REVITALIZING USE AND USE CASE ABSTRACTION:

A PEDAGOGICAL METHODOLOGY FOR DEVELOPING INNOVATIVE DESIGN THINKING IN NEW MEDIA LITERACY

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Abstract

This paper addresses the need for new pedagogical strategies facilitating design thinking in parallel to computational thinking, for increasing new media literacy in new media education and engineering. The paper describes the design practice in contemporary context, and provides a definition of design in interdisciplinary context. The concept of pedagogical installation will be introduced and linked to scaffolding theory. The installation can be considered as an open ended *tangible sketch* in order to provide a signature problem space for project-based learning and instructional models. Use and use case abstraction will be presented as a methodology in order to establish a pivotal point linking deeper understanding of human needs and design necessity to emerging practice in new media. The paper draws upon methodologies from the fields of engineering design, interaction design, and Human Computer Interaction to formalize needs and necessity and apply them to new media, in order to establish vital principles relating basic inquiry to emerging practices.

Keywords - Design thinking, tangible sketch, use case, new media, scaffolding theory, project-based learning, interdisciplinary courses

1 INTRODUCTION

The definition and theory of new media have been addressed in numerous literatures [1, 2, 3, 4, 5]. Many writers sum up the rise of new media attributed to digital, computational, interactive, distributed, individualized, adaptable, and customizable technological advances, and emphasize its critical role in social and global mediation. While much literature provides useful insights from theoretical and historical perspectives for facilitating critical thinking, few references provide insights from practitioner's perspectives for facilitating design thinking. Since computing machinery has been evolved and integrated into a functional role in many disciplines, computational thinking is mandated and recognized as a necessary capacity across disciplines [6]. This paper assumes design thinking as similar capacity that must be recognized in order to establish proper guidance for abstraction and orientation for diverse design activities across disciplines.

The concept of *tangible sketch* is introduced. A physically constructed tangible sketch is an initial setup for a pedagogical installation. This is a method to provide a cognitive scaffold not only for the learning model also for the instructional model to facilitate project based learning. Expected learning outcomes serve to give a particular signature to the sketch and this turns out to be a potentially powerful method for achieving effective project-based learning. This method is recommended both for new media and engineering design where the implementation of tangible installation takes a strong priority. The paper also presents use and use case abstraction as a methodology in the context of new media and engineering design and presents a preliminary report from interdisciplinary courses.

In the remainder of the Introduction 1) we discuss the necessary context for the role of design by way of asking "what is design?", and 2) we revisit a few contemporary conditions from which design activities are influenced. Section 2 discusses the background for design motivation in order to speculate and mine a deeper design motivation from anthropological perspectives. Section 3 presents the project-based learning context in which use and use case abstraction can be exercised. Section 4 presents a methodology for constructing progressive use cases. Section 5 summarizes conclusions.

1.1 What is design?

More than ever, digital and computational media open up many possibilities of design domains beyond the familiar ones such as visual [7], graphical [8], information display [9], or architectural design [10, 11]. Practically every domain of practice can be associated with design practice including software [12], engineering [13], and interaction design [14, 15] to mention a few. There is no binding theory about design encompassing all domains and it is neither possible nor desirable to have one. However, most designers will agree the design seeks for solutions to existing problems to optimize built-in conditions in an attempt to transform the old to new. The creativity in design solutions is inspired by observational, interpretive, and referential skills of the designers to bring about the new conditions of living. Designers often have to work with existing materials such as in industrial design or computer chip design, or adapt existing modules and functions written by others, like in software design, or work around the built environment, like in architectural design. The origins of such materials are associated with a *purposeful use,* and their original use specification predates the involvement of the designer.

The designer inherits constraints associated to 1) available materials and 2) existing intentions for using the materials, the *intended purpose,* or intended *use case*. Repurposing materials to other use case or vice versa can be done as it is exercised often, but it takes place only after a careful observation and abstraction by decoupling the two classes of constraints. The most important quality of a designer is being able to work with constraints and being capable of transforming undesirables to desirables by effectively using the constraints. Design is a practice of identifying and solving the problems with constraints in order to bring transformative quality to the existing conditions.

