Design Method Adoption in Industry as Uncovered Using Semi-Structured Interviews

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Abstract
Engineering design education frequently focuses on the methods and tools that enable and enhance product creation. These tools range from individual and group ideation techniques to innovation portfolio management for organizations and originate from a diversity of consulting, academic, and industrial sources. The factors that drive the adoption, use, and ongoing success of these tools are not well understood and are likely driven by a complex interaction of human, organizational, and economic factors. This paper investigates innovation method and tool adoption in industry through semi-structured interviews with individuals from a Fortune 500 company. This work explores three resulting themes 1) individual incentives and motivation for adoption, (2) the appropriateness of tool selection for the organizational product domain and compatibility with existing processes, and (3) executive and management support for adoption. The implications for engineering education are also discussed.
Keywords: *Innovation, New Product Development, Design Methods, Method Adoption*

Introduction

This work investigates the adoption of design methods in industry through semi-structured interviews with individuals from large R&D organizations such as Fortune 500 companies. The interviews seek to understand how industrial organizations collectively select and implement methods, the catalysts and barriers to method adoption, and how organizations evaluate design methods. The research interviews encourage participants to reflect on their experiences using the methods, asking them to recount what went well, what went poorly, and their thoughts on their experience. To gain proper breadth when understanding this adoption problem, interviews are aimed at a spectrum of users, from individual practitioners to middle management and executives. Additionally, the research team addresses potential academic-industrial language barriers through the incorporation of industry and academia experts among the team of interviewers. An open coding approach is used to allow for the coding of a wide range of ideas and concepts. This work discusses the interview and coding methods used in this research, the results of the interviews conducted with one company, and the implications for design method instruction and adoption.

Background

Our goal is to understand how and why industrial design organizations adopt innovation methods for new product development (NPD) and to identify and transfer best practices for NPD method adoption to academic and innovation communities. To continue to address critical societal challenges, not only must we develop new and better methods and tools for innovation, but we must also see them adopted by key innovation drivers. While researchers continue to create new design methods with great potential, they generally have had little impact on industry [1-4]. Industry leaders and executives focus on best practices at the levels of strategy, market research, portfolio management, people, and processes such as stage-gate and Agile [5], with process improvement typically focused on developing criteria and tools to support go-no-go, gate-based decision-making at the management level [6]. Historically, specific tool and method use for idea generation has been relatively low priority, usually with limited penetration in an organization, though with considerable variability across organizations [7].

The lack of adoption of design methods is significant, with multiple researchers noting the plethora of methods developed with limited impact to industry [2, 8-10]. Several papers identify challenges with industry adoption, but most base themselves on the author's experience with industry or a very limited number of organizations [4, 8, 9]. Jastrzembski et al., (2021) reviewed over 500 examples of biologically inspired design (BID), demonstrating that many innovations occur based on BID [11], but this provides little information about the adoption of the approach within those organizations.

The application of qualitative, phenomenological research allows for an understanding of the experiences of individual practitioners, managers, and executives as they interact with tools, methods, and processes for design [12, 13]. Semi-structured interviews are particularly useful for exploring experiences related to poorly understood topics [14], such as catalysts and barriers for adopting novel techniques within R&D organizations. This approach also allows for the construction of data sets without the need for pre-existing theory or a priori hypotheses, therefore permitting the discovery of unexpected insights and causal factors.

Methods

Semi-structured interviews were conducted with individuals at participating organizations to seek answers to the research questions [12]. Because organization size influences the behavior and diffusion of innovation adoption [15], this research project focused on trends within Fortune 500 companies. Within the companies, interviews were conducted with individuals of all levels involved in the design and development of new products. These included personnel ranging from design engineers to directors and vice presidents.

