

A QUALITATIVE INVESTIGATION OF IDEATION PRACTICES IN ENGINEERING AND PRODUCT DESIGN

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Abstract

We use semi-structured interviews to examine ideation practices from a more comprehensive perspective, with the objectives: 1) to further explore the variety of activities that serve as catalysts for creative ideation in engineering design projects, 2) to examine the qualities and attributes of these activities and the context in which they take place, and 3) to discern principles which may underlie the usefulness of various activities for creative ideation. This study builds upon our previous work, increasing the number of interview participants from 7 to 20, and extending the pool of participants to include design instructors and industry practitioners as well as students.

We identified 190 activities described by participants as reflective practices for ideation, and eleven characteristic traits, or attributes, frequently associated with these activities. Some notable trends emerged, such as the frequent mention of activities allowing mental disengagement, activities involving social interaction, and activities involving physical exercise. This paper presents the results of this extended study, and suggests principles underlying successful ideation strategies employed by many designers.

Keywords: Ideation, Creativity, Reflective practice, Design methods, Human behaviour in design

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1 INTRODUCTION

In both academic research and industrial practice, ideation in design is primarily studied and promoted within the context of targeted work activities such as brainstorming, morphological analysis, TRIZ, etc. Researchers and educators often limit their studies to time and activities falling within the traditional work day and workplace, and fail to consider the broader context in which ideation occurs (Lamm & Trommsdorff, 1973, Jablin & Schibold, 1978, Ogot & Okudan, 2007, Hernandez, Schmidt & Okudan, 2013, Shah, Smith & Vargas-Hernandez, 2003). Some research has shown, however, that designers and creative practitioners often get their great ideas in the shower, while driving to work, and during other non-work-related activities (Murth, Currano, Steinert & Leifer, 2011, Currano & Steinert, 2012). These studies inspire our current research.

It is not immediately apparent how to rigorously study the context and setting in which new ideas emerge in design. Typical laboratory studies, even those which look at designers performing real-life design tasks, may not give rise to any particularly interesting or novel ideas. (Furthermore, new ideas that do arise cannot be verified in a reasonably short-term study for their usefulness and success in meeting the design challenge.) Additionally, and perhaps more importantly, the reliability of laboratory experiments depends on the researcher's ability to control and measure relevant variables, but in this case the vast majority of variables is unknown, and the pool of potentially relevant variables is virtually limitless.

In studying the emergence of new ideas, other researchers have used various methods which include: 1) focusing on a particular (already accepted) practice, such as brainstorming (Lamm & Trommsdorff, 1973, Jablina & Schibold, 1978); 2) measuring limited phenomena, such as idea counts (Reinig, Briggs & Nunamaker, 2007); and 3) using semi-objective measures and/or expert judges' opinions to evaluate or compare the ideas produced. These methods are useful in assessing the effectiveness of small numbers of pre-defined practices, but are not designed to bring to light new methods of ideation, nor to identify and evaluate the broad range of underlying factors contributing to their success.

Other researchers have approached the study of creativity and ideation by evaluating creative performance on discrete problem solving tasks (Ritter, van Baaren & Dijksterhuis, 2011, Liikkanen *et al.*, 2011), typically in laboratory settings (Ritter, van Baaren & Dijksterhuis, 2011, Akin & Akin, 1996). Such an approach reflects Simon's perspective of design as a subset of problem solving, often with a focus on solving complex or wicked problems (Ritter, van Baaren, and Dijksterhuis (2011), Buchanan, 1992). This approach is also dominant in Psychology and Cognitive Science studies examining potential mechanisms behind creative and insight thinking (Segal, 2004). Other studies, smaller in scope, focus on behaviors or outcomes of complex open-ended design tasks (Dorst, K., & Cross, 2001). It can be difficult, however, to evaluate ideation techniques focused on insights and "aha!" moments in a short-term laboratory study, as there is no guarantee that during any given time participants will gain a significant insight. Some studies use interviews to analyse creativity and ideation more comprehensively, post-facto, and with smaller sample sizes. Murty (2006) examined creative insight both theoretically and contextually, through 45 in-depth interviews with primarily experienced architects. For nearly all participants, he found that insightful activity was involved in their conceptual design process, and for many, their insights and discoveries came while not engaged in the work of designing. The current study likewise examines creative insight, among primarily engineering designers and instructors, through 20 semi-structured interviews. Our aim was to qualitatively explore reflective ideation practices that accompany creative insight on primarily small-scale self-selected and industry-sponsored engineering design projects, with a particular focus on practices that happen while not engaged in standard design tasks.

