Interactive Ideation: Online Team-Based Idea Generation versus Traditional Brainstorming

A Dissertation

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Dedication

In loving memory of my Haitian grandfather who always believed in me and always knew I would get my doctorate one day. I know you are watching from above.

Dr. Antony F. Michel

Rest in Peace

Abstract

Social media and social collaborative platforms are becoming ever more integrated into our lives at all levels. Past research has shown electronic brainstorming and idea generation can be viable options when compared to traditional methods. Building on existing research into the benefits and challenges of ideating through online environments, this study asks if an established collaborative planning platform can be more conducive to generating a high quantity of ideas and high-quality ideas than traditional methods. In this context, the quantity of ideas generated, the quality of ideas as rated by participants and experts, and group success building upon ideas are evaluated as metrics. The two conditions are compared on performance in an idea generation session. The analysis demonstrated that idea generation through the digital platform Slack, compared to traditional brainstorming, produced more ideas, approximately twice as many high-quality ideas as rated by experts, and nearly twice as much building upon ideas. The results of the study suggest existing online social platforms are viable options for conducting idea generation in small groups and provide an option for collaboration without meeting in person.

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I-INTRODUCTION

1.1 *Problem Statement*

In 2019, we have incredibly powerful smartphones, robust cloud computing, massive online social networks and more new innovations connecting us each day. With this influx of new technology arises new social, economic, moral, and political challenges. Digital voice and social media have quickly become a dominant force in marketing, communication, and lifestyle. Social media and online collaborative tools like Slack and Google Docs are becoming increasingly useful for productive tasks in addition to leisure and socializing. The number of active users on these platforms is in the billions. Even with the relative youth of these platforms, research is already being conducted on ways to utilize these platforms for more productive tasks (Kaplan & Haenlein, 2010). Massive

online platforms like Facebook, Slack, and Twitter present future opportunities for massive-scale collaborative work online.

Online social networks can be seen as a creativity enhancement tool backed by the unmatched communication and interaction channels they can achieve (Cache & Da Costa, 2007). Social Media and collaborative platforms tend to have rather diverse populations with users all over the world. One of the key elements of a good brainstorming session is diversity in the participant population. Examining all of these potential contributors as problem solvers, there is undoubtedly a spectrum of problem-solving ability, creativity, and expertise. Diversity has been shown to increase performance in groups of problem solvers, with randomly selected groups outperforming groups selected from the best problem solvers in a population (Hong & Page, 2004).

Another potential challenge to these platforms is encouraging collaborative behavior in groups of much larger sizes than traditional face-to-face problem-solving groups. Dormant participants and trolls, users who demonstrate destructive rather than constructive behavior in online social environments, could become an issue in these domains. Nonetheless, one study conducted comparing an online mass-participation brainstorming system to traditional brainstorming practices found the massive participation system was better at encouraging constructive and collaborative behavior (Krieger & Wang, 2008). Though there is minimal research on scaling and collaborative tasks in general, there is even less on the utilization of these relatively new platforms. This presents a research opportunity looking at collaboration and scaling in some of the

most widely used platforms in the world today. This research examines this through idea generation.

1.2 *Idea Generation, Brainstorming, and Brainwriting*

Idea generation is the process of generating ideas for creative problem solving or new product concepts. There are over 170+ idea generation methods (Smith, 1998), but Brainstorming is perhaps the most well known. Brainstorming is a method of idea generation where participants generate lots of ideas in a set amount of time. Traditional Brainstorming is done interactively, where brainstormers communicate actively during the brainstorming session. The nominal case for brainstorming, where participants generate ideas individually rather than interactively, is called brainwriting. Nominal Brainwriting makes testing of individual performance in idea generation simpler and more controlled than Traditional Brainstorming. However, Traditional Brainstorming allows users to create associations and take concepts further due to the stimulation of hearing and seeing the ideas of others in real time. Communication through digital platforms in real time is one of the building blocks for social networks and online collaborative platforms.

1.3 S*ocial Media & Idea Generation*

Social media presents an opportunity for massive-scale group/collective idea generation. Several major social media sites, including Instagram, Twitter, Facebook, Reddit, and Pinterest, were examined to understand how social media sites are structured for collaboration, whether they are conducive to brainstorming, and common ways people

already use the platforms to generate ideas. Social media also presents a platform where conversations, timing, and frequency are out of any manager or facilitator's control (Mangold & Faulds, 2009), this element makes social media very difficult to conduct controlled studies through. There appears to be a rising research interest in social media.

1.3.1 *Instagram*

Instagram is a social networking app made for sharing photos and videos from a smartphone. Instagram is completely photo-based, with text only used as captions or comments on photos or bios. Instagram's greatest strength is that it has a simple and clean interface that's very easy to navigate. Instagram is effective for feedback, specifically on photos. The primary social-psychological motives for Instagram users are social interaction, archiving, self-expression, and escapism (Lee Et al., 2015). Teens are more active on Instagram and post more selfies on Instagram than adults, so there is variability in the usage of the platform by age (Jang Et al., 2015). You can see examples of idea generation on Instagram in the comments of some photos that ask a question or pose a challenge. Instagram's lack of text options and emphasis on photos make it intriguing as a platform for research on the role of photos in ideation.

1.3.2 *Twitter*

Twitter is a social networking and news platform where people post short messages of 280 characters or less. Tweets can act as short life updates, messages to people who you interact on the platform with, or shares (re-tweets) and comments on another tweet. Twitter has over 330 million monthly active users. Twitter's short character limit and

hashtag functionality make it different from most other platforms that emphasize photos or allow for more full-length blog-style posts rather than microblogging, short blog-style updates. Twitter affordances include sharing media in the form of links, photos, and videos. Twitter has strong community dynamics as well with the trending topics function and searches for tweets relevant to hashtags. Conversations on Twitter can lead to a discussion of ideas in thread-form as replies. This system has been shown to facilitate conversation through the use of tagging (Honey & Herring, 2009). The platform is conducive to posing a question and crowdsourcing responses nominally, however, it lacks the chatroom format suited for interactive brainstorming. Twitter replies are only seen as a list of replies to a particular tweet rather than a thread where all posts can be seen chronologically. The platform isn't set up well for structured idea generation because of this difficult to follow thread format, however, studies have been conducted that propose it can be effective as a connector of ideas rather than a generator of ideas (Parise *et. al*, 2015).

1.3.3 *Facebook*

Facebook is a social media site where users can share news, personal information, all forms of media, and links. Facebook users have the most extensive profile of the social media platforms examined. The main functional building blocks of Facebook are friends, photos/albums, instant messaging, pages for businesses or groups, and newsfeed. Currently, idea generation happens through Facebook in many forms: post comment threads, group chat messages, Facebook group page posts, etc. Messaging, customizable profiles, and comments on posts make Facebook well-suited for social interaction.

Nonetheless, the multitude of features, combined with the amount of personal information that's easily accessible to others, make the platform difficult for conducting a collaborative study. Nonetheless, studies have been conducted, and Facebook groups have been shown to enhance student learning and collaboration (Choi, 2013). Studies have found evidence of social cognitive factors like extraversion and introversion impacting the usage of the platform (Ross *et. al*, 2009). Motivations for use also fall into many different categories for Facebook, including social connection, shared identities, content, social investigation, surfing the social network, and updating status (Joinson, 2008). This makes understanding the user landscape difficult for designing a collaborative study.

1.3.4 *Reddit*

Some consider Reddit to be the front page or newspaper of the internet. The platform is built in a forum style where users can discuss topics of varying levels of specificity. Some forums discuss creative challenges, advice, and problem solving similar to idea generation sessions. The draw of Reddit is its upvote and downvote system that positions forum responses based on audience votes of their relevance, usefulness, or correctness. With 250 million active users it’s a rather large platform and the voting system is an interesting potential system for ideation, specifically for idea evaluation and selection, but research has found under-provision to be an issue on the platform with some 52% of popular links getting overlooked on first submission (Gilbert, 2013).

