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Social influences on student perceptions of failure in learning design processes: Instructional implications

While the Silicon Valley aphorism would encourage all involved in design to ‘fail early so that one can succeed earlier’ such a concept may be hard to translate to classroom instructional strategies, especially due to the negative connotations of failure in school settings. Failures in design serve a somewhat distinct purpose from failures in schooling; however, for learners, this distinction is hard to distinguish, and the subjective experiencing of these forms can be highly similar. In this paper, we discuss the role of failure in learning, especially in the design process. We examine the ethnographic case study of a grade nine class involved in a design instruction course, and find that while students were aware of the positive attributes of failure, they had difficulty embracing failure as a classroom activity, and take risks to accomplish projects. We trace these perceptions to the social messaging around failure that these students experience, and discuss some implications these findings may have for failure, risk aversion, and ultimately, schools as sites for educating innovativeness in societies.

Introduction

The current interest in design and innovativeness, especially framed around discourses of ‘21st century competencies’ is perhaps not surprising given the times that we find ourselves in. With increasing automation and information processing, the obsolescence of entire categories of jobs are rapidly moving from mere rhetoric to reality in some cases. Considering that jobs which require imagination and creativity will still be secure for the moment against the onslaught of relentless algorithmic and robotic takeover of routinisable tasks, economic planners and pundits alike have no doubt placed heavy emphasis on the need to educate the current generation of students to thrive in innovative economies. In that regard, places like the Silicon Valley, where large amounts of wealth has accumulated over the inventions surrounding the information revolution, have been held up as models for innovation. The design process has been portrayed as a key method underlying these successes, especially in the light of highly profitable consumer-facing corporations such as Apple revealing their business philosophies and strategies. However, just as teaching science to students does not necessarily make them scientists or even enhance their appreciation of the methods of science, teaching ‘the design method’ may not lead to desired outcomes. One factor that ought to be recognised as a potential influence to the success of these approaches is the sociocultural attitudes towards innovativeness and the inherent risk taking that accompanies any creative venture. This is not an argument for *any* form of essentialism that purports that particular groups may be more or less inclined towards creative outcomes, but a recognition that, as with any educational venture, instructional strategies require localisation and careful adaptation. Specific to design and risk taking, the spectre of failure most commonly associated with efforts at passing the gatekeeping functions of school poses challenges to student learning of the value of failure to design. Especially in the context of school systems and societies that place high-stakes demands on standardised testing, the influence of rationalised procedures can have irrational outcomes compared to other public statements as students and teachers struggle to reconcile contradictory pronouncements and practices.

Innovation: what is it and why it is important

Putting aside for the moment concerns about the sustainability and ethics of unequal economic development, the clamour surrounding educating for innovativeness and innovation has been increasing in recent years. This is likely especially so with the computing and automation revolution, which in recent years have seen the democratisation of access to tools of information and persuasion, and more recently invention and manufacturing [democratisation of invention]. Indeed, the recent maker movement that has witnessed the rise of makerspaces as in schools builds upon the ubiquity and comparatively low cost access to manufacturing tools such as computer aided design and 'push button' machines such as 3D printers and laser cutters. Key to the compelling value of these developments is the separation of the design from the manufacturing--while the physical making remained messy and localised in space and time, designs, essentially languages and representations of ideas could be infinitely portable and communicated over numerous means, for sharing, extension, and re-purposing in other contexts. Invention and innovation is perceived to be of the highest importance as means to develop reasons for making things, as well as actually making the things in themselves that could solve the problems that were perceived to exist. To be sure, much of our knowledge in innovation is common to our knowledge of creativity; after all, a large part of innovation is the creative effort necessary to come up with novel solutions to problems. However, while creativity is generally defined as useful novelty, innovations possess a further criteria of implementability, and some version of social desirability in order that the innovation be widely taken up. In terms of the traditional disciplinary knowledges, innovation is truly interdisciplinary: understanding the psychology of creativity can inform particular practices of innovative teams and individuals; to understand how innovations may be designed to meet users' needs requires the knowledge of anthropology; more recently, efforts at marketing require sociology.

In any case, at least creativity has held the attention of the academic community since the 1950s, when the then president of the American Psychological Association urged researchers to consider the problem of understanding creativity (Guilford, 1950). While prior researchers have focussed on the imagination, perhaps events immediately post war brought into sharp relief the need for new ideas and new ways of thinking over a host of problems (Plucker, 2001). While we live in different times, there is no shortage of problems which require our collective attention. Additionally, economic considerations especially in post industrial economies 'require' more frequent 'updates' to cater to shorter attention spans and competition based on novelty. To repeat the foregoing, if we understand innovation to sit at the intersection of technical feasibility, social desirability, and business viability (Kelley & Kelley, 2013), educators require a distinct disciplinary model of coping with the challenge of communicating innovation to learners than what we currently possess. It is in design that we turn to for such a model.