The interviews were conducted by a mechanical engineering professor who was assisted by a senior research scientist and a Ph.D. student, all co-authors on this paper. The professor was able to maintain control of the interview and ensure that all pertinent questions were answered, the research scientist made use of their industry experience to navigate the academic-industry culture boundary, and the Ph.D. student documented acronyms and ensured consistency between interviews. The semi-structured interview format allowed the interviewers to further investigate topics of interest while using pre-written questions to ensure that all necessary discussion points were reached [13]. An example of a question used: "Can you describe a time when there was a new innovation method or tool was attempted?"

Interviews with individual practitioners and managers lasted for one hour, while interviews with executives were limited to only a half-hour to respect their time and increase their willingness to participate. Zoom telecommunications software was used to conduct interviews for ease of scheduling and to permit recording. Interviews were transcribed using Rev, an online transcription service. After the transcriptions were received, they were checked for accuracy and de-identified to remove any information that could be used to identify the participants or participating organizations.

Transcripts analysis was conducted using NVivo [16]. An Initial Coding approach, also called Open Coding [17], was used to create the code book. This approach was used because the research team did not have established theories to address their research questions, and this

method would result in a large quantity of data that would lay the groundwork for later theory development [13]. Before coding began, a code structure was created by assigning parent codes to match the research goals of identifying how design methods are selected, how design methods are rolled-out, what acts as catalysts or barriers to adoption, and how to evaluate the use of design methods. For greater ease of coding, catalysts and barriers were separated into two separate parent codes, while the other research goals were given their own parent codes. Additional parent codes were created to track observed company traits, such as customer focus or sustainability, and specific design tools, such as Six-Sigma or Design Thinking. As transcripts were analyzed, more codes were created under each parent category to match observations and sentiments from the participants. Coding was conducted by the mechanical engineering Ph.D. student and was repeatedly discussed with the rest of the research team. This paper presents the initial results of the first cycle of coding.

Participants

This work contains analysis of interviews from a multi-national, consumer packaged goods company. Five of the participants identified as female and five identified as male. One participant had been with the company for one to five years, three had been with the company for six to ten years, and six employees had been with the company for more than ten years. Five participants reported ages between 35 to 44, four participants reported ages between 45 and 54, and one participant reported an age between 55 and 64. Lastly, two participants had bachelor's degrees or equivalent, five had master's degrees or equivalent, and three had doctorate degrees or equivalent. Four interviews were conducted with individual practitioners, three interviews were conducted with managers, and three interviews were conducted with executives for a total of ten interviews.

Data

Interviews with individual practitioners and two of the three managers lasted for one hour while the executive interviews and one manager interview were half an hour in length. The interviews resulted in 167 pages of transcript data after de-identifying and cleaning. After analysis, a total of 1,181 coded references, that is, text assigned one or more codes, to the ten transcripts were made. See Table 1 for a breakdown of references per parent code.

Table 1. Number of references per parent code

Parent Code	Reference Count	Percentage of total References
Selection of new methods	93	7.9%
Process of Adoption	220	18.6%
Catalysts to Adoption	385	32.6%
Barriers to Adoption	237	20.1%
Evaluation of use	42	3.6%
Company Traits	50	4.2%
Specific Methods	154	13.0%
Total	1181	100%

Themes

The codes and associated quotes were clustered into associated themes, also referred to as categories in other areas of research. For this analysis only codes related to catalysts and barriers were considered. All other codes were removed. Codes were then sorted by frequency, and more frequently occurring codes were analyzed and combined into categories based on perceived similarity. For instance, the codes “individuals experience benefit from use” and “well aligned with individuals” were both grouped into a "motivations for individuals to adopt new tools" theme. Less frequently occurring codes were then considered, usually grouped into an existing category, though clusters of less frequently occurring codes may develop into their own category, as the frequency of observation does not necessarily indicate significance [17]. The entire research team participated in iterative theme development until the themes for catalysts and barriers were agreed upon.