1.3.5 *Pinterest*

Pinterest is an online pinboard where users interact through liking, commenting and re-pinning collected visual pieces of multimedia from the internet. Following and messaging are other features of the platform. With 200 million active users, Pinterest's annotating features and tagging of websites expands the reach of ideas that spread through the platform (Zarro & Hall, 2012). Pinterest users already engage in a form of ideation by collecting and sharing bookmarks in an organized fashion as pins (Linder & Kerne, 2014). Similar to Instagram, Pinterest is an image-based platform, with commenting, which presents interesting prospects for sketch-based idea generation but further understanding of the comment dynamics are needed for text-based ideation in this platform. Additionally, gender differences in the usage of social features of the Pinterest platform shed light on the need for an understanding of social cognitive factors in online environments (Ottoni *et. al*, 2013).

1.3.6 *Social Media Implications and Impact*

The young professionals of the next few decades will have grown up with social media being an integral part of their life in some form. Reputation, relationships, presence, sharing, conversations, and identity are all major functional building blocks of social media and all are influential in personal development (Kietzmann, 2011). Each of these blocks manifests itself differently depending on the platform, the user, and the frame of reference. Social cognitive factors impact each of these blocks differently as well, leading to a complicated composite of individual user behavior. The Internet has a tendency to complement existing behavioral patterns in digital contexts (Dimaggio et. al, 2001). The complexity of the social cognitive factors involved in social media needs further research

before targeted structured collaborative activities can be studied effectively in these platforms. Social media platforms like Facebook and Twitter, while also possessing powerful functionality for digital communication with groups, are full of ads, feature add-ons, and social platform engagements that can distract from a study such as this. Additionally, there are greater complications with anonymizing studies on social media platforms.

While most social media has great potential to make idea generation more engaging because of its social aspects and massive user bases, it lacks the structure and boasts extraneous entertainment features. In most cases, this creates more challenges than affordances for conducting idea generation research. Such studies might require manipulating the site and managing participant information. Social media platforms present far more uncontrollable channels for influences like motivation and leadership than collaborative planning platforms with the variety of channels of communication, information to be consumed, and emotional contagion (Kramer Et al., 2014). The unpredictably of social media presently requires more research before an understanding of how to control social-cognitive factors in the platforms can be synthesized.

1.4 *Online Collaborative Innovation Platforms*

Social media aside, online collaborative platforms, in general, present an opportunity for massive-scale idea generation. Crowdsourcing sites like Amazon Mechanical Turk and Wikipedia, and collaborative innovation sites like OpenIdeo, Innocentive, and Quirky were examined to understand how non-social media online collaborative platforms are

structured for collaboration. Efforts were made to understand whether they are well-suited for team-based idea generation, and common ways people already use the platforms to generate ideas. These platforms represent the closest thing to structured online idea generation and innovation. The power of crowdsourcing platforms is already being utilized for more significant and impactful, non-social collaboration. For example, one study examined the power of crowdsourcing in social media for disaster relief (Gao et. al, 2011). The most robust crowdsourcing platform thus far is Amazon Mechanical Turk.

1.4.1 *Amazon Mechanical Turk*

Amazon Mechanical Turk (MTurk) is a hub for work that requires human intelligence. Workers are paid to contribute to HITs (Human Intelligence Tasks), such as identifying something from a photo or video, writing descriptions of products, or completing surveys. Amazon's Mechanical Turk marketplace has about 500,000 registered workers worldwide, although not all of them are active. A study of ideation through Amazon Mechanical Turk found that showing workers currently on the ideation task the previous workers' rationale for their contributions to the task slightly improved average quality of ideas (Xiao, 2014). Studies have also been conducted highlighting ways to effectively utilize the features and crowdsourcing power of Mechanical Turk (Kittur et. al, 2008). Mechanical Turk has strong structuring for nominal crowdsourced tasks but lacks in-platform functionality for online team-based idea generation.

1.4.2 *Wikipedia*

Wikipedia is a free encyclopedia, edited and written collaboratively by the people who use it. Many people are constantly improving Wikipedia, making thousands of changes per hour to various articles in many languages. Users must login as an editor, make changes and have them approved to become a part of the Wikipedia article they edited. The English Wikipedia currently has 33 million users who have registered a username. One study of Wikipedia and another social collaborative knowledge system called Del.icio.us found a shift happening in these platforms from elite or expert user contributions dominating to a more diverse pool of more common users contributing (Kittur et. al, 2007). Wikipedia also presents evidence of the need for understanding the social cognitive factors that influence collaborative interaction online. A study of social capital in the platform found users with higher social capital got their article pushed to higher status faster and featured more quickly (Nemoto et. al, 2011). These social factors influence the fairness and transparency of collaborative projects if certain users get preferential treatment or if it is difficult for new users to contribute because of lacking social capital. Wikipedia lacks a peer-to-peer communication component suitable for team-based idea generation.

1.4.3 *OpenIDEO, Innocentive, and Quirky*

While the research on these OpenIdeo, Innocentive, and Quirky is minimal, studies on them have focused on things like the benefits of a structured design process in collective design open-innovation communities (Paulini et. al, 2011). Innocentive is a challenge-driven innovation platform that nominally crowdsources solutions to problems on large projects. OpenIDEO is an open innovation platform facilitated by the company IDEO for

crowdsourcing contributors from all over the world. The query-based platform allows users to submit challenges and respond nominally to challenges with solutions. Quirky is a now-bankrupt submission and development company that would take user ideas from submissions and crowdsource different components of the product development process nominally in the form of challenges. The company would carry products that performed well through to production with the original inventor receiving a percentage of the profits. The Quirky and OpenIDEO platforms are suited more to designers and freelancers with a pre-motivated pursuit of design and collaboration. A study of these platforms found designers valued "supportiveness, collectiveness, appreciativeness, responsiveness, trustworthiness, and tangibility of outcome" (Hajiamiri & Korkut, 2015). It also found these qualities to be interrelated with issues like participation quality, rewards or incentives, ownership, and evaluation. Nonetheless, the platforms mentioned are not well-suited for interactive groups because structurally their systems operate in a nominal fashion.

1.4.4 *Online Innovation and Crowdsourcing Platforms Implications*

While online innovation platforms represent a much closer alternative to a traditional idea generation session, in many cases they lack the structural collaborative functions (messaging, conversation threads, visibility of others' work) and focus more on elite users than the average consumer that wants to contribute their ideas. Today's elite designers and creatives can leverage more platforms for collaborative learning and creative opportunities in their respective domains (Peppler & Solomou, 2011). The benefit of socialization of online platforms long-term is the ability to access people anywhere,

anytime. Social media and collaborative planning platforms can do most of the things online innovation platforms can do.

1.5 *Collaborative Planning Platforms*

Online social networks can also be a tool for aligning individual thinking and collective or collaborative intelligence (Cache & Da Costa, 2007). No tools align individual and collective intelligence in the same professional yet social manner as collaborative planning tools like Slack and Google Docs. These platforms represent a combination of social media and crowdsourcing or collaborative innovation platforms in terms of the balance between social features and usability for a non-expert.

1.5.1 *Google Docs*

Google Docs allows for collaborative projects in which multiple authors work together in real time from geographically diverse locations. All participants can see who made specific document changes and when those alterations were done. This platform is an online collaborative text editor and is set up very well for various types of collaboration. Beyond normal typographical text editing features, the functions of the platform include commenting, suggestions for edits, a dedicated messaging thread adjacent to the document, and the ability to invite anyone with an email to contribute without the need for a particular account. One study found participants working in groups on documents prefer the use of the suggestion function for editing the document because of the increased collaboration (Blau & Caspi, 2009). The platform is also set up for controlling participant identity information and features few non-activity-related distractions.