Innovation and learning

As a discipline, design is probably the youngest and least well established of the typical departments that would make up a classical university. This state of affairs has as much to do with the relative recency of the recognition of design as a job category, as with the relative mystery surrounding the way designers arrive at their design solutions. As retold by

design researchers (Kolko, 2010; Tomiyama, *et al*., 2003), the process appears opaque--after collecting information about the design problem through interviews with the client, and other means, the designer retreats to make sense of the information, before emerging with proposed solutions that respond to the problem but gives little hint to how the designer could have gone from problem state to solution state. Indeed, the problem is more general, in that while we can, after the fact, logically analyse the suitability of solutions as response to problems, the processes of creativity is largely thought of as psychological and immune to rational analysis (Walton, 2005). As far as we can tell, the reasoning mode of creativity appears to be abductive. While deduction is the reasoning of the properties of the particular from known general rules (chalk is white, this is chalk, this must be white), and induction is the generating of rules from the aggregation of observed particulars (this is chalk, this is white, chalk is white), abduction is distinct: given a particular case, and a previously known rule, abductive reasoning makes the speculative assertion of a result that may or may not be. For instance, we could observe that we have a substance that is white, and we know that chalk is white, therefore we could reason that this *could be* chalk.

This probabilistic conclusion is important, and while it appears to not be very reliable, happens to be the default mode of human reasoning (Kolko, 2010), and in use by such professions as engineering, medicine, education, or any practice-based pursuit. Educators may have a good store of pedagogical content knowledge, of particular rules to accommodate diverse learning situations. In the classroom, educators essentially make assumptions based on the signs and partial feedback from their learners as to the type of learning practice most appropriate, and in the case of novice educators, can often be wrong. Interestingly, it has been argued that the logic of scientific discovery is also abductive in nature (Lawson, 2004; 2010)--take the case of planetary discovery: While perturbations in the observed orbits of known planets were discovered, an abductive epistemic leap was made to propose the existence of hitherto unobserved planets. After calculations were made to predict the location of these planets, enhanced instruments confirmed these predictions. To further belabour the point, Einstein's multiple *gedankenexperiment* in relativity were essentially abductive leaps, eventually proven right when the technologies of empirical investigation caught up.

In design, or any creative venture where the result is not merely intended as aesthetic expression, there exists significant risk inherent in the reasoning processes of proposing novel solutions to problems. While businesses conceptualise this risk as a failure of an idea to gain market share, the point here is to consider this risk as more fundamental to the process of *any* form of learning; if we are to more robustly query the tenets of constructivism, and move away from a model of learning whereby it is imagined that one may mechanistically build knowledge (Roth, 2015), we arrive, currently, at candidate solutions such as Productive Failure (Kapur, 2015), which in essence is a hypothetico-deductive model engaging learners in episodes of abductive reasoning prior to instruction. If we are to consider the acquisition of new knowledge as a process through which we internalise new patterns of reasoning and behaviour, learning does not occur unless and until these new patterns are tested against an external reality, a process for which failure will be an essential tool. In this manner, learning and innovation can be seen as highly similar processes, and an emphasis on innovation should not be seen as merely one as a preparation for economistic goals. Rather, innovation processes can be used as a disruptive (and genuine) model for learning.

Failures and design

If failure is important in learning in general, its importance in design is even more central. To appreciate this position, it is important to review the nature of the knowledge and practice of design. Although design has been largely underestimated and misunderstood up to around the turn of the century (Dym, Agogino, Wris, Frey, & Leifer, 2005), prominent researchers have pointed out the distinctiveness of design knowledge since at least the 1960s. For instance, the pioneering work of Herbert Simon (1996), distinguished the design as a science of the artificial, as opposed to the natural sciences. Key to the distinction is that while the natural sciences are concerned with the way things are, design's concern is with the way things ought to be. The practice of design has been described as reflection-in-action (Schon, 1983), again in contrast to the 'technical rationality' of conventional descriptions of professional knowledge. As opposed to the positivism inherent in technical rationalism, design knowledge consists of an underlying basic disciplinary resources, and crucially, a set of skilled dispositions developed through embodied experiences that guide the application of these disciplinary knowledges in the solution of design problems. Design problems belong the category of the wicked problem, so-called not for its evil nature, but because they resist solution, are open ended, ill-defined, ill-structured, have no true or false answers, are essentially unique, and are symptoms of other problems. Solutions are always partial, contextualised to time and space, generate further consequences of their own, and are essentially 'one-shot' attempts which cannot ever 'solve' the problem (Rittel & Webber, 1973, Rith & Dubberly, 2007). This Sisyphean approach to generating design solutions means that designers need to become inured to the inevitability of failure, as when users being designed for interact in ways unforeseen, or when design solutions generate further problems of their own.

