The Power of Feedback: Improving SketchTivity's Feedback System

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Abstract

Perspective sketching is a skill that is required for a variety of jobs including, but not limited to, architectural design, graphic design, and engineering. Sketching however, is a difficult skill to grasp for people early and can take a while to learn. Recently, there have been many intelligent tutoring systems (ITSs) designed to help improve people's drawing skills. The feedback system for the perspective drawing lessons in SketchTivity, one such ITS, is currently limited to smoothness, speed, and accuracy of the lines. Our team plans to improve upon this feedback system so that the feedback provided to a user is now more nuanced as well as more actionable to reaffirm future learning. To evaluate our system we will conduct a user study with 40 students that involves going through several sketching lessons and then sketching a street corner in 2-D perspective. We plan to run a between-subjects user study with our participants to determine if our adjustment has any effect on the improvement of sketching skills and the usability of the application. We hope to determine that providing the user with data for their smoothness, speed, and accuracy after four sketching prompts can cause an overall improvement in the students' scores in comparison to at the end of their sketching session. The algorithm that we created to identify a student's potential issue we hope will be able to provide accurate, actionable feedback in most situations. The visual alterations we made to SketchTivity we expect to have a positive impact on the perspective feedback system and alter the students sketching performance. In future iterations the algorithm should be further refined and the data collected from the students sketches should be further developed to provide more data to create more actionable recommendations for improved sketching performance and retention.

Keywords

Human-centered computing, usability testing, user interface design, user feedback, intelligent tutoring system, sketching, computer assisted instruction, user experience design, design education

1. Introduction

One of the most important skills that an engineer or architecture student can have is the ability to quickly and accurately sketch something. From doing a quick mockup of a prototype to designing how a street looks, sketching is a crucial skill one must have to succeed in these fields. Being able to sketch is a fundamental skill that enables more effective communication to peers within this technical field. However, many engineers do not receive any formal training in sketching, with sketching skills expected to come from natural ability [1]. To combat this, there have been a number of applications that have been created to cater to the improvement of those seeking out skills in drawing and sketching. Intelligent tutoring systems (ITSs) have made great strides in this area. These systems are designed to replicate the benefits of one-on-one instructors and personalized tutoring. In the case of sketching instruction, these systems focus on teaching users basic concepts of drawing with the experience from a professional artist [2] and providing personalized, automatic feedback. Systems like this provide an enjoyable experience and actually are able to improve the users drawing abilities. One such ITS is SketchTivity, a system developed that strives to improve the technical sketching skills for those that enroll in its course.

SketchTivity is an ITS for teaching sketching fundamentals [3]. It was established as a means to assist students in developing their sketching skills and become more comfortable with communicating their thoughts to image representation. During its development it was tested by being deployed in both high school and university classrooms to assess the overall improvement in the students' sketching skills [3]. From its initial development it was determined that the system was able to effectively offload the work of grading for instructors, cultivate explorations and community, provide real-time feedback, and establish a means of motivation for students. That said, SketchTivity's feedback system has several avenues for improvement. For a given prompt, the current system will indicate whether or not the drawn item is correctly in terms of perspective correctness and line quality, but it will not tell the user how to improve their drawing or correct their mistakes with specific, ac-

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tionable feedback. In other words, the system is able to provide performance metrics in terms of accuracy, smoothness, and speed, but it does not indicate how these metrics can be used to improve the users skills and abilities.

Current research shows that SketchTivity has helped users increase their sketching skills and gained confidence in their drawings [4]. This indicates that there is potential to see even further improvements in both quantitative numbers and confidence if the feedback system is improved. Feedback quality is vital in the assessment process [5], so in order to improve upon this system there must be consideration into how students perceive the feedback process to measure its effectiveness. With our research into improving SketchTivity's perspective feedback system, we plan to adjust the current system that uses smoothness, speed, and accuracy to bring nuance to the feedback responses and provide useful actionable feedback to assist the user in improving their sketching skill. The updated system will provide the user with similar, numerical feedback corresponding to their accuracy and precision as well as an actionable sketching tip based on their performance. Through our research we hope to be able to further improve a student's sketching skills and confidence. Our contributions will include insight on the design and application of feedback systems for teaching sketching skills as well as give a deeper understanding to the user's perspective on actionable feedback within ITSs.

2. Related Works

There are already many ITSs that are catered toward teaching users how to sketch. All of these systems are uniquely designed with different users in mind as well as a focus on teaching the user a specific style of sketching or drawing [6, 7, 2, 8]. Due to this, the style and manner of feedback that a user receives varies system by system. This section explores some of these existing systems and why there's a need to improve how feedback is delivered to the end user.