Suggestions can be transposed as edits and accepted or declined. These suggestions appear visible when the comments function is set to show but is not visible or easy to locate when this is not the case. This and similar text editing auxiliary functions that Google Docs provides could cause issues in the idea generation sessions by distracting users from the main task of generating ideas.

1.5.2 *Slack*

Despite the robust functionality and versatility of the platform, the structure of Slack, which creates group "channels" that resemble chat rooms, allows for a centralized and focused experience. The localized message thread for idea generation avoids the levels of distraction other digital social platforms have. Several affordances and features of Slack warrant mentioning such as emoticon reactions to messages in the thread (text-insertable graphics depicting emotions), thread replies to create subthreads, and channel search functions. Though it is worth noting this is not an exhaustive list of Slacks platform features, these are mentioned because they are functions of the Slack channel. These features are non-obvious and do not appear to distract from the channel as all their functions execute within the channel and are focused on the subject matter. These are important factors for understanding how elements not present in traditional brainstorming, such as internal platform features like emoticons or internal platform search, impact the idea generation process or result, if at all.

II-LITERATURE REVIEW

2.1 *Brainstorming Background and Factors*

Brainstorming requires deferring judgment of ideas, encouraging seemingly outlandish ideas, generating as many ideas as possible and building upon the ideas of others (Osborn, 1953). Group brainstorming performance appears to be inhibited by social and cognitive influences, though the process can still be very effective (Paulus & Brown, 2007). A benefit of traditional brainstorming is that exposure to ideas, both during exposure and after, has been linked to enhanced idea generation (Dugosh *et al*., 2000). Exposure to other people's ideas can cause pressure to perform up to standard, however, when controlled properly with even highlighting of ideas, more ideas lead to greater cognitive stimulation and ultimately better performance overall (Paulus & Brown, 2007). Hearing ideas that other participants suggest helps participants develop prompt-related ideas as well (Nijstad & Stroebe, 2006). Many performance losses in Traditional Brainstorming could be partially due to factors like social anxiousness and introversion (Camacho & Paulus, 1995), and these factors influence brainstorming in both digital and face-to-face contexts.

2.1.1 *Production Blocking*

Production blocking refers to the suppression of ideas because of distraction or relevance. Production blocking has been shown to interfere with both the process of knowledge activation and the process of idea production (Nijstad & Stroebe, 2006). One of the benefits of online environments is a potential reduction in production blocking due to the

ability of participants to simultaneously present ideas in the session instead of having to wait while another participant announces their idea. This keeps participants engaged in the session.

2.1.2 *Social Loafing*

Perhaps the most significant potential factor in participation with the scaling of collaborative groups is social loafing. Social loafing or free riding is a phenomenon where users allow a few participants to do most of the work because they are seen actively contributing. A simple proof of the concept of social loafing is demonstrated by a study that found participants asked to clap and shout exhibited significantly less effort individually when performing in a group rather than alone (Latane et. al, 1979). As group size increases, the number of non-participants, or social loafing participants, increases as well (Bray Et al., 1978). Moderating variables of social loafing include the potential for evaluation of performance, expectations for performance, group culture, and how meaningful users find the task (Karau & Williams, 1993). Increasing task difficulty has also been shown to decrease social loafing (Harkins & Petty, 1982). Task visibility is inversely associated with social loafing as is intrinsic motivation to participate in the task (George, 1992). Social loafing refers to the phenomenon where a participant in a group activity contributes less to the group effort because they see others carrying some of the workload. This differs from social anxiety or nervousness where participants might feel apprehensive because of personal psychological or physiological factors, lack of familiarity with the activity, or other factors like a language barrier.

2.1.3 *Group Size*

Social media and collaborative planning platforms present opportunities for massive-scale ideation online. Group size studies allow us to analyze the potential impacts of utilizing these massive online spaces for ideation. However, the research is minimal on electronic brainstorming with group size manipulation. The findings of one study by Gallup Et al. (1992) show the benefits of electronic brainstorming in groups for productivity, with those benefits increasing with group size. Non-electronic brainstorming groups did not see the increased performance with increased group size (p. 363). However, this is reversed in the electronic context, where electronic idea generation groups perform better than nominal brainwriting groups (Dennis & Valacich, 1993).

2.1.4 *Evaluation Apprehension and Accountability*

Evaluation apprehension is a fear of criticism from others or from facilitators. Asking participants to justify their process of ideation, their outcomes, or both, has been shown to have a negative effect on the uniqueness of ideas and increase participant stress (Häusser Et al., 2017). The Häusser Et al. (2017) study found that "outcome and process accountability, as well as their combination, have a negative net effect on idea generation: Being held accountable, participants produced fewer and/or less unique ideas" (p. 270). Additionally, process accountability extends the length of idea generation sessions because of added steps.

2.1.5 *Peer Feedback and Social Comparison*

Social factors inevitably have an impact on idea generation performance. Team-based idea generation involves social interaction whether electronic or in-person (Paulus & Dzindolet, 1993). Peer feedback is an important social factor with implications in idea generation. Peer feedback can come in a variety of forms. One example would be participants saying they approve of or appreciate the idea of one participant during the exercise. Another would be participants seeing the ideas of others and adjusting their path of ideation or making associations to create new ideas. Both of these forms influence the idea generation session and the flow of ideas. There are both positive and negative effects to peer feedback. Negative feedback can come in a variety of forms and is difficult to assess the impact of because different ways of conveying similar or identical meanings may be interpreted by the receiver of the negative feedback in many different ways (Zhu Et al., 2013). It is consequently very difficult to ascertain the cause behind a particular response to negative feedback. Positive feedback can certainly increase motivation for work or participation but has not been shown to have an impact on task performance (Zhu Et al., 2013).

Social comparison has been shown to increase performance in online idea generation. A Michinov and Primois (2005) study found "results revealed that individuals with a basis for social comparison on a shared table for their online group outperform individuals with no basis for social comparison" (p.22). Visibility of the ideas of others, how unique they are, and how many of them there are, may influence the motivation and performance of participants in idea generation. According to Dugosh and Paulus (2005), exposure to higher numbers of ideas increases both the number of "non-redundant" ideas generated

and the number of unique or original ideas generated (p. 318). Peer feedback studies suggest that social comparison and visibility of the ideas of others can have positive effects on productivity and quality. The research, however, is not extremely consistent on the impacts and studies vary greatly in structure and variables. The structure of an idea generation session both in the digital platform and traditional brainstorming contexts emphasizes the ability of participants to see all the ideas of others as they are generated.

2.1.6 *Instructions, Facilitation, and Goal Setting*

In Team-based idea generation the initial phase of idea generation group performance has been shown to predict the overall performance of the group through to the end of the session ((Paulus & Dzindolet, 1993). The initial instructions participants receive influence how the session begins and consequently the performance of the group for the rest of the session. Research also suggests the use of a facilitator and clear instructions for discussion can enhance productivity as group idea exposure can, at times, lead to distracting discussions (Dugosh *et al*, 2000). Interacting groups with a facilitator have been shown to outperform interacting groups without a facilitator as well as nominal groups (Offner *et al*, 1996). Different goal setting strategies in brainstorming have been examined with emphasis on quantity, quality, or both in the prompt. Quantity focus in the idea generation prompt generates more and better ideas than quality focus or a combination of quantity and quality (Paulus Et al., 2011). Other goal setting strategies have focused on participative and individual goal setting. Goals such as “do your best,” group goals, participation goals, and individual goals have been examined. Group goal

setting reduces effects such as social loafing or free riding as opposed to a condition such as “do your best” (Wegge & Haslam, 2005).