Designing and engineering new media requires a broad scope integrating many technologies in software and hardware, while directing diverse tangible and intangible processes. No one designer can provide all the necessary skills and directions. New media is an interdisciplinary field by nature, still demanding a good definition for the literacy required for both practitioners and audience-users. In the context of emerging practice, the inquiry will be twofold in an ongoing basis: 1) design thinking - what is the proper cognitive orientation for designers to develop design thinking while working with diverse media, data types, and hardware and software environments?; 2) new media literacy - how do we facilitate the agile literacy in instruction of new media? With pedagogical orientation for new media disciplines, this inquiry leads to Section 4 which presents a use and use case abstraction methodology to facilitate design thinking and new media literacy with respect to technological constructs.

1.2 Contemporary context: the philosophical consideration

The concepts of climate and population in design context revisited: to re-examine our design context and to stabilize design motivations we turn to the concepts, *population* and *climate.* Since early cybernetics theory, it is generally accepted that the technology we invent and use shapes our way of life; further, the relationship between human activity and technology is constituted in one big feedback loop of mutual influence [16]. With more colorful writing, McLuhan draws our attention to how new technology alters our senses and cognitive organization leading to changes in social organization [17]. The accordance of contemporary lifestyle heavily reflects on these thinkers projection and even beyond. Our life condition presents increasing dependencies on mediating agencies leveraging on technological advances for every day communications and activity. By observing the fast adaptation of diverse media in everyday life in new millennium, one comes to note there is yet another dimension to the technological mediation beyond the familiar feedback loop theory between human activity and technology.

The explosion of technological dependencies does not solely have to do with opportunities brought by technological advances, maybe more to do with the increase of population. And obviously the population is an ultimate target for media marketing. Mass media takes an inverse role in a new millennium, shifting its necessary construct from a one-to-many broadcasting model to a many-to-many distributed model. Such inverse role may well camouflage the tradition in a new cloth by internalizing the model of mass media from within, resulting in all distributed and individualized media thrown into and reduced to homogeneous experiences. Aesthetics emerging from new media experiences cannot be assumed to be free from the emergence of this new face of mass media relapsed into a thin and vast surface of distributed media experiences. In this context, how do we define the role of technology designer and educator?

We may state that human life is an ongoing dialectic process between the perception of its own existence and the perceived environmental conditions through which life forms its ontology as an entity [18, 19]. Today the designation of "climate" has been invoked as an explanatory principle—an explanation as an excuse—that does not attribute relevance to applications of design thinking in "media environments." As if culture is as natural as climate and design does not function in the wild, the social and political climates are no longer acknowledged to be caused by identifiable chains of human intentions; rather they are spoken of as highly susceptible to unspecific factors unforeseeable from original intentions. This misdirection or obfuscation of intention is highly infectious in design aesthetics and activities as well. Whether such factors may play in and cause desirable or undesirable effects or pleasures, it is expected that they may alter whatever the original designs and plans were set out to accomplish. This often leads to unexpected outcomes caused by accumulations of chains of emergent reactions to the extent one may no longer be able to trace the mechanics behind the complex outcomes. This generally accepted concept of contemporary "climates" puts a serious test on a design rigor, such that one must examine many assumptions as to where and when design is necessary and what constitutes design thinking for a new media that differs from the previous generation of media.

What are the thinking directives to counteract the undesirable side of the two concepts under our scrutiny? There was an era when aesthetics of serendipity and accident was held favorably. Such aesthetic resonates with the concept of climate if one does not examine closely. John Cage, for example, reacting to the hyper-deterministic aesthetics of the Darmstadt school, promoted the concept of chance as an alternative procedure applied to designing compositional activity. With respect to our examination in Section 2 of purpose leading to use and use case, Cage invoked the term "purposeful purposelessness" [20]. Our examination of purpose in abstracting use and use case presents a different context (see Section 2). In Cage's experiments, the question "when is the unpredictable outcome preferable or not?" is irrelevant. Cage's experimentation directs our attention to the particular era in historical context, but indeed his approach does not abandon a design process, rather he designs a rigorous process to overcome habits of music and performance. Similar to Jackson Pollack, Cage set out to generate alternative human behaviors in face of alternative ways of generating new expressions. Preceded by new experimentation and subsequent possibilities for new aesthetics, the following era endowed us with a wealth of new design tools such as statistical methodologies, cellular automata, various non-linear systems, chaotic systems, and genetic algorithms, to mention a few. It is time to examine what were the uses cases for such tools and how they transformed production models and designer's cognitive orientation.