2.1. Importance of Actionable Feedback

In any educational setting, receiving feedback is extremely important since students and beginners are constantly learning and working to improve various skills [9]. When a student is beginning to learn a new skill, they may be unsure of what the next step is in order to complete the task. They may know the general heuristics needed to complete the objective, but they may not know how to apply them to the current task they are working on [10]. That is why providing effective and actionable feedback is so important when teaching students new skills. By providing students with effective and actionable feedback, it can help reinforce when a student is on the right track while also giving them an idea of what to do next [9].

When it comes to providing actionable feedback there are many factors to consider. Some factors include "when should the feedback be given?" and "what information should be conveyed to the student?" [10]. All of these factors must be considered when designing actionable feedback due to the fact that feedback is highly contextual [11]. The highly contextual nature of actionable feedback comes from the fact that actionable feedback is only useful to a student when they are uncertain of what to do but still make a move that is close to correct [10]. What also makes providing feedback difficult is that if feedback is not given properly to a student it can actually hamper their performance [11]. As a result, providing personalized actionable feedback can be very effective when done correctly, however great care must be taken to ensure that the feedback does not end up actually hampering a student's progress.

2.2. Current Sketch-Based Intelligent Tutoring Systems

Due to the growing class sizes at all levels of academia instructors are struggling to deliver individualized actionable feedback to their students [9]. This is especially true in the realm of sketching. While many universities have engineering students sign up for sketching classes, they can usually only get feedback from their professor during office hours which may not always be accessible to all students [12]. In order to try and address the problem of lack of individualized feedback and sketching training multiple ITSs have been developed [6, 7, 2, 8]. Each of these ITSs approach the sketching problem from a new angle. For example, some of these ITSs are primarily focused on teaching the basics of sketching [12]. While other systems, such as EverybodyLovesSketch, are more focused on teaching how to sketch various 3D objects from a 2D point of view [6]. Some systems also teach students how to draw in perspective or have future plans to implement perspective drawing features [13]. While each of these systems handle teaching sketching in different ways, they all have helped students improve their sketching skills to various degrees [6, 7, 8].

2.3. User Experience With Feedback

When it comes to providing the user with feedback each of the ITSs went about it in different ways. Some of the systems were designed to provide feedback to the user in real time [2, 12], while other systems gave the user the option to choose between having feedback provided in real time or at the end in a summative manner [13].

A few systems, such as EverybodyLovesSketch, forgo giving feedback at all and instead only provide assisting lines as needed in order to avoid visual clutter [6]. No matter the approach that was taken, students reported that the feedback they received from the ITS they used was helpful at improving their sketching skills [2, 13, 12]. Some students did admit during qualitative interviews though that the feedback at times was not helpful and instead harmful [13]. Due to this our goal is to further improve the feedback system for perspective sketching in SketchTivity to minimize or eliminate this problem while also making the feedback more actionable. In this process we also hope the knowledge gained can be applied to other ITS systems.

3. Design

Since our research builds upon the existing ITS, SketchTivity [14, 12, 8, 13], the system design section will cover SketchTivity as it existed prior to our research at a high-level and then what our changes to the system were.

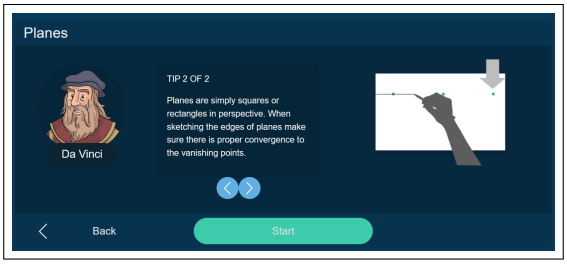

Figure 1: Starting page for a lesson with drawing tips

3.1. Original Design

SketchTivity is a web-based ITS that is both touch and stylus capable. The ITS is designed to help students practice their design sketching skills via the usage of lessons. These lessons range from basic two-dimensional geometric shapes like lines and squares to more complex shapes and structures that are in three dimensions [14]. The canvas the student draws on provides dots indicating where the student should draw their lines. The three dimensional lessons and the perspective lessons also include a support grid to help give the student an idea of what angle they are drawing from. After a student completes the drawing the system then works to analyze and evaluate the sketch using sketch recognition techniques. Once all the lessons for a certain shape have been completed, SketchTivity then shows the users their average Precision, Smoothness, and Speed from the exercises. These three metrics are tied very closely to how well someone is able to sketch and are thus conveyed to the user as benchmarks in order to highlight their progress. The Precision score indicates how accurate the user's sketches were to the calculated "perfect shape" for the exercise. This "perfect shape" is hidden from the user while they are completing the exercise and is only shown to the user after they finish the exercise. The closer the user is to matching this shape the higher their score will be. The Smoothness score tells the user how smooth their lines are in the drawing. For example, a user whose hand shakes a lot while drawing will have a low smoothness score due to all the motion in the line. If a user's line has minimal shaking or movement in it the Smoothness score will be higher. The Speed score simply tells the user how fast they completed their drawing in pixels per second. The Speed score is calculated from when the pen is placed on the screen to when it is picked up. SketchTivity also provides the user with some basic feedback for how they can improve going forward.