2.1.7 *Gender Bias and Anonymity*

Studies have found gender bias in all kinds of organizations, organized activities, decision-making processes, and institutions. Online communities and platforms are no exception to the gender bias influence. From collaborative planning and task-oriented platforms to social media, gender bias remains a factor. Wikipedia studies have found evidence of gender bias in language, meta-data, and network structure (Graells-Garrido, 2015). In Tinder, an online dating application, studies have found gender bias and sexist behavior connected with interface design aspects (Lopes & Vogel, 2017). Pinterest has shown evidence of gender roles and differences in user experience for men versus women (Ottoni Et al., 2013). It would appear that even though the world continues to grow and change, becoming potentially more accepting, more equal for all, and more culturally aware, gender bias issues may be difficult to bring to a balance without sufficient time for the changes to take hold (Ridgeway & Correll, 2004). One study of what user personalities interact on social media found that gender and age influence social media use as well as extraversion and openness to experiences (Correa Et al., 2010). It is imperative to consider that gender bias, diversity of other user personality traits, and cultural characteristics may have an impact in any kind of collaborative activities that are studied and thus needs to either be managed or addressed as a limitation if unaccounted for in the experimental design.

Anonymity is important for reducing or eliminating gender bias. The intent is that regardless of self-identified gender, participants will be able to contribute ideas to the session without fear of their ideas potentially revealing identifying information about their gender. This issue could arise with a topic of ideation participants may perceive as less gender neutral. Though anonymity alone has not been shown to impact ideational performance, it is maintained in this study for the anonymity of participants and to eliminate potential issues of gender bias in social comparison (Valacich Et al., 1992).

2.1.8 *Motivation*

Motivation to participate in idea generation can be complicated. Motivation is broken into the extrinsic and intrinsic dichotomy. Common examples of extrinsic motivators are payment and social acceptance. Intrinsic motivator examples include things such as passion for the activity or emotional investment in the work being done. A classic definition of intrinsic motivation in a work context is found in Brief and Aldag's (1977): "Intrinsic work motivation is a cognitive state reflecting the extent to which the worker attributes the force of his or her task behaviors to…outcomes which are not mediated by a source external to the task- person situation" (p. 497). They define extrinsic motivation in a work context as "a cognitive state reflecting the extent to which the worker attributes the force of his or her task behaviors to having and/or expecting to receive or experience some extrinsic outcome" (p.497). Later definitions are more specific about the factors that influence motivation and the characteristics of the two types of motivation. According to Ryan and Deci (2000): "Intrinsically motivated behaviors, which are performed out of interest and satisfy the innate psychological needs for competence and

autonomy are the prototype of self-determined behavior. Extrinsically motivated behaviors—those that are executed because they are instrumental to some separable consequence—can vary in the extent to which they represent self-determination" (p. 65). The definitions of intrinsic and extrinsic motivation have become more refined with time but there is still a need for understanding of this dichotomy in online contexts before assertions can be made about their impact on idea generation.

Some studies have examined the impact of motivation on task performance in online environments, specifically crowdsourcing. One study of Amazon Mechanical Turk found that intrinsic motivation, and the framing of the prompt in a way that would increase a participant's intrinsic motivation to participate, can increase task performance (Rogstadius et. al, 2011). The same study found that increasing pay, or extrinsic motivation, increased task performance regardless of intrinsic motivation levels (Rogstadius et. al, 2011). Self-determination based on competence, autonomy, and relatedness as psychological needs for intrinsic motivation is one way the motivation category has been examined (Ryan & Deci, 2000). These psychological needs must be understood in the context of idea generation studies to analyze potential motivating factors.

2.1.9 *Online Environments*

In online brainstorming, multiple participants can share ideas almost simultaneously without interrupting each other. Explicit goals and performance feedback have been shown to produce high performance, with respect to both quality and quantity of ideas, in

computer-mediated brainstorming groups (Jung *et al.*, 2005). Electronic brainstorming production impediments include the distraction effect of reading others' ideas, production blocking from these distractions, focusing too much on originality constricting free flowing ideation, cognitive fatigue, and dispersion of cognitive effort when too many trains of thought run simultaneously (Pinsonneault *et al*., 1999). Goal setting has been shown to positively influence electronic brainstorming as well, and its positive effects are found to be stronger in anonymous electronic brainstorming groups than identified electronic brainstorming groups (Sosik *et al.*, 1998). Research highlighting issues with overvaluing of electronic brainstorming productivity levels suggests caution in drawing conclusions from perceptual satisfaction measures (Pinsonneault Et al., 1999).

Crowdsourcing environments like Amazon Mechanical Turk present a lens for the examination of online communities for idea generation as well. Though Mechanical Turk functions nominally, group tasks can be set up for MTurk workers through links. Understanding the functional challenges of MTurk for crowdsourced tasks can shed some light on potential challenges in Slack and Google Docs. Crowdsourcing affords two particularly important abilities: the ability to create new organizational structures and environments fast, and the ability to situate them in a context that is experimental (Kittur, 2013). Similarly, collaborative planning platforms provide a space for structured collaboration and the ability to utilize platform features to aid in quick construction of such a space. Similar to the thread style digital idea generation, MTurk workers often have to work on something with others' work already contributed (Kittur, 2010). The main difference is that they are not seeing the work of others in real time in most MTurk

tasks. MTurk workers accept tasks quickly. Within a few minutes or hours, a posted task can already have dozens of workers on it (Kittur, 2010). This also presents a useful research tool for iterative studies or quickly testing a method.

Online communities like social media and collaborative planning platforms, as well as editors and information gathering platforms like Wikipedia present large user bases with potential for beneficial scaling of contributing groups. Taking a crowdsourcing example from Wikipedia, it appears that when more editors are added to an article, under simple coordination conducive to the proper and smooth functioning of the group, the article quality was improved in comparison to fewer or individual editors (Kittur & Kraut, 2008). While there are many functional differences between brainstorming and article editing, both involve problem-solving, and in this case, both are done digitally in a collaborative format. Both platforms, with their large user bases, can scale the number of these collaborative activity participants by powers of 10, 100, or more, a capability we may never have for traditional brainstorming.

2.1.10 *Nominal Brainwriting, Traditional Brainstorming, and Electronic Brainstorming*

There is research in support of nominal brainwriting over traditional brainstorming for effectiveness, justified by theories on evaluation apprehension, production blocking, and social loafing (also referred to as free riding), though nominal brainwriting is said to eliminate these theoretical impediments (Diehl & Stroebe, 1987). Cognitive stimulation from idea exposure is the fuel behind traditional brainstorming, as exposure to more ideas

and exposure to common ideas leads to the generation of more and more original ideas (Dugosh & Paulus, 2005).

An important note is that the majority of research still supports nominal brainwriting over electronic group brainstorming or traditional brainstorming, but as the world becomes increasingly social and collaborative through digital means, the need for group brainstorming strategies beyond the nominal approach increases. Academics in the field of brainstorming continue to research electronic brainstorming conditions that may outperform nominal brainwriting significantly and provide empirical evidence for the superiority of interactive groups (Pinsonneault Et al., 1999).

According to a 1963 study on the effect of group participation on brainstorming performance, 23 out of 24 groups performed better in the nominal condition than in the interacting group condition (Dunnette Et al., 1963). Large electronic brainstorming groups have been found to outperform nominal groups, while smaller nominal groups outperform the electronic brainstorming groups (DeRosa et. al, 2007). Under conditions that facilitate attention to the ideas of others, and allow for incubation of ideas by participants, traditional brainstorming groups can even outperform nominal groups (Paulus & Yang, 2000). Situationally, nominal groups may perform better than traditional brainstorming groups, or electronic groups better than traditional brainstorming groups. However, each of the types of group idea generation has success factors that may have positive effects when applied to others. This concept is one of the bases for this study,

applying concepts from traditional brainstorming research in a very new, fast-growing, and widely used platform.