The new millennium brings unique and strange mixes between old and new design space. Many design activities undergo either strictly formula driven exercises or ill informed repetitions of hit or miss trials. Digital transformation offers virtually unlimited outputs from which designers pick and choose, and they simply forget at times they are generating unlimited variations within an extremely limited universe locked in proprietary commercial tools. This is an example description of how the principles of climate and population lurk deeply in design activity in which alternatives simply do not exist. Design must predict the unpredictable and must afford certain "climate" without losing steering. The contemporary context urges design thinking to inquire unlearning certain habits and refresh design motivations to counteract a trivialization of human experiences. How do we facilitate the significance of individuals in a mass population? How do we facilitate diversity and multiple perspectives without trivializing them as merely one of many others?

2 BACKGROUND: THE ORIGIN OF PURPOSE IN NEED AND NECESSITY

The origins of technology go to ancient times when humans began utilizing materials to incorporate them in activities. The discovery of flint to make fire is the discovery of the material interaction between the stones: when put into persistent friction, the material interaction causes fire. Humans discovered they did not have to depend on the natural phenomenon for fire to occur. But if we 'desire' fire we must acquire skills and knowledge to set up the conditions from which we can obtain fire. This is at the heart of design discipline. This also departs from the standard digital media education focusing on students' acquisitions of skills using black box tools, which are prone to achieve results oriented to surface effects. This directs us to challenge how to deepen students' technologically informed design skills to prepare the conditions from which their desired outcomes are to be expected.

Identifying need illuminates necessity. The necessity then reveals what are required to take care of the need. The needs might have been to protect from various dangers or to take care of hunger. Probably all discovery originates from the necessity to meet the need. The necessity is to acquire the conditions and constituents to deliver the results adequate and proper to the need. Fig. 1 illustrates beautifully an example of such condition and constituents with the evolution of Chinese character, fire. The Chinese writer Ken Lai explains, “The Chinese character 火 (fire) consists of two parts: the human (人) and the two strokes components, which can be the abstraction of two flint stones. A man (人, ren or human) with two flint stones – that is the image of the Chinese character “fire!” [21] We can see in the evolution of the Chinese character, the Chinese word for “fire” symbolizes a man holding two stones. The logo portrays an interaction necessary *to make fire* rather than a “fire” as a natural phenomenon.

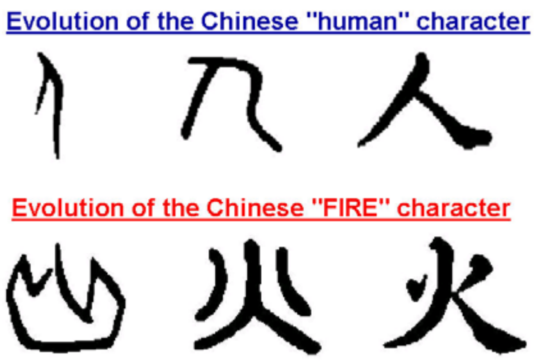

Figure 1. Evolution of Chinese characters.

Necessity prepares conditions from which needs are met: the body needs fuel to function properly. It is necessary for the body to signal “hunger” so that the signal may be accounted for by subsequent actions. The subsequent actions lead to satisfy the desire to eat.

We transfer the relationship between needs and necessity from a natural domain to a technological domain, limiting our scope of consideration to design. Two most important investigations are:

- How does design meet certain needs?
- What constitutes necessity in design?

In order to meet the need we must prepare the necessary conditions. The problem in first ethics occurs when this simple lesson is overlooked. As a designer, the first step to interaction design is to refresh this lesson as we live in an advanced technology era. We are surrounded by many things thrown at us before we even know whether we need them or not. How to meet need involves human observation to identify need, human constructs to prepare the necessary conditions, human intelligence to build adequate variety into the system of conditions to generate alternatives, and human interaction proper to the system of conditions to make sensible choices. In all of these courses of actions, tools and instruments are the foremost mediating agents in design.