Analysis and Discussion

The adoption of any new innovation is a complex, interrelated system of incentives, motivations, experience, training, domain, and economics, to name a few factors, no one of which can be considered “the critical success factor” [18]. Rather it is the interaction among factors that result in adoption or rejection. This paper focused on themes associated with catalysts and barriers to adoption. Within the catalysts and barriers parent codes, our analysis found clusters of interrelated comments thematic with (1) individual incentives and motivation for adoption, (2) the appropriateness of tool selection for the organizational product domain and compatibility with existing processes, and (3) explicit and implicit executive and management support. In the following three sections we provide an analysis and discussion supported by sample comments with respect to these three themes.

Theme 1: Would this help me do my job? Individual Incentives and Motivation for Adoption.

The first theme identified was that scientists and engineers adopt design methods that help them do their jobs. Individual practitioners are the ones that will be using the method most regularly, and it was seen that adoption occurs more easily if the individuals can see the usefulness of the tool at an individual or organizational level, if they understand how the tool works, and if they are personally interested in the tool. While discussing how to implement a new tool, one participant highlighted the importance of individuals experiencing positive benefits from tool use.

> *People have to experience it in a way that they understand that "This is actually helping me to do my job more effectively, more efficiently, and I'm being rewarded for it," whether that's financial reward or a pat on the back that says, "You're awesome."*

While the benefits of each method vary, reducing the time spent on a task and using fewer resources were prominent among individuals. The previous quote alluded to participants experiencing benefits themselves through firsthand use, but that was not always seen to be necessary. Other participants emphasized that showing potential benefits through training also helps them adopt new design methods.

> *[What] helped support the adoption was probably some of the commentary that we [added] to the training, like, really bringing to life the tension this is solving for us in the context of the people who are going to have to do it.*

Additionally, while discussing positive experiences with previous design tools, multiple participants mentioned that they used the tool because they liked it. Sentiments like “*to me, that kind of mental approach makes sense*” and “*I am somewhat intrigued and enjoy processes and*

methods" reveal the potential benefits of introducing design methods that resonate with employees or engage their curiosity.

The observed benefits of improving efficiency and resolving tensions are contrasted against quotes about methods slowing people down or causing extra work with no perceived upside. In discussing a push to use a documentation-heavy method, a participant expressed the tension between delivering work products and method overhead.

> *Some people, a lot of people, realize that we don't have all the people to do all the work that we need to do. The tension that people feel is between, "Well, I could deliver what's needed, today, or I could document it."*

If engineers have conflicting perceptions of how a design method benefits them or the company, using it may feel like a waste of time. This position was echoed by a participant remarking on the introduction of a design tool that formalized one of their existing processes.

> *"Well, my argument to them would be, I'm already doing that. Why do I have to put it in this format?" Unless there is a clear reason why you have to do it and that it's detrimental to the work, you're going to have a hard time getting people on board with some of these design tools.*

It was observed that if the perception of the intended purpose and benefits of a tool was different from or conflicted with the goals of management or leadership for that tool, the adoption of that tool could face resistance. Situations where there was a mismatch in perception typically resulted in practitioners seeing the use of the method as a repetition of work that produced no extra value. It was also seen that this conflict could lead to the application of methods in ways that actively worked against company interests. One example of this was seen in an application of Technology Readiness Levels (TRL) [19] for product development.

> *I think the downside of it had been, it created a metric, right, for people. Everyone would write in their performance review, "Oh, I'll get from TRL whatever to whatever," and then I think that led to kind of falsely progressing things to the next level. But then also, it created a little bit of a dysfunctional motivation in that actually, in the front end, sometimes you shouldn't progress it, sometimes you should kill it. Right? You should end it and move on to the next thing.*

Some practitioners saw TRL as an incentivized milestone that could conflict with an unbiased assessment of product feasibility. When considered in isolation, the tool allowed the company to appropriately allocate resources based on technical product viability. However, when coupled with incentives, it created an unforeseen conflict leading to potentially biased results.