2.2 *Quantity of Ideas*

In a study of nominal electronic idea generation, idea exposure was found to have positive effects on the quantity of user ideas generated (Nijstad Et al., 2002). Idea exposure is an important component of traditional brainstorming as ideas are called out and displayed during the idea generation session. Cognitive inertia refers to when a participant's ability to switch to a new direction of thinking begins to fade. Clarity and understanding of the task, cognitive inertia, and eventual exhaustion are all noted as factors influencing idea generation functioning and quantity of ideas generated (Briggs Et al., 1997).

2.2.1 *Quantity in Nominal and Traditional Brainstorming*

Nominal groups outperform interactive groups in the number of ideas generated without sacrificing quality in ideas generated (Dunnette Et al., 1963). Despite the many papers to the contrary, there is some research that does support traditional group brainstorming over nominal brainwriting (Sutton & Hargadon, 1996; Lamm & Trommsdorff, 1973). Traditional brainstorming groups can exhibit collaborative fixation, where the participants are brainstorming in a reduced variety of idea domains because of conforming to the ideas exposed to (Kohn & Smith, 2011), though this does not influence the number of ideas generated.

2.2.2 *Quantity in Traditional Brainstorming vs. Electronic*

A meta-analysis of electronic brainstorming literature found that electronic brainstorming groups were more productive than traditional groups (DeRosa et. al, 2007). Electronic brainstorming may reduce many of the negative effects of production blocking because participants aren't interrupted by each other (Gallupe et. al, 1992). Electronic brainstorming groups also report greater satisfaction with the activity than traditional brainstorming groups, in addition to being more productive (DeRosa et. al, 2007). These factors can allow electronic groups to generate more ideas than traditional brainstorming groups.

2.3 *Quantity-Quality Connection*

One of the foundational principles of brainstorming is that the more ideas you generate, the better the ideas are. This principle has been individually tested and has shown strong data in support of the quantity-quality link (Adánez, 2005). A study by Dippo & Kudrowitz (2013) of the alternative uses test, a method of creativity assessment that is also a form of idea generation, found that: "participants that produced more responses had more novel responses and a higher average novelty score…later responses were significantly more novel than early responses…"(p. 7). The alternative uses test, is a divergent thinking evaluation where participants "list non-obvious uses of a common object" (Dippo & Kudrowitz, 2013). The Dippo-Kudrowitz study found that after 9 ideas the participants began to come up with highly novel ideas, with highly novel ideas referring to those that less than 10% of the participant pool also listed. The alternative uses test and the brainstorming activity done in this dissertation study have a similar goal,

generate lots of ideas. The main difference between the two studies is the Dippo-Kudrowitz study examines uses for a common object while the dissertation study is about new product ideas. Another key difference is that the alternative uses test is a nominal activity whereas this study focuses on interactive groups. The Bounded Ideation Theory supports the quantity-quality connection as mapping of the progression of ideas through the session finds most of the best ideas come from the middle of the session, and plateau towards the end (Reinig Et al., 2007). This supports the quantity-quality correlation in activities with a quantity goal as user needs to generate a lot of ideas to get to stronger ideas which come later in the session.

While the quantity-quality connection appears strong from previous studies, some have noted that high productivity and more ideas generated are not the only important metrics, as one study found by comparing two conditions with integrated idea selection in idea generation compared to separate selection and generation (Rietzschel et. al, 2006). Despite the evidence for a quantity-quality relation, one study in 2006 found that more than 20 percent of idea studies they reviewed used quantity as the only evaluator of an idea session (Dean Et al., 2006). Considering multiple factors in idea generation session productivity is important for understanding the underlying factors in these quantity-quality connections.

2.4 *Quality of Ideas and Creativity*

One theory of creativity is that an individual's creativity is based on one's talent for making connections between unrelated things that are not obvious or commonly noticed

(Mednick, 1962). The links between motivation and creativity have been examined in detail in past research. Self-motivation was second to only personality traits in interview reports of personal qualities that enhance creativity (Amabile, 1988). Five personal qualities were found to inhibit creativity and two of them were related to motivation: "being unmotivated" and "being externally motivated" (Amabile, 1988). Factors that inhibit creativity from a perspective of motivation are evaluation, surveillance, reward, competition, restricted choice, and extrinsic orientation (Amabile, 1997). Evaluation is a potential inhibiting factor of creativity in this study. Extrinsic orientation, or thinking about extrinsic motivators, is also a potential inhibiting factor for creativity.

2.4.1 *Creativity and Idea Generation*

Individual creativity is essential to organizational or collaborative innovation (Amabile, 1988). There are factors, however that influence creativity individually, and factors that influence it a group context. The novelty of ideas rises over time in interactive brainstorming (Kohn & Smith, 2011). A comparison of 2-, 4-, 6- and 12-person groups between electronic and traditional brainstorming found that participants in larger groups generated more unique and higher quality ideas (Gallupe et. al, 1992). Accountability or evaluation, whether during the process of idea generation or at its conclusion, has been linked to reduced originality in ideas (Häusser et. al, 2017). The benefits of exposure to the ideas of others in group brainstorming must be balanced against the issues of production blocking and task attention (Paulus & Yang, 2000).

2.4.2 *Quality in Nominal Brainwriting, Traditional Brainstorming, and Electronic Brainstorming*

According to Barki and Pinsonneault (2001), nominal groups generate ideas that are at least as high-quality, if not better quality, than electronic brainstorming groups (p. 194). Nominal groups tend to outperform interactive groups in quantity of ideas but the ratings of these ideas on measures like feasibility are higher in interactive groups (Rietzschel et. al, 2006). Group interaction helps participants in brainstorming get the creative process started in contrast to nominal groups. Nominal groups have even been found to perform better when there is group interaction before they begin individual work (Dunnette, 1963). Success factors from interactive brainstorming have been found to have positive effects on nominal brainwriting when applied.

2.5 *Building Upon Ideas*

An examination of the idea combination process found that idea generation groups benefited from the process of exchanging ideas (Kohn Et al., 2011). Another study found that "hearing ideas that other participants in group brainstorming suggest helps participants develop prompt-related ideas (Nijstad & Stroebe, 2006)." Participants in idea generation can respond in different ways to being exposed to the ideas of others. Some use it to help them develop more prompt-relevant ideas, others use it to build upon trends or common themes. Some use the ideas to adjust and make associations for new ideas. Osborn's fourth rule of brainstorming is to combine and improve ideas (Osborn, 1953). One study found that originality of design solutions from participants exposed to textual stimuli during the process of finding a solution was "significantly higher" than those

without, for multiple design prompts (Goldschmidt & Sever, 2011). This again suggests that exposure to the ideas of others does aid in the development of more unique and creative ideas.

2.6 *Research Questions*

There are many ways users already generate ideas on Social media, though not in the form of structured idea generation. Social media does, however, present challenges in study design, the anonymity of participants, recruitment, social factors, and a multitude of distractions. This makes conducting studies in a controlled manner on social media very difficult. Social media platforms are not included in the study because of the lack of control over the study structure and execution. Online innovation platforms are almost all nominal in nature, with participants submitting their polished ideas rather than collaborating with others to ideate on and develop solutions. These platforms, while easier to research, are not very social, and thus do not support online team-based idea generation research. For this reason, these platforms are not included in the study.