2.1 Prelude: from machine centric to human centric

Technology and tools evolve and become integral to human daily activities. From the post industrial era many discourses began emerging in different domains. In literature Karel Capek (1898-1938) authored a play R.U.R in which he situates humans and human created human-like robots in the narrative structure to speculate possible encounters [22]. In science Thomas Kuhn (1922-1996) laid out the shifting ground for scientific paradigms for scientific observation through scientific instrumentation [23]. In engineering Norbert Wiener (1894–1964) wrote *Human use of human beings* (1950) to draw our attention from a machine centric to a human centric view of the technological development [16].

Wiener’s theory employs the feedback system. The principle of feedback theory extends also to human-to-human communication. When there is a communication breakdown, all parties are potentially responsible because they are the constituents in the feedback loop. Wiener’s work marks the deeper ground for contemporary concepts of “social media,” far beyond those of most media theorists populated from the late 20th century to the present.

3 INTERDISCIPLINARY TEAM PROJECT BASED LEARNING CONTEXT

Interdisciplinary Team Project is a three-sequence course for the Emerging Media Technologies Program offered at City Tech, CUNY [24]. The course goals are 1) to encourage students to expand their technological and design skills of their concentration through the integration of other technologies and disciplines, 2) to facilitate collaboration through a unique team based approaches to learning, 3) to provide students with practical experiences from the conceptualization of the project to the production, 4) to develop a teamwork skills and an understanding of each other's role, and 5) to introduce advanced technologies to challenge students for novel solutions. For the last few semesters the course was taught to students from participating departments such as computer engineering, architecture, and entertainment technology. This experimental course created a complex and challenging situation for integrating diverse skill sets, talents, and attitudes of students from the various departments in order to stabilize a coherent instructional structure to facilitate different learning requirements for different departments. In this section we discuss how the complexity was dealt with, and how identifying different learning objectives from various departments led us to identifying a proper signature for the collaborative team projects.

3.1 Scaffolding with Tangible Sketch

The idea of scaffolding originates from Vygotsky early twenty century as to guide a child's proper behavioral development through the interaction with adults in socio-cultural context [25]. Bruner explicates the idea and elaborates it into the concept of instructional scaffolding in the context of language acquisition [26]. The theory of scaffolding has been favorably adapted by many educational researchers as it yields an intuitive metaphoric function for facilitating cognitive, behavioral, and linguistic development in educational context. Dominantly it has been adopted in language acquisition [27, 28]. Recently it also has been extended to other educational domains [29, 30, 31].

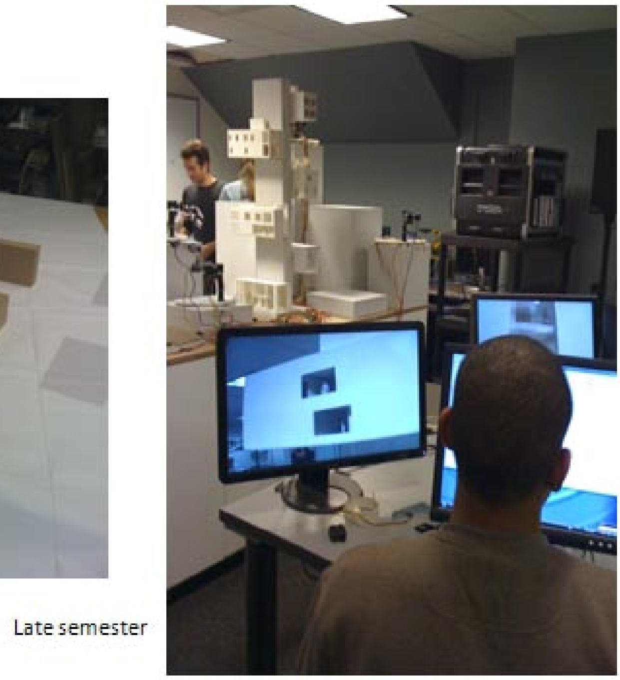

Figure 2: Initial layout of architectural model. Figure 3: Final stages of Tangible Sketch.