Individuals affinity for a tool was linked to the time and effort they were willing to invest, an important factor in early adoption. Participants remarked about the benefits of early adopters as examples for their co-workers to follow. One participant who self-identified as a "spearhead" for a new tool explained the importance of peer-advocates as leaders for change and not just examples.

> *I can do all the training that I want to make sure everyone knows it, but if I don't start being the one driving us to use these new tools and being the one to set up the new cadence of meetings and utilizing the method, I became, in my team that I'm on, became the spearhead to prove it out and start showing that we're acting differently and we're not just saying we're going to do stuff differently.*

They further explained the value of peer-advocates conveying their enthusiasm for new methods.

> *People are going to [not be] bought in, but if it's someone they trust and that person seems super bought into it and [that] this is going to unlock something we haven't been able to do yet, I think it's going to change the perception of how people respond to the new methods.*

Peer-leadership was seen as a powerful motivator to encourage hesitant co-workers to experience the benefits of the new method and encourage adoption. An executive explicitly named these early adopters or "champions" as a catalyst for method adoption.

> *[A] catalyst would be related to certainly having some level of organizational buy-in. Having not just a leader say, "Hey, we want to use this," but [also] have individuals within our teams who are somewhat being champions for doing this effort.*

Theme 2: Does this work well with my organization's products and processes? Appropriateness of tool selection for the organizational product domain and compatibility with existing processes

The second theme identified was that design method adoption is dependent on the extent to which it is designed to work with the existing products and processes of the organization; or alternatively, the extent to which it is effectively adapted to the organization. For example, when the organization introduced Design Thinking, a broadly adopted methodology in customer-focused organizations [20], into their product design pipeline, it was adapted and integrated into their existing design processes.

> *[The new framework] helps a little bit because [it] took the Design Thinking method, and it attached it to our internal gates and checks and balances of how we progress programs through our process.*

Multiple participants viewed tying new design methods and tools into pre-existing systems and processes as an effective way to encourage adoption as it provided an organization-specific context in which the new tools should be applied. Another participant remarked about the utility of the newly introduced TRL system, inspired by NASA [19], in conjunction with their standard research and engineering operations.

> *[We] actually leveraged a nine-step process that NASA uses for technical readiness levels as our inspiration. We then use that to say, what does that look like within our research and engineering function in [division within company]? This is actually one of the times that something has made so much sense.*

Later, the participant mentioned that although they intended to use the TRL system only for within the group, other business units adopted it because the method had "*so much logic to it*" that it became beneficial to use when communicating with leadership regarding decision making. Critical to its adoption, while the TRL approach was inspired by NASA's method, they adapted it to work specifically for their operations. This requirement to adapt methods to fit the needs of the company was further described by another participant.

> *[The] reality is, no matter if you're talking about design thinking or anything else, you have to ultimately adapt a process to meet the needs of the company and the individuals in the company. It's not like a one size fits all. And that's why most people, frankly, particularly in the research and engineering space, don't generally like processes, because they see them as rigid and something that is creating extra paperwork and preventing me from actually doing my job and the fun part of what I came to do every day.*

They also connect the need to adapt design methods back to the first theme, since a tool that is poorly suited for a specific industry may be less useful or superfluous. To this end, methods that

were not adapted could cause unnecessary tension and hinder adoption. One participant explained how Agile, a tool originally designed for software development [21], fit poorly with their work on physical goods.

> *A lot of the stuff is written around software. It's like, all the Agile stuff, it's just not the same when you're making stuff out of steel. The challenge is, management reads these books […] and then they try to implement this stuff rigidly and it's like, "I can't make progress in the amount of time that you want." It's not like, go back, code something, and then come back in a week. You have to engineer things and then do drawings and then fabricate.*

In this example, the method called for the delivery of a revised physical product on a schedule that fit digital goods but did not fit the timelines for prototyping of their physical product. After they adjusted expectations for time scale, the adapted method led to improved results. Other participants experienced or observed similar cases of applying methods that were unsuitable to their context.