Collaborative planning platforms like Slack and Google Docs represent an easier to constrain, more functional, and an easier to track and analyze set of platforms for studying group idea generation. Few distractions and less detailed profiles make conducting studies more controlled and make keeping participants anonymous much easier than on social media or even online innovation platforms, which often require an account to verify their information. Implications of this research for idea generation in collaborative planning platforms for future research include the understanding of how to

conduct idea generation studies in established platforms rather than built platforms, as well as an understanding of the flexibility of these collaborative planning tools for other collaborative tasks beyond planning. Research questions in this study aim to tackle the performance comparison of collaborative planning platforms for online team-based idea generation versus traditional brainstorming groups. The major research questions this study aims to answer are:

Quantity of Ideas: Does online team-based idea generation through collaborative planning platforms like Slack provide a space more conducive for the generation of lots of ideas than traditional brainstorming?

Quality of Ideas: Does online team-based idea generation through collaborative planning platforms like Slack produce more high-quality ideas than traditional brainstorming as evaluated by both the participants and external experts?

Building Upon Ideas: Do participants in online team-based idea generation through collaborative planning platforms like Slack have more success building upon ideas than traditional brainstorming?

III METHODS

The primary objective of this study was to observe the differences between online team-based idea generation and traditional brainstorming groups. The two main metrics explored in this study were those believed to be indicative of a good team-based idea generation: quantity of ideas, and quality of ideas. Additionally, building upon ideas, which is viewed as a tenet of brainstorming, was measured to see how, or if, this impacted quantity and quality of ideas, and what differences there are between online building upon ideas and building upon ideas in traditional brainstorming.

3.1 *Hypotheses*

These hypotheses reflect the three major areas of analysis: quantity of ideas, quality of ideas, and building upon ideas.

3.1.1 *Hypothesis 1: Online groups will generate and sketch more ideas than traditional brainstorming groups*

Generating ideas: Prior research suggests that idea generation groups online are more productive and more satisfied with their experience (DeRosa Et. al, 2007). The lack of interruption in an online context is one of the likely reasons for this observed difference. Reduced interruptions and managed evaluation apprehension in online groups suggested this was likely to be the case with this study.

Sketching ideas: Participants in the traditional groups generated and sketched ideas simultaneously. In contrast, online groups generated ideas in text only on their computers with no visuals for 10 minutes, then only sketched these same ideas for 10 minutes with both text and images. With a lack of research on online idea generation involving sketches, it was unclear whether online groups would indeed sketch fewer ideas due to the time constraint.

3.1.2 *Hypothesis 2: Online groups will generate more high-quality ideas than traditional brainstorming groups*

- *Hypothesis 2A: Online groups, as measured by participants in the session, will place more votes on their session-generated ideas, select more to be on the Pugh chart, and select more ideas to be in the top final ideas from the Pugh chart than traditional brainstorming groups.*
- *Hypothesis 2B: Online groups will generate more high-quality ideas than traditional brainstorming groups measured by quantitative expert ratings of idea quality.*

"Session-generated ideas" refers to the ideas participants generated during the idea generation session of the study. Also mentioned in the study are "pre-session ideas," referring to a group of ideas participants generated prior to the study. Along with evidence of online idea generation groups having greater success with the number of ideas generated (DeRosa et. al, 2007), the evidence of the increased quantity of ideas translating to greater quality of ideas (Reinig et al., 2007) suggested online groups would

perform better in this study. The interesting contrast point of the two hypotheses was to compare ratings from the participants to ratings from experts.

3.1.3 *Hypothesis 3: Groups that build upon ideas more often will generate more ideas and more high-quality ideas.*

- *Hypothesis 3A: Groups with more threads, or longer average thread length, will have more ideas.*
- *Hypothesis 3B: Groups with more threads, or longer average thread length, will have more high-quality ideas.*
- *Hypothesis 3C: Top ideas are more likely to be a part of threads.*

The conceptual approach to a measure building upon ideas was to attempt to quantify common themes between ideas that are observed. These themes referred to a connected group of ideas within the session with a common word or short phrase, as seen in the figures below:

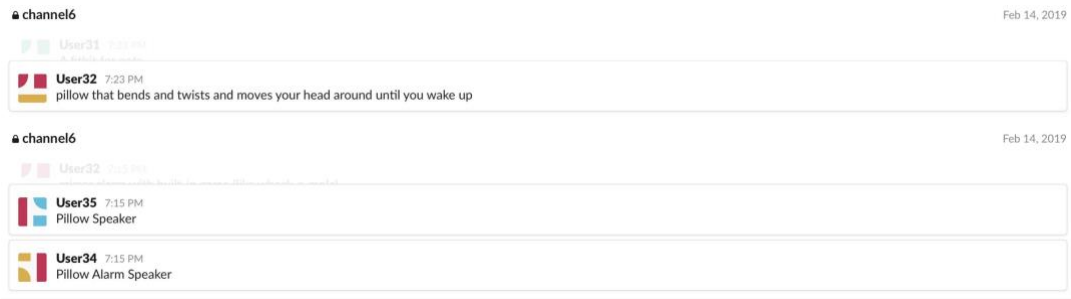


Figure 1: Slack channel ideas from the “pillow” thread in one of the groups

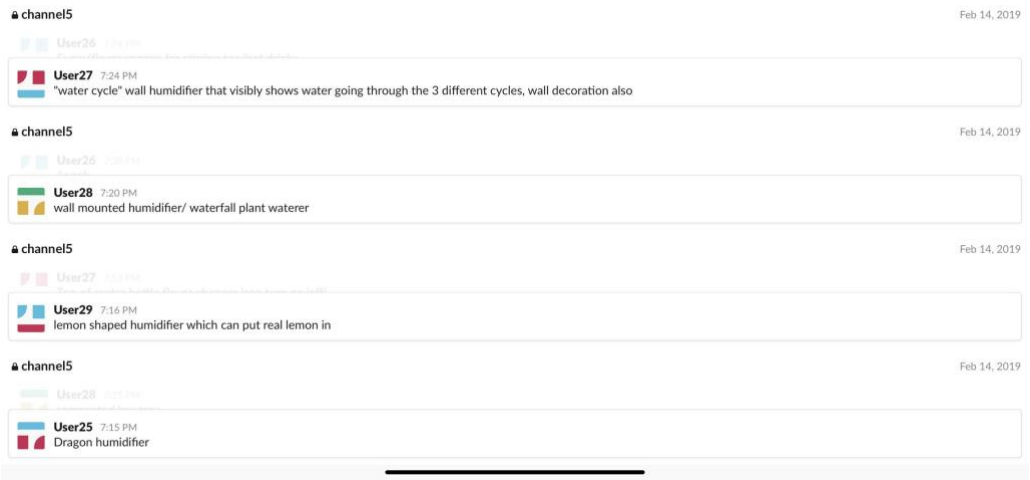


Figure 2: Slack channel ideas from the "humidifier" thread in one of the groups

Figure 1 and Figure 2 show two examples of threads of ideas from online groups, one with "pillow" as the thread concept and one with "humidifier" as the thread concept. Figure 3 and Figure 4 show two examples of threads of ideas from the traditional brainstorming groups, one with "dispenser" as the thread concept and one with "lava" as the thread concept. As with the online groups, all the ideas use the thread concept directly in the idea titles.