Thinking of design as a process of proposing *instances* of closure of the is-ought gap (Nelson & Stolterman, 2003) is necessarily an exercise in humility--it was no less than David Hume (2003/1739) who pointed out the lack of a rational connection between the descriptive and the normative. While developed as a principle for ethico-moral deliberation, similar considerations in the nature of design problems reveals failure to be central in the process of design. While an accurate apprehension of the design problem is necessary for effective solution, and a solution may be suggested by a careful study of the problem, the wicked nature of design problems means that there will be no unique, 'once and for all' type solutions, only merely better or worse attempts. Design solutions then, are essentially statements of 'ought'--where designers make the claim that a solution *ought to be such*, based off little else than aesthetic considerations of elegance in the case of material designs, and utopian ideals of social and interpersonal interactions in the case of the design of user experiences. Design processes then, by its very nature, are condemned to failure, in as much due to the virtual impossibility of completely apprehending the diverse aspects of the problem at hand (as a pragmatic limitation), as well as the impossibility of deriving the normative from the descriptive (as a theoretical limitation). When we add the statistical probability of there being more ways to be wrong than there are to be right, we see that this confluence of factors require designers to become comfortable with the knowledge that any design proposal will merely be an instance of failure, the obviousness of which is only deferred in cases of better solution.

Educating for innovativeness?

For states and school systems that desire innovativeness as an outcome, having citizens and students accept and appreciate the role of failure in the process needs to be perceived as essential. It is not at all surprising that popular culture depictions of Silicon Valley startup culture paint the process of launching a startup akin to flinging oneself off a cliff, building an airplane in mid air and expecting it to take off before an unfortunate meeting with the ground (Martinez, 2016). While a natural selection model may work for investment in technological innovations, doing similar in schooling may not be acceptable. Considering the role of schooling to educate a broad base of talent to achieve a wide range of foreseeable and unforeseeable outcomes, the social darwinist position has already been widely dismissed as being profoundly unjust. Further, for school systems heavily invested in systems of accountability, having assessments of student outcomes which bear multiple equivalent outcomes subjectively distinguished can be a threat to technocratic notions of validity and the discriminatory capacity necessary to fulfil the gatekeeping functions of schooling.

An even larger challenge emerges when school systems are tasked with the responsibility of creating, nurturing, or strengthening a culture of innovation, an especially pertinent task given widespread notions of the importance of innovation to societies and economies. It is an understatement to claim that education is a multiply-layered complex phenomenon, that cannot be understood and modified merely through influence at one layer. While studies often focus on one layer for simplicity, ‘real world’ success and change of practice requires attention to how these interpenetrating layers interact. This perspective drove our research approach and motivated our research question: considering the importance of failure in learning in general and in design instruction in particular, it was imperative to find out what attitudes students possessed with regards to failure, in general, and in the particular context of schooling. Additionally, we wanted to know the foundational influences on these perspectives, and if these attitudes posed any contradictions, either internally, or in relation to the goals of education.

The research context

We happened to encounter the natural experiment of the Singapore effort to improve its innovation outcomes. Known for its high standing in international comparisons of school systems, policymakers nonetheless do not rest on their laurels, and instead continue to implement changes to adapt to perceived challenges facing future economic goals. While Singapore’s creative outcomes remains comparable to the likes of Switzerland and Japan, at least one report (The Economist, 2014) points out the inefficiency of spending--comparing investments to outcomes, Singapore’s ranking, at first for spending inputs, yet only sixth for outputs, is low indeed. In the domain of manufacturing, government press releases and news reports indicate an awareness that lower value manufacturing processes are inexorably leaving the shores for places with an overall lower cost of doing business. In response, national economic policy has shifted towards high technology manufacturing, including digital fabrication, additive manufacturing, and high precision engineering (Huang, 2016; Lim, 2015; Ministry of Trade and Industry Singapore, 2013; Tan, 2015). While local universities appear to have started investments in research and education for these so-called ‘future of manufacturing’ opportunities (Agency for Science, Technology and Research, 2013; Agency for Science, Technology and Research, 2014; Nanyang

Technological University, 2013), less effort and resources appear to have been placed in 'upstream' efforts in K-12 schools.

