperienced students need to repeat training to improve skill. Drawing is mainly a handicraft and learning is very much about repeat and practice. The more time students have the more sketches they can produce, and this is important for the creative process.
An interesting behaviour can be seen in the range of results for the pencil and marker groups. Looking at the boxes for the sample interquartile range in Figure 1 we can see that the marker group ended up in a short span while the pencil group is much more widely spread. Our theory is that this is because the pencil with its versatility gives more room for individual excessive exploration. The marker is more "straight forward", when a spot on the paper is filled it's filled, and you move on. The similar time of completion is interesting and might indicate a pattern of how the subjects performed the task.

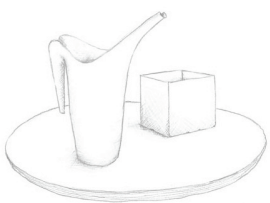

Figure 2

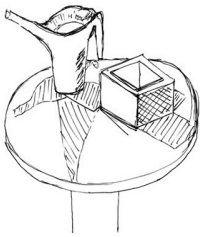

Figure 3

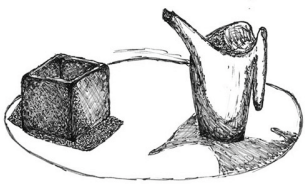

Figure 4

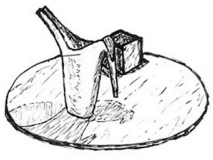

Figure 5

Another important insight that the method generated was that non-erasable tools makes it easier for teachers to guide and explain how students should do and think to achieve a good result because it is easier to see what a student have done or not done when no lines are erased. The vagueness in Figure 2 illustrates this problem. The lines are hard to see and no hints of the working process. Figure 3, 4 and

5 show drawings made of subjects with the same estimated experience level as in Figure 2. Marker drawers need less than half the time to present an acceptable drawing with more information.
This does not mean that pencils are useless. Of course there are many advantages with using pencils and the versatility the medium offers. Still the conclusion of this study is that students in programs where the artistic skills are of less importance than traditional art classes can have an important advantage if pencils are avoided.
A question that is not fully answered in this study is if marker drawings will provide a better learning outcome. We see that there is a need for further studies to see the full implications of the result. First of all, qualitative studies regarding the mechanisms for the result and the cognitive operations that take place. From this study we can't see if the learning happens at the unistructural or extended abstract level. There's also a need for a study of long term effects to see how the improvement curve is affected by the choice of tools, and if there's a level of experience where limiting the possibilities also limits progress.
So what are the reasons for the results? Our theory is that the main reason is the difference in cognitive load. Less options means less factors to be distracted by. When only having one value to work with, it's easier to focus on the task instead of the details of the drawing. A comparison between the sample interquartile ranges for the different tools supports this. Another part of it can be related to the "pretty picture syndrome", the subjects lowers their expectations on their work and get a relaxed attitude to the outcome. Also there's a process change happening when the ability to erase is removed. Instead of erasing and redoing a misplaced line, a new one is drawn with the first one as reference. This strategy is more efficient and the workflow isn't interrupted. In the words of Sandy Brooke [9]: *"Since you can't erase, you will find a certain freedom in knowing that you are going forward ... When you stop to correct lines, you can lose your train of thought"*.

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