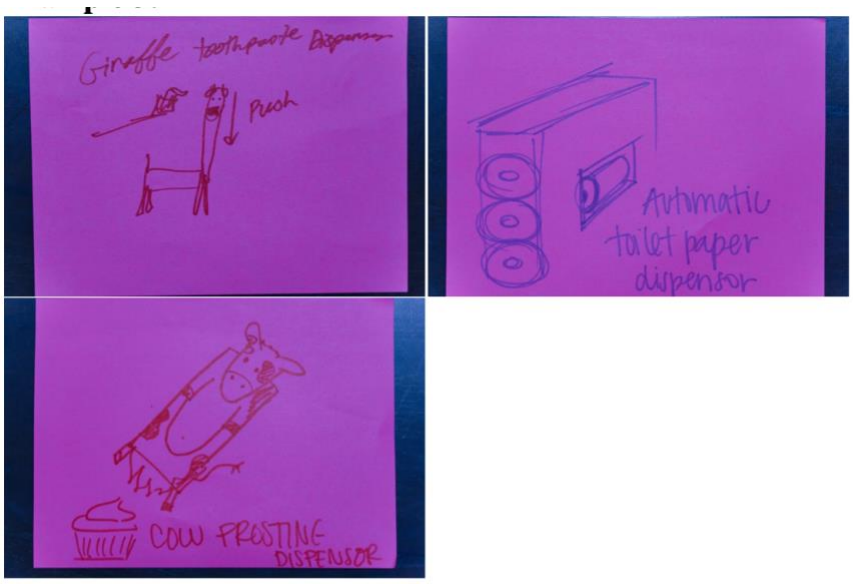


Figure 3: Sketched ideas from the “dispenser” thread in one of the groups

Figure 4: Sketched ideas from the “lava” thread in one of the groups

3.2 *Study Overview*

The study focused on factors that may impact idea generation in the context of an online social collaborative platform, with comparison to traditional brainstorming groups. Half of the groups participated in traditional brainstorming, the most commonly used and studied process, while the other half participated in online team-based idea generation through the platform Slack. These teams were randomly assigned. Participants generated ideas for novel products, produced sketches of the ideas, and then evaluated them. The ideas were also evaluated by experts. 76 individuals participated in the study. The idea generation session prompt was to "generate ideas for new, fun, and functional consumer home products." The more original a project is the more difficult it is for all those involved to participate (Luther & Bruckman, 2008). In idea generation, this could be examined as users having difficulty ideating on a prompt they don't understand or haven't heard of. The study prompt of "consumer home products" represented a topic the average participant was familiar with, was sufficiently narrow, and was combined with an emphasis in study instructions on generating creative ideas.

3.2.1 *Study Environment*

Each of the groups sat at a round table that was adjacent to a whiteboard and wall space. Participants in both conditions sketched ideas on 6x8 colored Post-Its. Facilitators for each group, who did not generate ideas during the session, were positioned between the table and the wall space for each team. This allowed them to easily place the sketched ideas on the board as the participants handed sketches to them. The instructor of the class was positioned in the center of the room so they were able to communicate easily with the entire room of participants and facilitators.

3.2.2 *Traditional Brainstorming*

For traditional brainstorming groups, each idea was said aloud by the person who generated the idea and sketched the idea and posted on the board so that everyone in the group could hear. Traditional groups spent the entire 20-minute idea generation session both generating and sketching ideas. Participants sat at a round table and sketched ideas on the large Post-Its. They wrote a title on the sketch. Saying the ideas aloud provided everyone participating in the opportunity to hear each new idea. Participants handed their sketched and announced ideas to a facilitator for the group. The facilitators placed the ideas on the board adjacent to the table so all participants in the group could see them. This was to prevent overlap of ideas and encourage building upon ideas.

3.2.3 *Online Idea Generation*

Idea generation for the online groups of this study was conducted through the digital collaborative platform, Slack. It is a productivity and communication-oriented platform that is used by many corporate companies to handle communication channels. The platform is designed for collaboration and provides a variety of helpful tools for users, though said tools are not included as functions of this study and participants were instructed to focus on the idea generation channel. One major benefit of Slack for a study such as this is the easy real-time remote monitoring. This capability allowed the study facilitator to easily visualize participation in the activity in real time from an iPad, iPhone or other app/software-based internet connected device. The message style format of collaborative planning platforms like Slack allowed participants to generate ideas and be exposed to ideas in many of the same ways as traditional brainstorming.

To login all of the participants in the online groups, each was presented with anonymous account information for login that included a participant number, an email, and a password for logging into Slack. Each group channel was pre-populated so that when participants logged in they would immediately be in the idea generation channel. The main facilitator had access to a tablet that was logged into a Slack account with access to all 6 online groups' channels. The Slack channels also automatically saved all the messages within the channel. Being an online platform, participants in the Slack groups could access the internet during the study. They were instructed not to leave the Slack channel or browse the web during the study. During the first 10 minutes, the idea generation portion, they were instructed to type their ideas in text form within the Slack

channel, creating a message style chat conversation filled with only ideas. At the 10 minute mark, participants were instructed to stop ideating and begin sketching only the ideas they individually generated within the Slack channels. This was a countermeasure to prevent multiple users from unknowingly sketching the same ideas from the Slack channel and to maintain consistency with the traditional groups for the follow-up voting and sorting processes. Participants sat at a round table and sketched ideas on the large Post-Its. They wrote a title on the sketch before handing it to the facilitator to place on the board as with the traditional groups. However, the ideas were not announced before placement on the board as all participants had seen all the ideas generated during the first 10 minutes of the session.

3.2.4 *Recruitment & Participants*

The participants recruited came from a product design class at the University of Minnesota called “Toy Product Design.” The class environment encourages and fosters technical as well as creative approaches to the product design process. This semester-long course focuses on building product design skill sets and educating students on the entire process of designing and developing a consumer product.

One consideration for this study was that participants from the Toy Design class did receive training on general idea generation in lectures prior, but students in the control and experimental condition all received the same. Nonetheless, participants in the study came from a wide variety of academic backgrounds and their skill levels related to design varied at the time of data collection. While participants' levels of education and sources

of education on idea generation prior to the class may have varied widely, the specific toy design class notes and teachings they received in the weeks prior to the idea generation sessions were the same. These lessons focused on the basic principles of idea generation, some research on factors that enhance idea generation performance, and some basic practice of the techniques they applied in this study. The 76 participants were broken into thirteen groups total: eleven 6-person groups and two 5-person groups total across the two conditions:

- Traditional brainstorming groups totaled six 6-person groups and one 5-person group
- Online team-based idea generation groups totaled five 6-person groups and one 5-person group.

3.2.5 *Consent*

Participants were engaged in this activity for instructional purposes, rather than specifically for the study, so forms were signed to obtain consent for use of the anonymous data generated. Students were given the option to opt out of having their data used in the study, which would have then excluded that group's data from collection.

3.3 *Procedure*

3.3.1 *Step 1: Pre-session ideas*-Participants first sat down with the group and brought out the ideas generated in a prior class idea generation activity. During this time the participants discussed and narrowed down the pre-session ideas to only those the group

thought were worthwhile. Once they had finished narrowing down these ideas, the pre-session idea sketches were stacked and set aside for the in-class idea generation session. The pre-session ideas were used later in the class during the idea selection process. Only the in-class idea generation session is considered the study portion.

3.3.2 *Step 2: Instructions and Setup*-The instructions given to the participants were as follows:

- *Time:* The professor for the course explained to all of the participants that they would spend the next 20 minutes in their groups generating ideas in the form of sketches with titles.
- *Reserve judgment:* Participants were instructed to reserve judgment during the idea generation session. They were instructed not to comment on ideas or share their thoughts on ideas. During the session, they were encouraged to build upon ideas.
- *No bad ideas:* Participants were told at the start of the study that there are no bad ideas and to generate as many ideas as possible while being as creative as possible.
- Once all online groups were logged into the interface and their proper channel, the instructor informed the participants when to begin the idea generation session.
- *Traditional Brainstorming:* The traditional brainstorming groups were instructed to spend the entire 20 minutes thinking of ideas, sketching the ideas, then announcing and showing it to their group, finally handing it to the facilitator to place on the board.