In order to support these perceived changes in the manufacturing landscape, and to provide an entry path for new initiates into advanced technologies, at least in the Singapore context, sites known as makerspaces have been set up by a combination of private and state funding (Makers' Block, 2014; Wee, 2014). Designed with a mind to 'spur design, innovation, and commercialisation of products' (SPRING Singapore, 2014; Wang & Kaye, 2011), such public makerspaces appear to be modelled after successful makerspaces in the US such as the Artisan's Asylum in Massachusetts, Techshop in many places in the US, and the Noisebridge Hackerspace in San Francisco. Makerspaces are often informal spaces, built for a variety of purposes ranging from social learning, practice, and commercial incubation of product startups. Thought of as central to the innovation economy, public makerspaces exist as part of the ecosystem supporting the democratisation of innovation (von Hippel, 2005), by providing easy access to equipment and a ready social network of highly skilled individuals who can teach others how to 'scratch one's own itch' (Banzi, 2009). Recurrent in popular media on making and makerspaces appears to be an emphasis on the innovative aspect of making; for instance, the online edition of Make Magazine (Bell, 2016) features interesting projects to be made with a combination of craft making techniques or cutting edge materials and processes. Certainly, closely following public policy pronouncements of the importance of innovation and its subsequent commercialisation, makerspaces appear to be ideal sites for the nurturance of innovative dispositions in individuals and teams.

As part of these efforts, our research project started an effort to implement a makerspace in a school setting. As part of a pilot effort, we found a school with cooperative teachers, but where the physical setting was not ready with all the accoutrements of digital fabrication as may be expected in some makerspaces. Instead of considering this a drawback, we focussed on the processes of design, the instructional methods to nurture innovativeness, and functioned as with many makerspaces as communal activity space first and foremost, and as a place to learn about manufacturing technology subsequently.

Methods

Our single case study utilised an ethnographic approach to data collection and analysis. Due to the relative rarity of school based makerspace contexts in mainstream Singapore schools, in addition to our research goals of exploring deeply the circumstances that bolster or hinder the adoption of makerspace in high accountability contexts, the case study method is particularly apposite (Yazan, 2015). We spent 11 months in our research context, starting from late 2013 to August 2014. Two of us (first two authors) became participant observers, playing the role of teaching assistants for two of the student groups. The first author was formerly a teacher in a Singaporean school, and as such, was familiar with the cultural patterns of schooling.

Participants

We found Hillside Secondary (all names pseudonyms) through an introduction. One of the school board members had already started to convince the administration of the importance of makerspaces, and the school's head of science was interested in our project. We were

introduced to Alex and Bob, experienced teachers of Physics and Chemistry respectively. They had extensive expertise in facilitating students in science fair projects, and their proven track record in school as high performing science teachers. Both of them had excellent rapport with students, and had a history of having a somewhat unconventional approach toward teaching their subjects. Through discussions, we found that Alex and Bob were also bold enough to eschew standard norms of pedagogy in the Singaporean school system. In fact, Alex became disillusioned enough with the system that he left teaching altogether after our project completed. Hillside was a selective independent school, with a strong Arts program, and an alternative graduation assessment system to the local norm. In this sense, Hillside and its teachers were probably not truly representative of the mainstream secondary schools here. However, this choice is still justified on the grounds that it represents one end of the continuum of school contexts. At the outset, Hillside, with the teachers and students in our project appears to be a school which presents a high chance of successful adoption of instructional principles for innovation within the school context.

In addition to Alex and Bob, we had a class of 12 grade nine students, divided into three groups of 4 students each. These students were drawn from across different classes in the level; the school had a social service program entitled Community Service Time (CST, a pseudonym), for which students signed up with projects proposed by teachers. These students had volunteered to take part in a program that was advertised as a design-centric process to address the needs of a group of people of the student participants' choice. We had nine girls and three boys, with varying degree of technical ability, and experience and enthusiasm towards designing and making. On the one hand, two students were formerly involved in gifted education school contexts, and were able to handle the technical challenges of programming the Arduino microcontroller development environment completely by themselves. On the other hand, and by quirk of team formation, another team ended up with technology-phobic individuals who could not bring themselves to try out even basic electronics.