1.1 Research Perspective

In our effort to study contextually the broad phenomenon of reflective practice in design, we have adopted the perspective initially developed by Donald Schön (1983), through his studies of architectural design, and described in his book *The Reflective Practitioner*. Schön questioned the prevailing perspective, adopted/exemplified by Herbert Simon's theory of design as rational problem solving, opting instead to view design through a more holistic lens of reflective practice. We find Schön's perspective helpful in characterizing the mode of work that designers employ, which enables them to go beyond analytical reasoning and to create new things.

1.2 Objectives

Currano, Steinert & Leifer (2011) introduced the term “reflection-out-of-action” to further distinguish the nuances of designers’ ideation practices, in particular, to call out the distinction between the relatively small body of accepted and encouraged practice from the largely ignored but clearly important array of non-standard sources of creative ideation. Currano & Steinert (2012) then continued this work and expanded on the concept of reflection-out-of-action, demonstrating preliminary evidence that student designers draw from a broad array of activities in generating new ideas, and that they identify them at various points along the spectrum from in-action to out-of-action. The current study expands on these prior findings through a larger dataset and a broader participant base, and introduces some principles that may underlie successful out-of-action ideation strategies.

The current study has three primary objectives: 1) to further investigate/verify the applicability of “in-action”/“out-of-action” and other distinctions in describing the range of reflective practices that assist creative ideation, and 2) to explore the range of designers’ reflective ideation practices in greater detail, and 3) to discern principles of successful ideation strategies that may contribute to hypothesis of “reflection-out-of-action”.

2 METHODOLOGY

2.1 Interview Structure

We conducted semi-structured interviews with individual design students, design professors or instructors, and product/service design industry professionals. Because our goal was largely exploratory in nature, we crafted the interview questions to elicit stories from participants about their reflective practices. Participants were first asked to illustrate their design processes, and then to describe the activities they use in getting new ideas or insights. This prompted them to recall specific examples of ideas and the reflective practices that led to them, and helped us to see more clearly the context in which they occurred.

We began each interview by introducing reflective practice as our topic of study, and defining it as “*an activity that you engage in which helps you to think through design situations and leads you to new insights or ideas.*” To clarify, we added that “some examples might be: sketching, going for a walk, making a mindmap, making analogies, baking, etc. These could be within your work or outside of your work.”

We then asked the participants to *tell us about a specific design project* they’ve done, and to *describe the design process they used* (or the process which they teach their students to use, in the case of professors and instructors) and to sketch it or write it out on paper. The majority of the time we spent with them centered on this question.

After this, we restated the definition of reflective practice, and asked them to *identify where in their process (or outside of the process) their reflective practices were occurring*. Lastly, we asked them to step back from that specific project and process, and to *comment, in general, on what other reflective practices they have used, which help them come up with new ideas*.

2.2 Participants

Twenty individuals participated in the current study, including eleven students, seven academic instructors, and two industry professionals who concurrently teach part time. We intentionally recruited participants at various levels (undergraduate and graduate students, university lecturers and tenured professors, and industry professionals with varying years of experience), as shown in Table 1.

2.3 Miscellaneous

Interview times varied between 16 and 64 minutes, with an average of 29 minutes, determined primarily by how much each participant chose to say in response to our questions. Each interview was video-recorded, fully transcribed, and coded according to topics of discussion, including process descriptions, reflective practices used, specific design project details, and ideas/insights mentioned.

Table 1. Attributes of participants' reflective practices and corresponding frequency of occurrence in the data.

Participant Category	Occupation status/level	Area of Study/ Employment	Number of participants
Students:	Undergraduate	Mechanical Engineering	2
	Undergraduate	Engineering - Product Design	2
	Masters	Mechanical Engineering	4
	Masters	Engineering - Product Design	3
Instructors:	Tenured Professor	Mechanical Engineering	4
	Tenured Professor	Computer Science - HCI	1
	Senior Lecturer	Mechanical Engineering	1
	Professor	Mechanical Engineering - Design	1
Industry Professionals:	Company Founder & Consulting Assistant Professor	Mechanical Engineering - Design	2
Total:			20

3 ANALYSIS AND FINDINGS

3.1 Initial Coding

The rich nature of the data and the correspondingly small number of participants interviewed warranted a primarily qualitative approach in analyzing the data. We generated a preliminary list of general discussion topics from the interview questions, and assigned two researchers to review and code each of these interviews sentence-by-sentence, according to topic. During this initial round of coding, we expanded the list as new topics relevant to ideation were identified. Two researchers then coded the full set of interviews, reviewing cases of uncertainty in consensus, refining the list to clarify topics, which had caused confusion during coding, and eliminating those, which occurred infrequently or were deemed to be less important to our study. The final list consisted of the following four topics: general process description, mention of reflective practice, details about particular design projects, and references to specific ideas gotten.

