Sketching as a Tool to Measure Concept Application in an Informal Learning Environment

Kristen Morris, Charlotte Coffman, Fran Kozen, Katherine Dao, Denise Green, Susan Ashdown, Cornell University, USA
Lucy E. Dunne, Jordyn Reich, University of Minnesota, USA

Keywords: Assessment tool, sketching, STEM learning, K-12 Education

Introduction Style Engineers (initially titled Smart Clothing: Smart Girls) is in its 4th year of development. Cornell University and University of Minnesota researchers, in partnership with 4-H and Girls, Inc., we introduce girls age 10 to 15 to STEM principles through their interest in fashion using hands-on fashion-focused activities. We introduce experiments and activities leading to solutions to a design challenge throughout the weeklong program. The girls then create a final prototype garment to meet the challenge. Conceptual sketching is one strategy to promote critical thinking, introduced as part of our focus on the engineering design process. We introduced a systematic guided sketching activity to determine whether it could contribute to an effective response to the challenge. Use of sketching in the ideation phase can provide a catalyst to stimulate new and different interpretations, explore possibilities inherent in the idea, and communicate the idea (Aspelund, 2010; Buxton, 2007). Sketching is fundamental to the cognitive process of design, and introduces a reasoning that draws on a diversity of experiences, rational thought process, and creative imagination often resulting in a new perspective (DeLong, Hegland, & Nelson, 1997). As Buxton (2007) states, "Sketching is an activity/ process, not an artifact. It is the vehicle, not the destination." Therefore, the primary goal of this activity was to encourage students to draw on the content taught to them throughout the program, to identify and then develop ideas through sketching, and to solve the design challenge innovatively. Repeated sketching was intended to build on concepts toward a final comprehensive design. Here we report on the value of sketching as a tool to measure concept application.

Methods This activity was delivered at both Cornell University and the University of Minnesota (UMN) during the summers of 2013 and 2014. In 2013, 37 middle school girls (Cornell n=20; UMN n=17) participated, resulting in nine groups of 3-4 members. In 2013, the sketching process was localized into the final stages of the program and mixed with many other activities. On the 4th day of a 5 day program, students sketched ideas for a prototype garment for an explorer of the fictional planet SCSG-13. From 2013 to 2014 we modified the process to introduce sketching earlier, to intersperse it throughout the program and focus it explicitly on the application of problem-solving concepts. In 2014, 43 middle school girls (Cornell n=29; UMN n=14) participated, also resulting in 9 groups. The final challenge was to design a costume for a pop star, giving a performance on the fictional planet SCSG-14. The

Table 1: Count & mean scores of concept application (higher scores = better application

		Free Draw I	Movement	Silhouette	Visibility	Free Draw II
Cornell	n=	103	183	124	62	43
	$\bar{x}$	1.01	1.09	1.02	0.99	0.76
UMN	n=	69	69.5	68.5	44	56.5
	$\bar{x}$	1.27	2.24	1.79	1.12	0.94

Table 2: Mean scores of individual sketches, final group sketches, and actual prototype garments on concept application (higher scores = better application)

		Cornell			UMN		
		Guided sketches (individual)	Final Sketches	Final Garments	Guided sketches (individual)	Final Sketches	Final Garments
2013	n=	-	12	4	-	18	5
	$\bar{x}$	-	1.47	1.54	-	2.07	2.04
2014	n=	515	19	6	308	3	3
	$\bar{x}$	1.35	2.37	2.46	1.47	1.74	2.54

students started sketching from the first day of the program, and sketching activities applied major learning concepts (mobility, the creative pattern silhouette, and visibility) which were crucial to the final challenge. In total, the students completed three content-prompted sketches and two additional 'free' sketches that captured the students initial ideas (pre-program), and comprehensive application of concepts (post-program). Similar to 2013, the teams brainstormed a final group sketch before initiating the prototype development. All the sketches and the corresponding final garments were scored on a 3 point scale for the observed application of concepts using a rubric. During the 2014 sketching process, adult leaders observed the engagement (could either be sketching or brainstorming with team members) of selected groups in the activity. The girls also evaluated whether they liked the activity.

Results/Findings In 2014 the number of sketches, overall mean scores (3-pt. scale) on the application of concepts and total requirements fulfilled varied significantly depending on the concept at both locations (Table 1). At both locations, the Free Draw 1, Movement, and Silhouette concepts had the highest number of sketches. The number of sketches to address Visibility dropped significantly at both UMN and Cornell. For both locations, the number of sketches produced was also lower as the week progressed. On the other hand, the leader observations indicated that the girls were hands-on and attentive 95% of the time, with no observed changes in engagement as the week progressed. Results from the participant evaluation showed an increase in enjoyment for sketching from 2013 to 2014. These findings indicate that the girls remained involved with sketching, spending more time creating fewer sketches later in the program. These sketches did not always overtly meet the design prompt requirements, as they invested themselves in creating sketches not necessarily project related. However, there is a positive increase in mean scores on concept application from the individual sketching activities, to the sketches used by the group to develop final garments and to the final garments at both locations (Table 2). Ambiguous concepts in the final sketches were more concretely addressed in the final garments, evident through increased mean scores. An increase in mean scores on concept application from the final sketches, to the final garment is observed in 2014, which was not necessarily the case during 2013.

Conclusions Although the application of the concepts in the sketches was not always overtly obvious we found an overall positive impact with the introduction of a systematic sketching process. We observed a decreasing trend in the numbers of individual sketches during the week, but engagement remained high. It appears that students may have spent more time brainstorming with their team members, rather than producing sketches. It is possible that the more the girls exchanged ideas, the less they sketched. That is; they eliminated some ideas through discussion. We found an improvement in meeting the design challenge requirements in 2014, which we attribute to a guided sketching process that spans the entire program (not isolated in the final days).

Acknowledgements This work was supported by the National Science Foundation under Grants 1139466 and 1139501

References

Aspelund, K. (2010). *The Design Process*. (F. Books, Ed.) (2nd ed.). New York.

Buxton, B. (2007). *Sketching user experiences : getting the design right and the right design*. Amsterdam:Morgan Kaufmann Publishers.

DeLong, M., Hegland, J., & Nelson, N. (1997). Encouraging Critical Thinking in the Classroom: An Example from Aesthetics. *Clothing and Textiles Research Journal*, *15*(2), 86–95.