Task

Working closely with Alex and Bob, we developed a curriculum for a 14 week course of two hour sessions weekly. The initial planning started in late 2013, where we met regularly to discuss project ideas and implementation issues. Our first meeting with the students was in March of 2014, and the project ran through August of the same year. As we took stock of the facilities and equipment that we had to conduct this course, we quickly realised that we were going to be limited to very light duty making. Teachers in Hillside did not occupy fixed classrooms, we were not assigned any fixed space, and only had Alex's personal space to store the students' in progress projects. As a result, we decided to make use of freely available resources from the Stanford University Hasso Plattner School of Design as a means to organise the course for the students. We provided students a design prompt, asking them to respond to the prompt of "Design and make an interactive art project that best expresses an experience of the local environment". Loosely, we moved them through phases involving: (i) empathy development / user needs analysis, (ii) problem definition, (iii) solution ideation, (iv) iterative prototyping, and (v) prototype testing. Because the design process is non-linear, we allowed some free articulation of weekly activities so that the teams could modify their process as they deemed fit.

Data sources and analysis

Data sources for this project include field notes, audio recorded interviews, student artefacts, pictures, and videos of classroom interactions. We typically met Alex and Bob a few days prior to the sessions with the students, to plan the upcoming session; we also took the opportunity to conduct open-ended interviews and reflections on the session prior. While we participated in classroom discussions and work sessions, we video recorded and took notes of the classroom culture that developed as the course progressed. Towards the later part of the course, we audio recorded interviews with Alex and Bob, and pairs of students, using a semi-structured interview technique, designed to elicit their self-assessments of their projects. The interview questions are reproduced in Table 1 below for reference. All recorded interviews were then transcribed. We conducted a content analysis (Cohen, Manion, & Morrison, 2011, p. 563-573) among all the field notes and transcripts to discern dominant categories. When an initial version of this paper was presented at a conference, Alex and Bob provided contributions to ensure coherence in our findings. In this manner, we ensured a high degree of authenticity and trustworthiness of our findings. In recognition of the holism of the context and the complexity of change in education, we concur with Yin (2009), and Cohen, Manion, & Morrison (2011) that the circumstances that lead to change are not reducible to singular variables. We sought to explain the unique and dynamic context of our singular case, to understand the deviations from the plans at the outset, and where we eventually found ourselves, and how this case could contribute to a being a "catalyst for broader social action" (Lincoln, Lynham, & Guba, 2011) in the larger project to change schooling in Singapore.

What do you think of Community Service Time (CST, a pseudonym)?
Have you had any prior experiences with design activities similar to CST?
How was your experience with your team's project?
What do you learn about the design method?
Do you think of yourself as a designer?
What does design mean to you?
When you look back at CST, what are some of the highlights?
What are some notable failures you have experienced in CST?
What are some notable failures you have experienced in life?
What are some of the lessons you have learnt from failure?
What made you chose to come to this school?
What are some of the high points of your school life?
What are some of the low points of your school life?

Table 1: Semi-structured interview questions

Findings

The goals of the course changed over the weeks as Alex and Bob apprehended the challenges that running the course entailed. While they initially supposed that the students would be able to mount actual exhibits in public, and proposed this course of action for the students, they were quick to modify their expectations in negotiations with students. Alex and Bob also realised the scale of a public exhibition would be too much—given limited funding,

and insufficient time to both build their projects and raise funds—and so lowered the stakes for the students. They decided early on that the students should be in groups of four, and that the groups should be performing independent tasks instead of collaborating on one last project for the whole class. Each team of four students started with an anthropological approach of going out of the school to a site of their choice to observe people as they went about their business. Hillside was situated near a busy downtown transit interchange, and as such had a high pedestrian volume coming close to its premises. After some deliberation and ideation, students converged on the projects as shown in Table 2 below.

	Members	Project proposed	Group features
Group 1	Charlene, Charlotte, Chester, Chris	'The path less travelled', sensor driven lights to encourage pedestrians to take alternative route.	High technical ability group, self-taught programming abilities.
Group 2	Daisy, Dale, Darcy, Duke	Virtual gateway, walk through a door frame to activate a display about the school.	Medium ability group, required assistance, did not manage programming.
Group 3	Edna, Elizabeth, Emily, Eva	School bonding, an inter-level jam session during breakfast time to get students together.	Low technical ability, initially resistant to many ideas, but project actually materialised.

Table 2: Student group projects and characteristics.

The process by which they decided on their projects was by no means straightforward. Group 1, while most technically proficient, had some interpersonal conflict which manifested itself in members pushing work on one another. When they eventually managed to resolve their differences sufficiently, they agreed that a suitable project involved them diverting pedestrian traffic from the main thoroughfare near the school. The transit interchange had a small butterfly garden on one end of its premises. Pedestrians would usually adopt what was perceived as the shortest route to the interchange entrance which bypassed the garden. Through careful measurement, they found that the distances from a fork in the pavement through two alternative paths to the entrance were the same. Carefully noting that pedestrians avoided the path through the garden, they set out to change this behaviour, eventually planning an interactive light display that could respond to pedestrian movement, and turn on what looked like aircraft landing lights to direct them towards 'the path less travelled'.