To broadly define, scaffolding is a temporary structure which supports a progressive construction and refinement of ideas, meanings, or a configuration of stuff within, and can be removed partly or entirely once it is no longer necessary. We applied the scaffolding theory in the interdisciplinary course where students were expected to bring diverse talents from their home department such as architecture, computer engineering, and entertainment technology. With respect to the different learning requirements, students were guided to learn to integrate their skills and learn the open source applications on hardware and software involving robotics, interactive signal processing, media signal routing and processing, and architectural context modeling. Due to the complexity of diverse skill sets and expected outcomes, we have decided to combine project-based learning model and scaffolding methodology by providing a physically tangible sketch framework. Tangible Sketch is a pedagogical installation which is literally a physical scaffolding waiting to be progressively constructed and refined as the semester progresses. In this case the scaffolding needed a loosely structured design that affords progressions and revisions for both instructional and learning processes.

Fig. 2 and Fig. 3 show the physically tangible sketch as scaffolding evolved into a final shape through the semester. In brief the Tangible Sketch in this course was an architectural model with imbedded webcam video cameras controlled by robotic arms, which are in turn controlled remotely by software. This combination of technology subsystems enabled the incorporation of learning objectives from each of the participating disciplines. The details of the sketch are discussed in Section 4.3.

3.2 Scaffolding in relationship to prototyping

At a glance one may wonder how this scaffolding method differs from prototyping methods often used in design process. Both require iterative design and implementation processes. An important distinction is as follows. Scaffolding is a temporary framework to support mutually evolving instructional and learning processes guided by expected learning outcomes. Traditionally scaffolding is built in the cognitive domain rather than in tangible installation. Prototyping is an implementation of a rudimentary working model to test whether the design direction and components used are valid and meet expectations. In prototyping, the test and validation is strictly guided by well defined requirements. It is also worth to note, as a pedagogical installation, scaffolding as a tangible sketch serves both teachers and learners, as the teachers learn to refine and revise their pedagogical strategies and instructional materials.

The theory of Scaffolding has been introduced to the study of cognitive development, language acquisition, and learning models [26, 28, 29, 30, 31]. The theory has not been applied extensively to the study of uses of physical materials, as to provide a framework for learning in sciences, engineering, and design. By introducing a new context of tangible sketching we can see scaffolding 1) as the theory to provide a cognitive framework for ideas about materials; 2) as an orientation to performed actions and experiences with materials. In this sense tangible sketching is a stage for hypothesis development necessary for prototyping. To develop effective prototyping we must undertake a prior stage of design thinking to arrive at relevant testing methodology by 1) observing and assessing material properties and functionality, and 2) anticipating humans' responses to material properties and functionality. We advance the approach that scaffolding applied in the configuration of a tangible sketch can well characterize the conceptual orientation required for prototyping, providing a language to represent links between materials' properties and designers' and users' orientations to materials' properties. Tangible sketches present conjectures concerning relationships of materials to users' underlying rationales for prototyping. In sum, scaffolding applied in tangible sketching generates use case.

4 USE AND USE CASE ABSTRACTION PROCESS

In this section we present the configuration of materials in a tangible sketch as a process of learning design, by connecting the legacy purposes of materials with hypotheses of new uses of those materials. A design hypothesis is embodied in a tangible sketch and can be demonstrated by prototyping. The connection between tangible sketching and prototyping is the *use case*. A use case is an embodiment of previous intentions—constraints of existing materials, in the context of new intentions—the new use presented in a tangible sketch. Prototyping is the exercise of a hypothesis for observing consequences of a design, predicted by and latent in the tangible sketch. The function of a tangible sketch for teaching engineering design is determined by the structure of use cases hypothesized in the sketch. The process of learning engineering design is engaged through the exercise of use cases in the tangible sketch.

4.1 Use Case Concept

We are interested in knowing when design provides solutions to certain problems.

- When is the *case*?

We are interested in knowing how we go about articulating the problems.

- How do we elicit the *case*?