3.2 Identifying Reflective Practices

From the sections describing reflective practices, we compiled a comprehensive list of reflective practices mentioned by all participants. In total, we counted 190 reflective practices mentioned throughout all of the interviews. Of those mentioned by professors and instructors, some referred to activities that they observe or encourage in their students, and others referred to activities that they themselves engage in.

3.3 Characterizing Reflective Practice Attributes

From the reflective practice descriptions, we also expanded upon the preliminary list of reflective practice characteristic traits identified by Currano, Steinert & Leifer (2011). From the expanded list, we found that eleven in particular were frequently mentioned or implied from participants' descriptions.

Two researchers (one not from among the original group) coded the full set of identified reflective practices according to these eleven characteristics in two rounds. They first coded individually, compared differences and clarified meanings and definitions, and used consensus coding in the final round. Most of the initial differences were due to mis-readings of the interview comments, lack of clarity in the initial coding rubric, or just accidental omissions. The majority of these differences were easily eliminated upon the final round of coding. Six of the eleven (highlighted in table 2) were found to apply to 20 or more of the reflective practices mentioned (four of these applied to 40 or more). We focus on the six most common in this paper. (Note: frequencies such as 6.5 and 22.5, etc. indicate a small number of instances where the coders did not reach consensus in the final coding round.)

Table 2. Attributes of participants' reflective practices and corresponding frequency of occurrence in the data.

Attributes of Participants' Reflective Practices	Frequency of Occurrence
Mindless (involving mindless activity)	40
Mindless (not consciously thinking during the activity)	6.5
Involving physical exercise	20
Involving prototyping or 'getting tangible'	22.5
Involving Transportation	11
Break activities	8
Occurring in transition between activities	9
Involving social interaction	55
Involving changing one's environment	12.5
Occurring In-action	107
Occurring Out-of-action	81

Note that the term *Mindless*, does not mean that the participants are not thinking at all, which would be virtually impossible, but rather refers to the way in which they perform the activities, or the way in which they engage their minds during the activities. We settled on this word after several participants used it in describing their reflective practices.

Several quotes from participants' descriptions emphasize this attribute characteristic:

"When I play water polo Tuesdays and Thursdays – I don't think of any ideas because I'm so engaged in the game. It seems like more mindless exercise would be [preferable], like when you're on the bike..."

"Well doodling is yeah 100%... mindless"

"It's kind of in the back of my mind and as I'm in transit or... doing something that doesn't really require focused thinking on it - that's when it'll kind of "oh yeah this sounds kind of cool" and then [I] kind of start day dreaming about it."

"You need to not be doing anything too mentally taxing, at the time."

"I don't have to focus on anything except what I want to think about. And if I want to think about nothing, that's possible too. And, like sometimes ideas sort of creep into my mind when I'm in the rhythm of running"

"sometimes not thinking [is my reflective practice]"

Of the six most commonly occurring attributes, three are well-recognized in the field: *involving prototyping or 'getting tangible'*, *involving social interaction*, and *occurring in-action*. The remaining three, however, (*involving mindless activity*, *occurring out-of-action*, and *involving physical exercise*)

remain at odds with conventional accepted design practice. This contrast contributes to our development of a hypothesis of reflection in action, in particular, as the well-recognized three correspond closely to our notion of reflection-in-action, while the remaining three relate well to our concept of reflection-out-of-action.

The rubric for coding each attribute, was developed through reviewing the data over several iterations. Some, like *involving physical exercise* were fairly simple to code, and always included clear mention of physical activities such as running, walking, biking, going to the gym, or “taking a lap”. Practices *involving social interaction* were typically easy to distinguish by participants’ mention of talking, conversation, and meeting with others vs. being alone, which often came up explicitly as a natural part of the description. Likewise, practices *involving prototyping or ‘getting tangible’*, those *occurring in-action*, and those *occurring out-of-action*, could be coded with relatively high confidence due to participants’ rich descriptions in the data. Individual practices might now and then prove difficult to code for these attributes, if for example, a participant mentioned it only vaguely, or if there are multiple modes in which a given practice may be used.