For Group 2, interviews with selected passers-by confirmed their already held suspicions that many of them had misconceptions about students in the school. Hillside secondary school was perceived to be have high ability students, who could breeze through their academic responsibilities. Due to the school's strong Arts program, students from Hillside were also believed to only specialise in the Arts. From their own perspective, these notions were patently absurd; they often struggled through their work, and had confused identities as they tried to resolve their love for the Arts and the other disciplines that they had a similar passion for. Their project proposed a corrective to public perception of who the Hillside student was, with a static display behind an initially darkened glass fronted box. This box

would light up in response to people walking through a door frame; these lights would then expose another dimension to the display, which represented the truth of their student experience as they experienced it.

Group 3 was beset with the most issues among the three groups. While initially enthusiastic, all four members realised that their degree of technical proficiency and technological enthusiasm was fairly low. As a consequence, and arising from the group dynamics influenced by the dominant personalities within the group, these students turned from an initial scepticism into outright cynicism at times. They questioned whether their project could even be completed, if this completed project could even be of any conceivable social use; they vacillated on a target audience that their project could address, on the types of technologies that they would consider using; they refused to consider that they could possibly learn anything about the Arduino microcontroller that could make it less mysterious than it was currently. Through close personal counselling with the group, continual reassurances that the attempt was more valued than the result, and on occasion desperate attempts at threatening the group with a failing course grade, Alex managed to get the group to change their minds enough to try something. After two iterations were dismissed as untenable, they took a step back and realised that their problem was that the student body was not mixing sufficiently between grade years, and this affected the school morale. With Alex's permission, they abandoned the technological aspect of the solution attempt, and instead worked on a breakfast jam session that brought students of the common passion—the love of music, together for a session of music appreciation, and a free breakfast that many students often missed due to hectic schedules. Photographs of student projects are included in the following figures.

place Figure 1 about here

place Figure 2 about here

place Figure 3 about here

Evaluation

For the teachers, who had high initial expectations of what may be possible, there was a certain degree of disappointment with the results. Alex and Bob were inspired by the guerrilla artist colloquially referred to as 'Sticker Lady' (MacKinnon, 2012). She had produced and affixed stickers to pedestrian crossing signal buttons, with humorous and satirical (to the point of mocking) messages in local patois, poking fun at the tendency for people to impatiently push the button multiple times in quick succession. Alex and Bob felt that it may have been reasonable for the students to use a similar tactic to spread provocative messages to get people to reflect on their existence and their social relationships with one another. Against this benchmark, the projects of groups Groups 1 and 2, which never left the prototype stage, could be interpreted as failures. Group 3, which actually staged an event that had actual potential to change interaction norms in the school, came closest to success in these terms. On the other hand, on a possible criteria of engaging with an unfamiliar technology, making largely self directed attempts to understand it, and then assembling an aesthetic creation with this technology (the Arduino microcontroller), Groups 1 and 2 could fairly be judged a success. Some degree of

culpability for the lack of progress did lie in the insufficient facilitation provided by the teachers and researchers. The teachers and researchers did reduce the importance of technical instruction as we believed that there would be a large tendency for the sessions to devolve into teacher directed instruction. Such a situation would have run counter to the teachers' beliefs of the importance of student initiative and self-directed learning practices that they were trying to encourage in the students. Nonetheless, as with Alex and Bob, we did sense that the students were actively resisting taking the initiative for their own learning and proposing projects that represented them taking a risk. In fact, it would be appropriate to describe the students actively avoiding risk taking. We decided to investigate the underlying causes for their holding this position, the results are presented below.

Failure avoidance

Students complained that they were not adequately prepared as designers that could solve real life problems, that they did not think they wanted their work to face the challenging trial of an authentic audience, that their projects to date had taken place over a much longer time, and was smaller in scale (even though those tended to be solo projects). Students also complained that they lacked time to set aside to this project. They were also sceptical about being able to prepare a project to completion, to the point of creating a condition of self fulfilling prophecy. This indicated to us their product orientation; for instance, Edna reported: "Design is a problem solving process. It doesn't complete. It just keeps going and going. School drills to us that there is an end product". Similarly, Eva described the product-driven design process in school: "Our creations are works at the end of the day, they are graded. We have to churn out a good product." This product orientation caused the students to focus on whether or not their project would turn out to be a success, with the obvious implication that if they did not believe it would be, based on the way the project was progressing, they did not feel particularly motivated to complete it. Eva expressed this sentiment thus:

> I think the idea wouldn't be that feasible or marketable. If we work on something we don't believe in, how can we expect other people to believe in it? We felt we didn't do justice to our own project and so what is the point of continuing something that you don't want to do. Any project in general is never good if you resent it.