We are interested in examining the relevance of our work.

- Is there any purpose or *use* for the problems and possible solutions?

The deployment of use case has been well formalized in the software engineering field where multiple participants develop codes [32, 33, 34]. Modules are written with clear use cases to define boundaries of the function exposures and variables. The use case in HCI and Interaction Design stresses more human centric views on how technology is used [35, 36]. A frequently cited example is the use of an ATM. Each component in an ATM machine and the ATM card imply particular use cases [15].

The basic concept of use case constitutes user, system, and a goal: *User* uses *system* to achieve *a goal*. For example, the following is the use case of a telephone.

- Caller uses phone to make calls.

Once we state this, we know the concept. Note the use case is not the phone itself. The use case is *to make calls*. Once students note this and remember it, they know half of the process of developing a use case. The other half is to develop skills for the use case simplification and modularization.

Consider the mobile phone. The mobile phone has two primary use cases.

- Caller uses mobile phone to carry around.
- Caller uses mobile phone to make calls.

It may seem odd, but yes, caller *uses* mobile phone *to carry around*. The phone's portability itself constitutes the essence of its usability. An advanced cell phone may have many auxiliary use cases beyond the primary use cases. Those use cases must be developed based upon the particulars in terms of functions and goals. In that regard auxiliary applications virtual devices with identity associated to the cellular phone through functional and semantic association, but extend to other use cases such as to take photographs, to check weather, to make a schedule, or to send email, etc.

Developing use case is an important stage in interaction design for any project development. Can we have a design without a use case? If design does not have a parallel use case as introduced in Section 4.3, it may be mere decorative art. It is well understood that technologists must be well versed in developing systems and subsystems. It is less understood that artists and designers must be also well versed in a complex systems design comprised of a network of use cases ranging from a simple and narrow in scope to a complex and broad in scope. Use case is one of many techniques of a kind, but a good one; it helps heighten designers' awareness of the relevance of their activity and mine the essence of creativity.

The common syntax for use case is as follows:

- User *X*
- System *Y*
- Goal *Z*
- Syntax: *X* (a type of user) uses *Y* (a system or device) to achieve *Z*.

4.2 Limiting Single Side Use Case: Webcam Use Case

We adopted use case as a pedagogical approach for introducing design engineering, and applied in assignments for project collaboration in a course that enrolled students from fields of engineering, media, and architecture. We started with the following tutorial example of the webcam:

- A group of teens in India uses a webcam to show their classroom scene to a group of teens in United States. Each day the students set a new scene and the camera operates overnight so others in the USA can login and view the live image.

Fig. 4, 5, and 6 show the process of detailing this example use case. These figure use UML modeling notation [37, 38]. Fig. 4 illustrates a clear boundary between users and systems. Users are external to the system. When designing an interactive system, defining boundaries is an important step. Boundaries protect overall system integrity as well as provide criteria what is to be interfaced and how much internal state to be exposed. In the diagrams, note one of the most important functions of the webcam, the transmission through internet is left out because this use case is limited to the use of webcam from the use of the students in India only. Fig. 5 shows developing details. The use case diagram applies the <uses> arc to connect objects: “to take shots in a room” <uses> “to position webcam” and “to pan webcam.” Fig. 6 shows further details “to position webcam” <extends> to various positions in a room, or to window side, back side, front side, etc. The terms “uses” and “extends” and connecting arcs and arrowed arcs are adopted from UML diagram convention. Students were asked to apply these conventions in their use case assignments, which aided their formalization of representations of materials and relationships they were utilizing in their design process. This formalization aided the combination of use cases in assignments that followed.