> *[A] lot of times the methods get put out there, they spread, and they want everybody to do them, even though it may not fit with the type of work that you actually do, and therefore chaos.*

The emphasis on not fitting the type of work suggests conflicting perspectives on the applicability of methods, where leaders and practitioners may not have the same thoughts over where or how to apply the method. Another participant described how training that was not tailored to their industry segment made them uncertain about the applicability of the method to their work.

> *So I went through the training, it [took] many hours, and they used random examples. And I think that there is an important point when you see things and especially if you are not super on board with the idea and you get random examples, it's really hard to make the click. I remember making an example of an airline. I'm like *gestures in exasperation*. Right? So that is the part where you say, "Yeah, but how [do] I implement those things in my day by day?"*

This further highlights the need to fit the tool, and the training, into the context of use. Alternatively, examples of success, particularly if they came from peers or within the organization, increased their propensity to use the tool.

> *We're always bringing in case studies, just to show that we make it real. […] We have the project team member […] present the case study because we want to make sure we show it's a real project with a real team working behind it.*

Participants discussed that examples of authentic success within the organization encouraged employees to try new methods. External examples and speakers brought in for "*a fresh perspective, new language, [and] a sense of credibility*", were "*always complimented by internal*" projects and examples. Another participant remarked that while both internal and external examples of success are useful, they prefer examples from their organization.

> *Examples from outside, we use more at the inspiration phase, but once we implement something, I think the more examples we have inside, I think it lands a lot better than pointing to Apple or Disney or Netflix or Google, as an example.*

Theme 3: Is it supported by executives and management? Explicit and implicit executive and management support.

The last theme identified was that executive and managerial support of the design method demonstrates the importance of the method to the organization, thereby encouraging adoption. A participating executive explained how they wanted management to support the rollout of Design Thinking.

> *At the end of the day, we wanted them to be championing the use of Design Thinking, so that when they have project teams coming to them, they can start almost expecting it and saying, "So, tell me about the approach. How did you listen to the consumer? Did you go back, and [did] you prototype and bring it back to the consumer?" I think when leadership, or executive leadership expects it and asks about it, that's another way of embedding the mindset.*

This sentiment was echoed by other participating leaders, managers, and individual practitioners that implementation of a method must occur at all levels to ensure that it takes root in company culture. Asking employees for the results of methods and discussing those results appeared to be effective at driving tool use and adoption. If those discussions stop and the tools do not provide immediate value to those using them, tool usage would be expected to decrease, as explained by another participant.

> *[There are] also the people who probably are more motivated by, if my leader is telling me to do it and asking me questions to make sure I did it. It's just a stated accountability. And their focus is going to be, I'm going to do what my boss is asking me to do. For some people, that actually is enough of a why. But if the boss isn't showing up expecting something different, they are not going to change.*

Expectation of the use of certain tools as dictated by leadership was understandably considered a powerful motivator that could prompt usage by even those most resistant to change. Another executive described their point of view on why requiring tool usage is important.

> *You always want to create the compelling reason to believe in the burning platform, so to speak, but you're always going to have people who don't want to do it […] And I think there's times like that where you just have to say, "Look, you got to get on the train. It's heading out [of] the station, and we'd love for you to be on it. And we've done our best to show you the value that it brings. You're just going to have to trust a little bit and take the adventure with us."*

Leadership support also seemed to help communicate the usefulness of tools, especially when the benefits were primarily directed towards the organization rather than towards individuals. When that leadership support was not present, practitioners might ignore the tools or become confused about the intended implementation. One participant expressed their struggle with adopting new tools because they were not receiving direction for their application.