We found two major themes that seemed to drive students' decision making calculus when it came to effort in school. Loosely, they were enculturated into a schooling system of extrinsic development, a technocratic rationality where only the things that were measurable, counted. As a corollary of this cultural belief, things that were not measurable, were de-emphasised.

Fear of failure as extrinsic motivator

As Hillside was fairly high performing academically, the school administrators, teachers, and students felt that they had a joint reputation to uphold. Students reported that although they came to Hillside because of its strong Arts program, they found that the assessment culture quickly dampened their passion for their chosen art form. Emily had talent in, and was initially enthusiastic about singing:

> They had singing and I liked singing at that point of time. So I decided to sign up thinking I wouldn't get in [into the school] but then I got in, so I came here. But I don't really like this anymore. At first it was a really fun thing and it was a

> social thing but then it became a ‘oh, you got 72 out of 100 for your voice kind of thing.

Charlene also reported how she lost interest in Arts as it is became graded, and then became discouraged and despondent when she could no longer do well in something she was initially passionate about: “[...] because everything turned out to be a failure, it was good enough to pass, not good enough to be proud of”. Charlotte also conveyed the emphasis of assessment in the Arts: “We are under the situation that we create in order to get marks, we don’t have a choice.”

Indeed, this perceived lack of choice directed students into particular coping strategies to preserve their ego as competent artists. They had been taught that art was expression, and that it was problematic to consider one form of expression as necessarily better than another. Yet, in the face of assessment strategies that had to provide for meritocratic discrimination of ‘top student’ versus ‘failure’, they had to distinguish what they were doing as an effort in performing the assessment, or something else which was to be a representation of who they were. In the face of assessment requirements which alienated them from their passions, Edna conveyed how she changed her attitude towards success: “I just try to be confident of myself, it may not be the perfect idea but if you do it the best you can then it can be perfect in its own way”. It can certainly be argued that artistic effort is not merely unconstrained expression; just as with all fields and disciplines, there are discursive norms for which the communities have come to the jointly negotiated, tentative yet durable conclusion that particular canonical forms are more desirable than others. Yet, from the students’ points of view, their perception of this nuanced view was rather more jaundiced; they were definitely in positions which lacked any form of power, and were not offered means to negotiate. For instance, Dale reported: [My] Humanities and Social Science teacher didn’t like my style of writing so I didn’t score well, then I changed my style of writing to suit him”.

Yet, it was not as though they were unsophisticated with regards to risk and failure; these students had enough exposure to art lessons and other messaging so as to internalise the idea that risk and failure was essential to the creative process. Emily also reflected on the necessity of a tenacious disposition which she adopts despite having experienced some setbacks: “In any art [...] you just have to keep trying, you have to constantly try new things, I mean if you want to be groundbreaking.” Eva mentioned that it was important to “roll with the punches if something goes wrong.” Some of their previous teachers seemed to have helped with messaging; Daisy recalled that a teacher once told her that: “[...] grades don’t define you. It is about how you define it for yourself and what you take out of the grades”. Students seemed to perceive school as an environment where opportunities should be provided for them to learn from failure. Darcy shared her opinion that “We can fail a lot of times and now [as] we are still students, if we fail, people won’t scold us, so just do all we can now and learn from it”.

Overall, then, it seemed that they were experiencing some form of mixed messaging. Due to their participation in a strong Arts program, it was clear that they were familiar with the precedent and contributory conditions, as well as the associated dispositions for creative ventures. However, the assessment requirements of schooling privileged certain formalisms over others, such that the students had to quickly learn adapt particular mode of risk and failure orientation to adopt. Unfortunately, as we observed in the CST lessons, it was clear

that the influence of the assessment centric orientation to risk (i.e., don't take risks, don't fail) was non trivial for at least Group C, and spilled over to an activity explicitly demarcated as low stakes in the general scheme of assessment.

Sources of perceptions of failure

Contributory to their perceptions and beliefs about risk and failure were messages from parents, relatives and non-school related significant others. All of them have had experiences of failure, big and small, through which counselling from parents and others were part of the educative process of maturation. For instance, Chris recounted an episode that changed his attitude towards failure:

> There was this one time I had failed a test really badly, it was my [primary school] prelims [preliminary examinations] and I was lying on my table and crying, then I realized there is nothing I can do about it, except to do better next time. I came to the realization and told my parents [about it] and they said 'that's what we have been trying to tell you'.