While this version of SketchTivity has helped students improve their sketching skills [12, 13], it does have some limitations that can be improved upon. One such limitation that can be improved upon is the robustness of the sketch recognition algorithm. Another limitation example is the limited number of feedback prompts. In this iteration of SketchTivity the feedback that is provided for the user is based on what they get for their Speed, Smoothness, and Precision once they complete all the exercises for a lesson.The issue is that the pool of feedback responses is incredibly limited and simplistic. This issue is further compounded by the fact that the system prioritizes Speed over Precision and Smoothness. This leads to the user predominantly getting the feedback responses related to drawing speed and little else which can be frustrating.

3.2. Updated Design

In order to address some of the limitations mentioned above and improve the overall user experience we have implemented and modified various features in SketchTivity. For the limitations on feedback response we have implemented a few new changes. The first change is that we modified the algorithm that determines what feedback is presented to the user to be more nuanced and holistic. By changing how the algorithm works we have made it so that the feedback algorithm is not as focused on a single metric and instead on all of the metrics. The second change is that we increased the number of responses in the feedback pool along with making the responses more detailed. These two changes work in tandem to create a more meaningful feedback experience for the participants in our study. The increased response pool that relies on all metrics enables a wider variety of action-

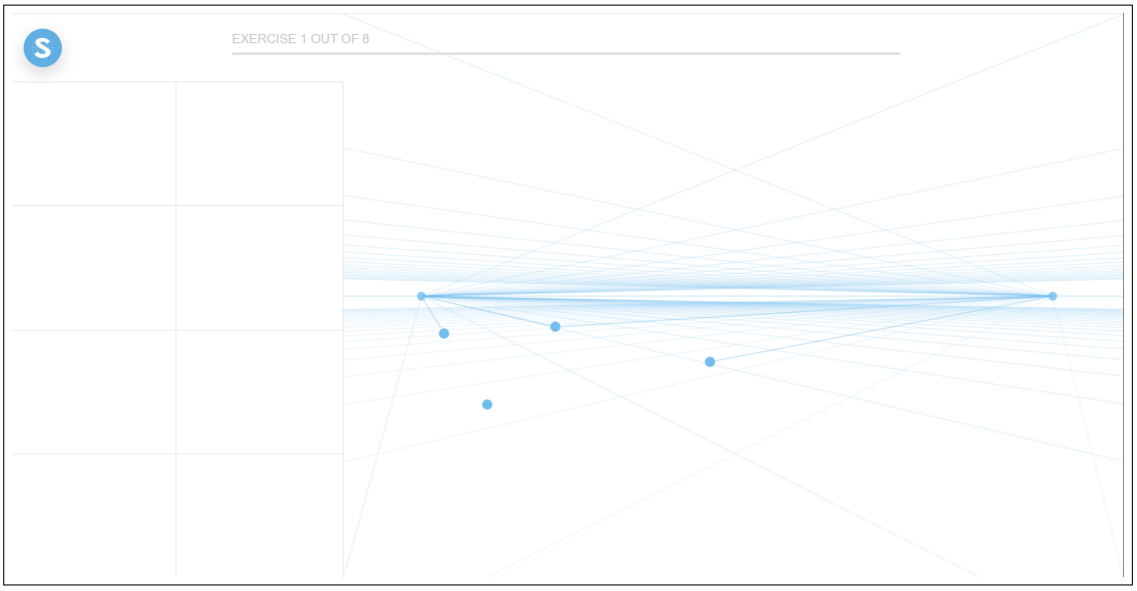

Figure 2: Canvas for an exercise

Table 1
Current Feedback Messages in SketchTivity

#	Message
1	"Try sketching a little faster! You may see a drop in precision, but both will increase as you get more practice!"
2	"You deviated a bit from the prompt. Confident strokes can improve both your smoothness and precision!"
3	"Keep an eye on the prompt! You'll get better at visualizing the shapes in perspective."
4	"Your lines are a bit wavy. Try focusing on your pen control on the next exercise!"
5	"Great job! Your sketch was smooth, quick, and precise. Keep practicing and keep improving!"