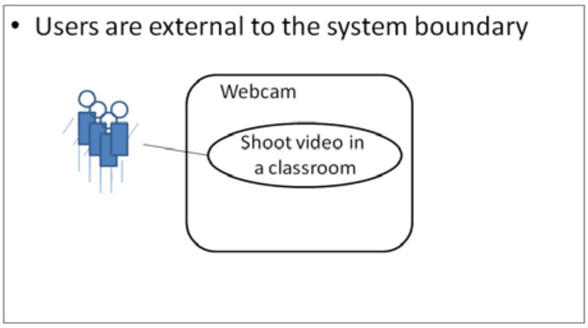

Figure 4: Single side use case

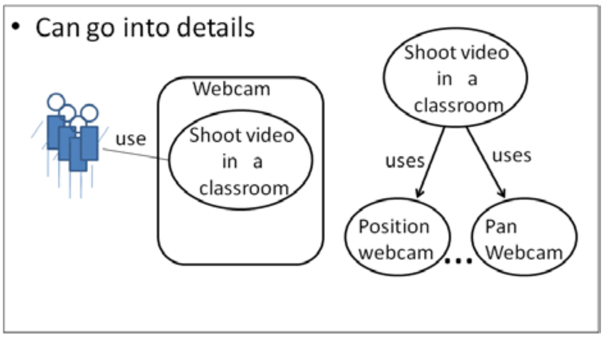

Figure 5: UML diagram of relationships of details.

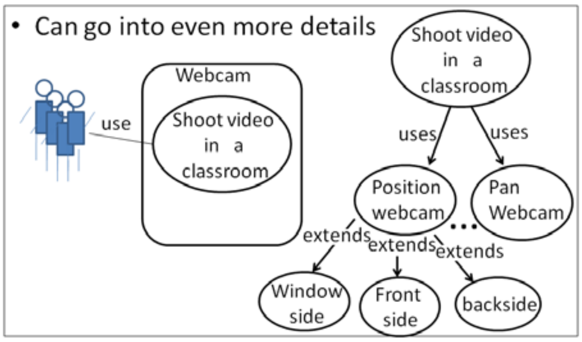

Figure 6: UML <extends> function example.

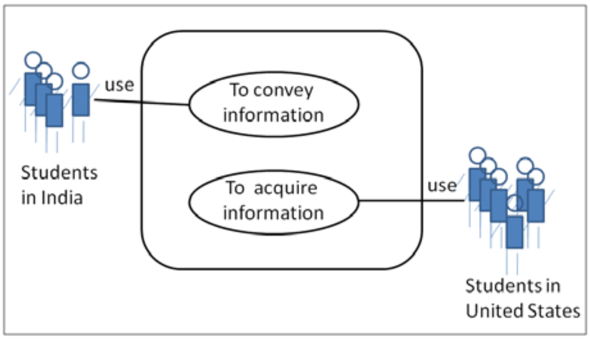

Figure 7: Parallel Use Case example

4.3 Issuing Parallel Use Case

The class was next introduced to the parallel use case, as in Figure 7. Here the students in the United States *issue* a separate use case. The webcam provides for a proactive (transmission) and receptive (viewing) process, the former through perceptually oriented predictive imagination of students in India, and the latter through perceptual capacity of students in the US. It is appropriate to present both in parallel by issuing two use cases, the viewer-centric use case and the producer-centric use case.

- Viewer uses webcam to acquire information about a remote environment.
- Producers use webcam to convey information about their environment.

The class was then assigned to defining use cases for a tangible sketch to be constructed as a team project. Several single side use cases were defined then brought into parallel relationship. Engineering students defined single side use case of a robotic arm; media students defined single side use case of a webcam; architecture students defined single side use case of a physical building model. Together these were used to design compound use cases such as coupling camera and robotic arm to create *kinematronic* systems, with the kinematic chain of the robotic arm hosting a cinematic function of camerawork. Fig. 8 illustrates the kinamatronic system situated in the architectural model to generate views of the model. This creates a reciprocal use case between the model and the kinematronic system, as the model-related use cases are to present information and to be observed.

Figure 8. Tangible Sketch of Kinematronic system used for engineering design pedagogy.

4.4 Constructing Propositional Use Case: Multiple LED Lighting Design Use Case

The propositional stance in media design and media arts requires opening alternative dimensions for use case beyond typical ones. After realization of the kinematronic tangible sketch in Fig. 8, students were assigned to develop propositional use cases involving multiple LED lighting design, to be integrated into the tangible sketch. First we state the typical use case of multiple LEDs as the following:

- Designer uses LEDs to illuminate models.