The Primary School Leaving Examinations (PSLE) are an exceptionally high stakes examination in Singapore, with local parents being known to take up to the year off to coach their children through the examination. Taken at the end of grade six, the results of these examinations determine the academic tracking and school placement of students. As such, primary schools have preliminary, practice exams prior to the state mandated event, often set at a higher standard to manage parents' and students' expectations. The fact that Chris felt bad enough about the failure to "lie on the table and cry" indicates the immense pressure he must have felt at almost failing the important PSLE.

Indeed, without much prompting from us, students referred to the PSLE as a significant milestone that taught them social messages of how to orient themselves towards failure. Dale recalled an episode that she remembered from grade one:

> Our education system sees failure such that once you fail you will not be able to get up again. [Being a] failure is like [being an] an outcast, once you fail you are out. [I was] interested in the Fine Arts but people say no, you need to focus and think of your PSLE in six years. "We want you to have a good score; [and to] go to a good school."

Daisy reflected that "Singapore is about meritocracy. In Singapore people emphasize success; they think that success is the way, they don't think that failures can lead to success." In a way similar to the mixed messaging found above, on the one hand, parents were generously providing coping strategies for the instances when students failed. On the other hand, these students could hardly be termed as failures, to have made it to the very competitive Hillside Secondary. In this sense, it is clear that students have enough ability, had internalised the social logic of meritocracy, and accepted the calculus of the importance of good grades and an avoidance of failure in the zero sum game of school. While we cannot conclusively claim that this perspective on failure also spills over to all other fields, it is hard to imagine it having a trivial effect, since student identities form such a prominent part of their self identity especially in the Singaporean context where there is precious little outside of school to develop alternative identities of.

Discussion

It is interesting to learn that these students possess fairly nuanced, yet somewhat contradictory relationships to failure. Perhaps unsurprisingly, these students report having been conditioned by authority figures to avoid failure as threats to their identities as successful individuals. In credentialed societies where flawless performance after flawless performance is seen as key to success, it is doubtless that students will have complicated relationships to failure, especially for students in Arts and humanities programs where the often subjective interpretations of quality implies that it can be harder to maintain consistency. While the projects that the students proposed and implemented can be counted as fairly creative in their approach, we are reminded that describing artists and designers as creative is faint praise verging on sarcasm (Currie, 2014); the bigger question is the degree to which these creative efforts could have been improved, and what may have been obstacles to their doing so. Our interviews with Alex and Bob recounted their many frustrations trying to motivate the students to try something new and to independently learn about the technologies without teacher support; it had seemed to them that the students needed continuous direction and encouragement in order to simply move their projects along.

Despite teachers' encouragement to take risks, to open up the space for students to fail safely, and students' already acquired intellectual knowledge of the importance of failure, it was obvious from this case that deep seated dispositional attitudes towards failure can hinder this form of an exercise in innovation. It may be fair to propose that one contributory cause of this state of affairs has been the students' overly full work schedules--they did report that, as compared to other activities assigned by their teachers, the relatively infrequent (once a week) demands of the project and relative lack of consequences for not producing work made it such that they lowered prioritisation for it.

All of these factors give us pause to reconsider the means through which innovation can be nurtured in school settings, as part of a formal approach. If schools were to signal its importance to students via traditional messaging of grades, the stress associated with students wanting to do well will likely channel them into 'safe' projects which have been known to do well in the past. On the other hand, if schools were to reduce the stress levels associated with the innovation project, with a mind towards encouraging students to initiate projects which appeal to their own creative desires, as with this project, teachers run the risk of students deciding that any reward may not be worth the effort. Of course, this analysis can be faulted for unnecessarily presuming students' behaviourist orientation towards school activity, but especially for schools systems strongly engaged in high stakes accountability regimes, it is hard to see what other forms of social organisation will result. Here, it almost feels intellectually lethargic to point to the well-used Foucaultian theory of how organisations discipline the kinds of individuals they desire, consciously or in contradiction to stated goals (Foucault, 1977). In the final analysis, innovativeness as a desirable outcome of schooling is an admirable goal for any school system to undertake. However, unlike the acquisition of particular fairly unproblematic knowledges such as statistics or gravitational theory (for instance), instruction in innovativeness needs to be seen as similar to the teaching of biological evolution, deeply intertwined with students' (and their parents') subjective valuing of the importance of schooling as opposed to other goals, and therefore an interesting problem to further study.

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Figure 1. Scale model of the project for Group 1: an LED strip light is controlled by an Arduino microcontroller with their custom program.

Figure 2. Daisy showing off a mock-up of the project for Group 2. A pedestrian walkway will be interrupted by a sensor laden framework.

Figure 3. Breakfast jam session organised by Group 3. Audience members were not students of the CST course.