> *[We] have all of these things that you can go onto [like] these websites [where you can] learn all these new amazing tools and tricks, but they kind of just get told to you like, "Hey, there's these new things." And no one truly walked you through how to use it and how to navigate it and how to leverage it and how to make it real in your world.*

In this case, leadership supported the participant by providing access to and resources for the usage of new tools, but there was less support for how to adopt and integrate those tools into their workstream. While individuals might attempt to adopt methods without managerial support, that was perceived to be unlikely with most people as it was thought that "*[people] have a hard time wanting to adopt [new methods] because they have […] developed their own way of doing things*" and that they would not want to change. This led to the sentiment that management needed to require tool use for adoption to occur.

Because in any situation, if you don't push something out and say, "You have to do this," there's a high likelihood, unless it just brings a ton of value through speed or ease, people go, "I'm not doing that, I'm not touching that."

Transfer to Engineering Education

The current results provide many hypotheses about what is needed in engineering classes where faculty teach design methods and tools. In many instances where faculty teach design methods in classrooms we see, and indeed are ourselves guilty of practicing, teaching methods for exposure, divorced from the context in which they are best suited. From the first theme, we can hypothesize that students need to see the clear connection between the methods and tools being taught and how it helps them to be more effective designers, to improve outcomes on the project, and often the prime objective for many students, to improve course grades. Instructors who have attempted to strategically include these connections into a course that also provides many of the other learning objectives common in a design course (e.g., team skills, technical writing, etc.) know the extreme challenges of doing this. From the second theme, we understand that methods need to be compatible with the products and processes of the organization. We hypothesize that for students to adopt the methods taught in the classroom, project selection – the product the students work on – must be compatible with the methods taught and must noticeably advance or improve the design outcomes. Alternatively, if the project is fixed, the methods must be compatible with or adapted to the context of the product being designed. While in most cases, students do not have advanced pre-existing design methods, just as with industry, one must still overcome the tendency to default towards what they have done before or what feels natural. The third theme, executive and management support, translates more abstractly. As with management requiring, attending to, and supporting tool use, we hypothesize that faculty must also require, acknowledge, and attend to the results of the methods themselves in reports and presentations, including providing feedback on the correctness of the methods and the quality of the results obtained. Students should also feel the methods are supported both within their system of work, the classroom, and externally, such that they recognize these methods will translate to future work.

Conclusion

This research presents insights into the adoption of design methods in industry. To accomplish this, semi-structured interviews were conducted with practicing engineers, scientists, managers, and executives at a multi-national consumer packaged goods company. Analysis of the interview transcripts through qualitative coding methods revealed three key themes for adoption. The first theme suggested that individuals tend to adopt new design tools that gel with their existing design tendencies and provide them with direct benefits. Cases where individuals did not perceive the value of a tool or were hindered by tool use resulted in tool abandonment. The second theme identified the appropriateness of a design method for an industry or product line as another indicator of adoptability. Design methods that worked in conjunction with existing organizational products and practice were seen as beneficial and helped the spread of methods. Conversely, design methods that were poorly suited for use in a particular industry were seen as difficult to use and became the cause of workplace tension. The third and final theme presented the sentiment that leadership support of design method adoption initiatives was a powerful motivator for adoption among individual practitioners. While management mandating the use and training for a new design method helped perpetuate the tool into the organization, tool users

also responded to implicit support, such as when executives inquired about or accounted for the results of the tool in the evaluation of the resulting products. Further discussion connected these themes to design education where hypotheses were developed regarding proper contextualization and support for methods taught.

Future work will involve further analysis of these interviews, in conjunction with data gathered from additional industrial partners, with further refinement in coding, analysis, and to establish reliability. Analysis of design methods and their path to adoption will also be conducted, with the goal of understanding best practices for design method selection and adoption. The connections between method selection, adoption (or rejection), and method evaluation will also be investigated to determine themes that exist throughout the life cycle of a design method. Interviews at additional companies are ongoing to ensure wider applicability of these results and to understand generalizability of results.

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