Then we state parallel lighting design use case as follows (Fig. 9):

- Viewer uses lighting to see details
- Lighting Designer uses lighting to illuminate details

We go on for detailing for a lighting designer as follows (Fig. 10):

To illuminate details *extends* to:

→ Boundaries in the space
→ Perimeters of the space
→ Objects in a space
→ Elevations of the space
→ Silhouettes in the space

To depict patterns *extends* to:

→Patterns in the space
→ Patterns in time

The proposition of use case beyond typical application requires a hypothesis. Imagine the lighting designer wants to achieve amplified depth cues. A hypothesis is that an illumination of multiple LEDs with careful positioning will heighten perspectives. And the use case is as follows:

- Lighting designer uses multiple LED illumination to depict depth perception:
  - To depict depth perception uses:
    → To illuminate foreground at a low level
    → To illuminate middle ground at a low middle level
    → To illuminate background at a middle level

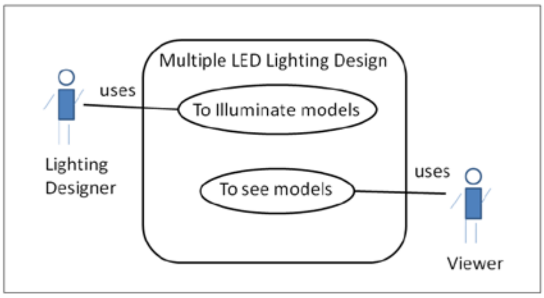

Figure 9: Initial use case for LED design

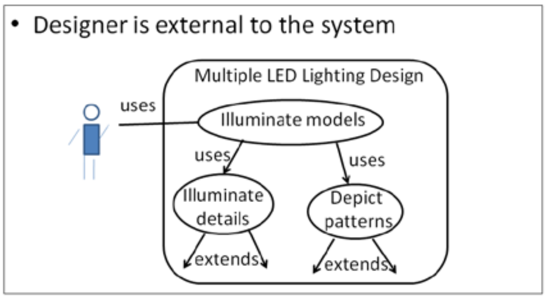

Figure 10: Extended use case for LED design

With propositional use case development a connection is made explicit from Scaffolding and Tangible Sketch to the traditional Prototyping stage of design engineering. Each of the LED design propositions can be transformed into test cases where the use case becomes a prototype study. Fig. 11 illustrates the test setup using the Tangible Sketch as an environment to host the LED test case for directing attention to changing perspectives.

Figure 11: Tangible Sketch being used to install LED perspective use case example for prototyping.

5 CONCLUSION

After running a couple of experimental courses, the tangible sketch has been proven to be an effective method to scaffold both learning and instructional models in the context of project-based learning. We recognize the skill to conceptualize the pedagogical installation and to design initial tangible sketch depends on the talents of instructors and the results may vary accordingly. However, once the practice is circulated and repertoire is established, we think the method is viable for new media design and engineering education. It can be as effective as well established science and laboratory methodologies, and it is analogical to the laboratory set up in science lab to test and learn to acquire particular knowledge and skills.

Combining design and engineering close to each other, our instructional space set up was configured as a studio-lab where students can rapidly navigate through design, implementation, and production workflow. Iterative design and use case abstraction processes were tightly integrated into tangible prototyping, feasibility studies, and implementation and production workflows. This helps to overcome the potentially limited scope of *learning by doing* which often resulted in project and production driven learning models. Use case abstraction guides students with generalized cognitive orientation for hands-on activities with diverse type of media components. It also frames vocabularies and terminologies with a common grounding making easy for collaboration. As use case conceptualization and writing exercises are emphasized while working with tangible sketch, the students' new media literacy is heightened in both linguistic expressions and components demonstrations enabling their design thinking agile.

Our future studies will pursue to establish a reliable matrix for assessing the relationship between scaffolding and prototyping. It is commonly understood the effectiveness of prototyping is hard to prove. We hypothesize tangible sketching as a methodology will play a pivotal role for bridging scaffolding and prototyping. Tangible sketching embodies scaffolding, at the same time it is an environment for hosting prototyping. It will help us develop a structure of outcomes assessment to draw the relationship between abstract model of scaffolding matrix and tangible model of material prototyping matrix.

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