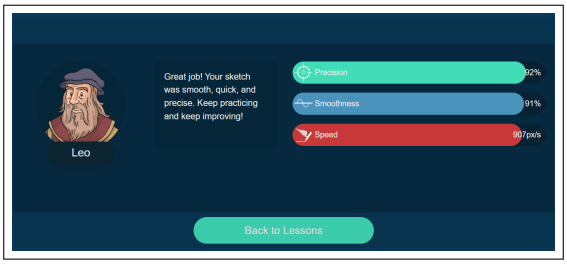

Figure 3: A user's results after completing a lesson

able responses that are more specific to the current user. To further increase user's engagement with feedback we implemented a "break menu" feature as well. The break menu is a modal that pops up halfway through the completion of a lesson. Much like the final results screen for a lesson, the break menu shows the users their current Precision, Smoothness, and Speed based on the lessons they've completed so far. The break menu also pulls from the feedback system mentioned above to provide the user with feedback on how they can improve during the last half of the lesson. Once the user is done looking through the provided feedback they can click the continue lesson button to resume the lesson and complete it.

4. Methodlogy

We plan to conduct a between-subjects user study with 40 participants in order to determine the effectiveness of our design alterations. We will split the participants into two categories, the control group, who will be receiving the unmodified version of SketchTivity, and the experimental group, who will be receiving the modified version of SketchTivity. Participants are undergraduate and graduate students from either engineering or architecture programs. We plan on recruiting a variety of

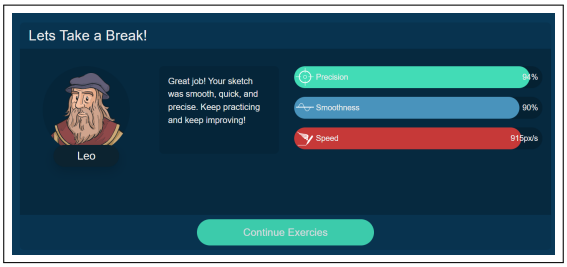

Figure 4: A user's results being shown to them in the break menu

participants that provide a variety of majors through our convenience sampling through email and word of mouth. The criteria of the students participation will be determined by self-reported responses and assessed by the research personnel. Upon opting in study participants will be informed and provided a consent form to review. Our study will consist of three key sections: Initial skill assessment, Sketch Lessons, and Post-Lesson skill assessment.

The initial skill assessment will involve a questionnaire that will obtain basic information on the participants drawing ability and prior knowledge of drawing/sketching in perspective. After the questionnaire, the participant will be asked to draw a city corner in two point perspective without any training from the ITS and given a reference image of a city corner. The participant will draw in the free-drawing tool under "Perspective" on the navigation bar with the 2-point perspective guidelines enabled. They will be allotted two minutes to complete their sketch. Only two minutes will be allowed as we aim to improve not only the quality of their line work and sketching skills but also the speed at which they are able to complete their sketches.

Once the first section has been completed, the students will begin the Sketch Lessons. The participant will be required to watch and complete five of the sketching lessons within SketchTivity: two from the Basics lessons, Lines and Squares; two from the perspective lessons, 2 PT and Planes; and one from Primitives, Cubes. Each lesson will consist of a one to five minute long video that teaches the fundamentals of sketching the specific lesson objective and then 8 exercise sketches. An exception is the 2 PT lesson as it is just a video and does not have a follow up exercise. These exercises will collect the participants data for their Precision, Smoothness, and Speed and show the results of their exercise. For those participants that fall within our experimental group they will be shown both the results from their exercises and feedback during the midpoint of their lesson and also at the end of their lesson. For those within the control group they will only receive the data results and the feedback at the end of the lesson. Once all lessons have been completed the participant will then be permitted to move onto the third section.

The Post-Lesson skill assessment will be similar to the Initial skill assessment. The student will be asked to draw a city corner in 2-point perspective but to now take into account the skills they learned from the SketchTivity lessons. They will be allotted two minutes to complete the sketch. Once the sketch is completed and collected the participant will then be asked to complete the post-study questionnaire that will collect thoughts and feedback regarding the ITS's visuals and feedback usability. Immediately following the questionnaire our team will engage in a follow up interview where we will record the verbal responses of the participants regarding the feedback system.

5. Next Steps

After completing the updates to the feedback algorithms, we will conduct our described evaluation and begin analyzing the collected data. From our trials we will have collected both qualitative and quantitative data in the form of questionnaires and data from SketchTivity itself. In order to see if our feedback changes did promote growth, we will analyze multiple factors. This includes seeing if quantitatively, the experimental group had more growth in their sketching skills than the control group. How we will determine this is based on how much their precision, smoothness, and speed changed over the course of the experiment. We will also look over the survey questions to see if users had a better experience overall with the experimental or control system throughout the experiment.

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