Others, including *break activities*, or those *involving changing one’s environment*, proved more problematic, as they represent possible elements of many *out-of-action* practices, but were not always explicitly commented on. In these cases, we included them when they were either stated directly or implied, and excluded them when there was not enough evidence to conclude one way or the other.

While most of the above attributes are straightforward, and require no further definition, a few represent developing constructs and require further explanation:

Occurring in-action, for example, refers to practices that happen in the context of work, primarily with respect to the nature of the activity being performed, (brainstorming vs. going for a walk), but also with respect to the participant’s relationship with others involved (teammates vs. friends and family), and to the time and place in which they occurred (being in the shop, waiting for something vs. laying in bed). This rule does include some exceptions, however: a practice such as brainstorming done with a friend primarily for fun, while driving to get boba tea, would be considered out-of-action. On the other hand, biking around campus to do needfinding for a project on students’ biking experience would be considered in-action.

Our rubric underlying the coding of in-action and out-of-action, therefore, reflects that they do not stand alone as independent attributes, but instead represent combinations of other attributes. This reflects societal norms which tend to constrain the assignment of productive value to work-type tasks done in the work context, as defined by a particular time, location, and/or social setting (i.e., at the office, from 9am-5pm, while alone or with colleagues). Descriptions and accounts from our data demonstrate the importance of activities removed from the workplace and work time, in coming up with new ideas for design projects.

3.4 Grouping Reflective Practice by Type

Additionally, we observed trends in how frequently similar activities were mentioned, and grouped similar activities according to type, as shown in Figure 1.

Many practices fall naturally within clearly defined categories, such as Explicit ideation methods, which includes tasks like brainstorming, benchmarking, and needfinding, or General recreational activities, which includes activities like exercising, gardening, and joining an extracurricular group.

Some groupings, such as Relaxed Attention Activities or Conversations, represent activities that may fall into one of two or three broad categories of practice. Examples may be conversations with colleagues vs. conversations with friends. Blended work and non-work activities represents individual activities that contain both work-related and non-work-related facets. In this case, the primary example is online research, which one participant describes as both “research online” and “procrastinating online”, and which another participant describes as “web searches” and “surfing online”. Their choice of descriptions denotes that they considered this practice a mix of work and non-work.

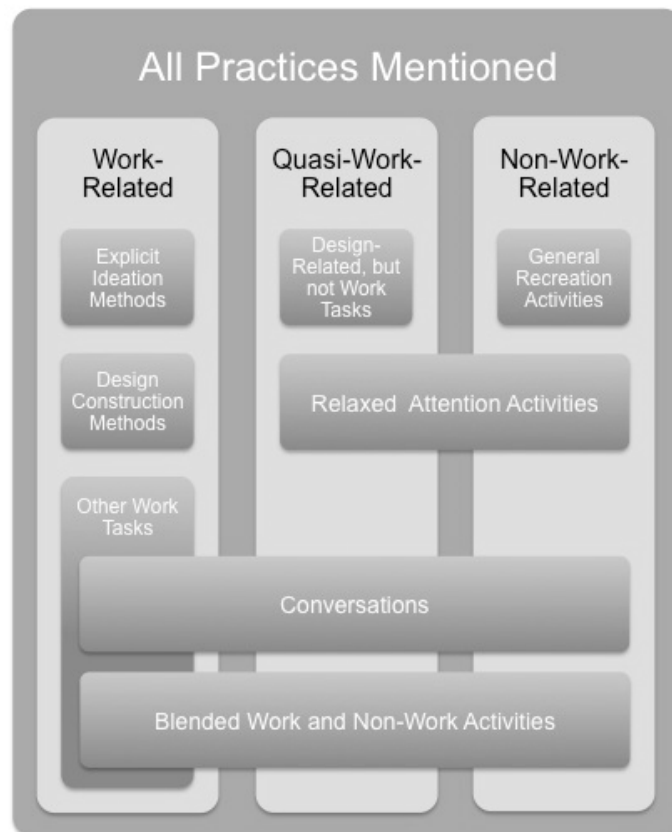


Figure 1. Grouping of Similar Reflective Practices by Type

4 DISCUSSION

Through our previous work, we postulated that reflection-out-of-action is an important source of creative ideas for designers. The current study provides further evidence to support this, and the rich interview data from designers, both student and instructor, offers insight into potential principles at work. We offer five possible principles that may underlie the effectiveness of various reflective practices for creative ideation:

1. **Relaxed Attention:** Incorporating an element of relaxation, and an element of attentiveness can help designers become more fluent ideators. Participants cited random “aha” moments, being inspired by things around them, whether nature or manmade objects, and emphasized the role of serendipity in their ideation practices. One participant, a professor and industry professional, and founder of a well-known design firm, coined the term ‘Relaxed Attention’, citing it as one of his primary reflective practices. He articulated it as: “a place where your mind’s active and you’re consciously thinking and so forth, not on that particular problem exactly... And I want it to be more free flow... my intuitive mind is doing the work, not my rational mind.” Another participant stated, “I’m listening to a lecture on something unrelated... this was just me, kind of in that, flow-state but still, at least I think I was still pretty attentive to what [the lecturer] was saying.” And another stated, “Because, because you’re kind of in a relaxed enough state [while driving], and I often listen to the radio, so I’m often hearing something different, and then it just allows you to kind of take that thing that you heard, and relate it to something else you’re thinking about” In total, participants described over 30 reflective practices that suggest a state of relaxed attention.
2. **Going beyond traditional work activities:** Allowing and appreciating the value of mental disengagement and out-of-action activities can be an important factor in designers ability to think of new ideas. Engaging in activities that don’t require mental engagement frees up the mind to ruminate on other things, and to form associations that lead to new ideas. The above principle of relaxed attention illuminates how these kinds of activities may operate as sources of reflective practice.

3. Incubation and moments of transition: Another professor/industry professional, and founder of another leading design firm, emphasized the moments of transition between activities, and the accompanying loading and unloading, or switching between different types of activities, as more important than the activities themselves. Other participants called out practices, which follow this pattern of transitioning and loading-unloading. Examples include “changing your environment (when you get stuck)”, taking a break, and “walking from the building to my bike. Somehow like that stretch of time is actually kind of good for thinking cause it’s kind of a transition period. So I’m not doing anything, but I’m not too worried about where-, I’m not exactly going anywhere yet either... I just finished doing something and I haven’t quite started going somewhere else.” We see these transitions as micro-incubation times. The value of breaks, and recreational types of activities mentioned cannot be divorced from hard work. Many researchers suggest that the time away from work is valuable precisely because it allows incubation or sub-conscious mental processing necessary to reap the benefits of the work time (Shah, *et al.*, 2003).
4. Incorporating a repertoire of different practices provides a more productive ideation strategy than looking for the one most effective practice. Our data shows that designers use a broad array of reflective practices, and that practices routinely encouraged and touted as highly effective, while mentioned often, were less emphasized in comparison to other, non-standard practices. In the words of one participant “Any time you introduce something new: brainstorming, let’s do some brainstorming - woah! Results are much much better...[but] when you then take a class through this process suddenly stuff doesn’t work so well. The results don’t look so good. They feel stymied”
5. Achieving a kind of healthy blur between work and life: This principle is supported as well by the principle of relaxed attention and the principle of going beyond traditional work activities. Over 40% of the reflective practices mentioned by participants fall under the attribute *occurring out of action*. These practices happen while doing various non-work activities. One participant emphasized, in commenting on the tendency to divorce work from the rest of life, “It’s like this false choice between what you do with your work and what you do with your life... There’s no difference between what happens at work and away from work. You know it’s all part of what’s going on in your, in your head” Another participant remarked, “you can get ideas from anywhere... In some sense the sign of a good designer is that it’s chronic and they can’t turn it off. That there’s sort of some part of the back of the mind is always thinking about ways to do things.”

5 CONCLUSION

Our research provides evidence that designers of various levels employ and encourage a broad variety of practices in coming up with new ideas for design projects. These include both traditional work tasks such as brainstorming and needfinding, but also a nearly equal number of activities that would not be considered ‘working’, including going for walks, and having conversations with friends and family.

Detailed analysis of the data revealed twelve characteristic traits, or attributes, applicable to many of the activities described by participants. Participants’ descriptions and accounts demonstrate the importance of activities removed from the workplace and work time, in coming up with new ideas for design projects. More prevalent attributes include *involving prototyping*, and *involving social interaction*, as in conversations with friends and colleagues, and. Other surprising trends also emerged, such as *mindless* activities (activities allowing mental disengagement), and *involving physical exercise*, as in going to the gym or riding bikes to and from class. Lastly, the rich stories and descriptions provided by participants provided a means to draw out a set of principles underlying designers’ successfully ideation strategies.

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