- *Online groups:* Online groups were instructed to spend the first 10 minutes generating ideas within the Slack channel in the form of text. After the 10 minutes, they were instructed to switch from the Slack channel to sketching the ideas they generated with Slack for the remaining 10 minutes.

3.3.3 *Step 3: Idea generation session*-The study participants engaged in the 20-minute idea generation session.

3.3.4 *Step 4: Voting on ideas*- Following the idea generation session the students engaged in an idea sorting and voting process. See Figure 5.

Figure 5: Participants voting on ideas with dot stickers

- *Sorting:* Participants took all the session-generated ideas, and all the retained pre-session ideas and displayed them. Ideas were all placed on the wall for easier visibility, rather than sorting through the ideas on a table. Students were instructed to form categories and not talk until the categories were formed. They were also told not to cover up any ideas so all were visible.

- *Multivoting:* Multivoting refers to the group decision-making process of a structured series of votes. Once the wall space contained all the ideas, each participant was provided 12 stickers to vote with. The participants reviewed the session-generated and pre-session ideas together and placed votes on them.

3.3.5 *Step 5: Top 12 ideas*- After sorting and voting on the ideas. The group was instructed to select their top 12 ideas as based on the results of the multivoting. Participants discussed which ideas they felt deserved to be in the top 12 based on the votes and team agreement on idea quality. After discussion, participants selected the top 12 ideas and set them aside for the next step, leaving the sticker votes on all the ideas for later data recording.

3.3.6 *Step 6: Top 6 ideas*- Participants created a Pugh chart for their top 12 ideas to further compare the ideas on different criteria.

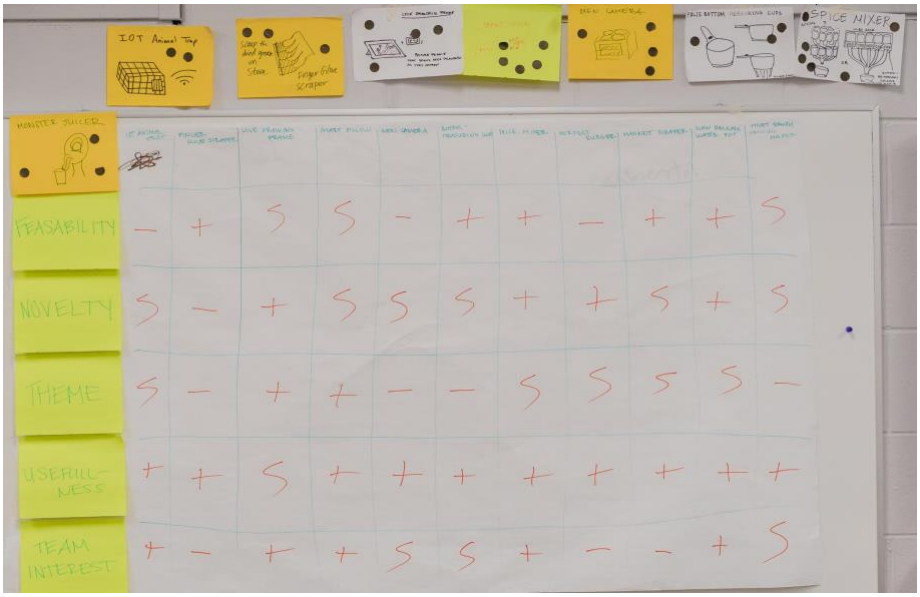


Figure 6: an example Pugh chart from one of the groups

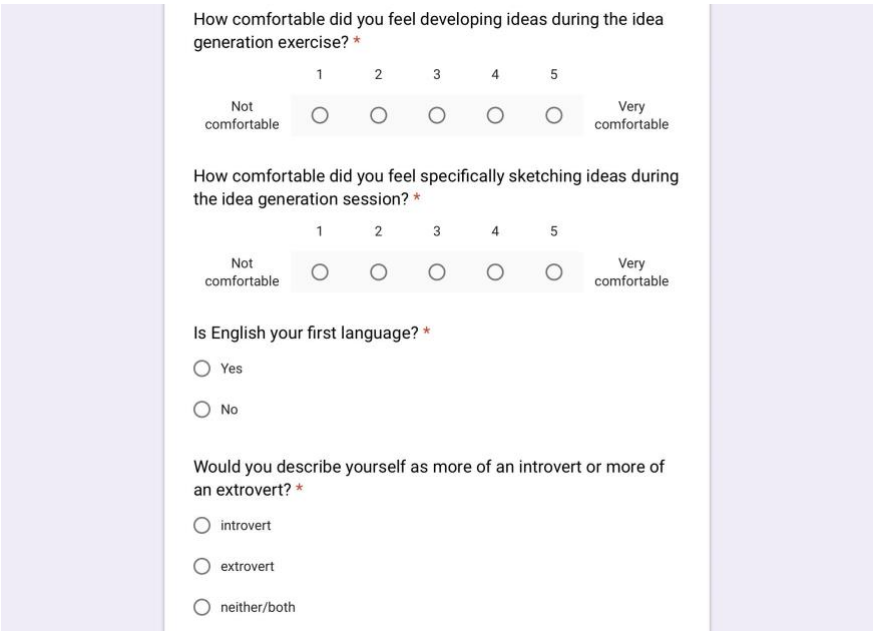
The criteria for the Pugh chart is shown on the left side of the chart along the y-axis in Figure 6. It was decided upon by the participants of that particular group, however, some common criteria across groups included novelty, feasibility, usefulness, and more. In the process of filling out the Pugh Chart, the team selected a product concept to be the benchmark which each idea was compared to on each category. In Figure 6, the benchmark is seen above the criteria on the y-axis. Participants rated each column idea from their top 12 against the benchmark idea for each criterion. They gave a "+" if the idea was better in that criteria, an "S" if it was the same, and a "-" if it was worse, as seen in Figure 6. Participants discussed and deliberated on which were the best ideas of the Pugh chart based on ratings and criteria. Using the results (both scores and discussion) from the Pugh Chart, teams selected a final best 5 or 6 ideas equivalent to the number of group participants. The physical sketches of the 12 ideas from the Pugh chart and the top 5 or 6 were recorded for later analysis and the count of votes.

3.3.7 *Step 7: Experience Survey*- One week following completion of the study, participants were sent the online survey through Google forms to collect the final portion of data. The survey aimed to gain further insight into the group's performance and experience. Individual responses were collected anonymously with matching to group data determined by a group identifier. The survey was conducted through Google forms. A snapshot of the form is shown in Figure 7. The questions on the survey measured the participants' self-reported experience performing in this idea generation session and factors that may have influenced it. Participants answered the following questions:

- How comfortable did you feel developing ideas during the idea generation exercise?

    - 1-5 from uncomfortable to comfortable
- How comfortable did you feel specifically sketching ideas during the idea generation session?
    - 1-5 from uncomfortable to comfortable
- Is English your first language?
    - Yes
    - No
- Would you describe yourself as more of an introvert or more of an extrovert?
    - Introvert
    - Neither/both
    - Extrovert

The survey data were analyzed to determine relationships and correlations between the survey questions responses and idea generation performance metrics.


How comfortable did you feel developing ideas during the idea generation exercise? *

	1	2	3	4	5	
Not comfortable	○	○	○	○	○	Very comfortable

How comfortable did you feel specifically sketching ideas during the idea generation session? *

	1	2	3	4	5	
Not comfortable	○	○	○	○	○	Very comfortable

Is English your first language? *

○ Yes

○ No

Would you describe yourself as more of an introvert or more of an extrovert? *

○ introvert

○ extrovert

○ neither/both

Figure 7: Snapshot of the survey sent to participants through Google forms

3.4 *Data Collection & Tracking*

3.4.1 *Slack idea generation channel*: Ideas were maintained within one continuous chat that is scrollable, as seen in Figure 8.

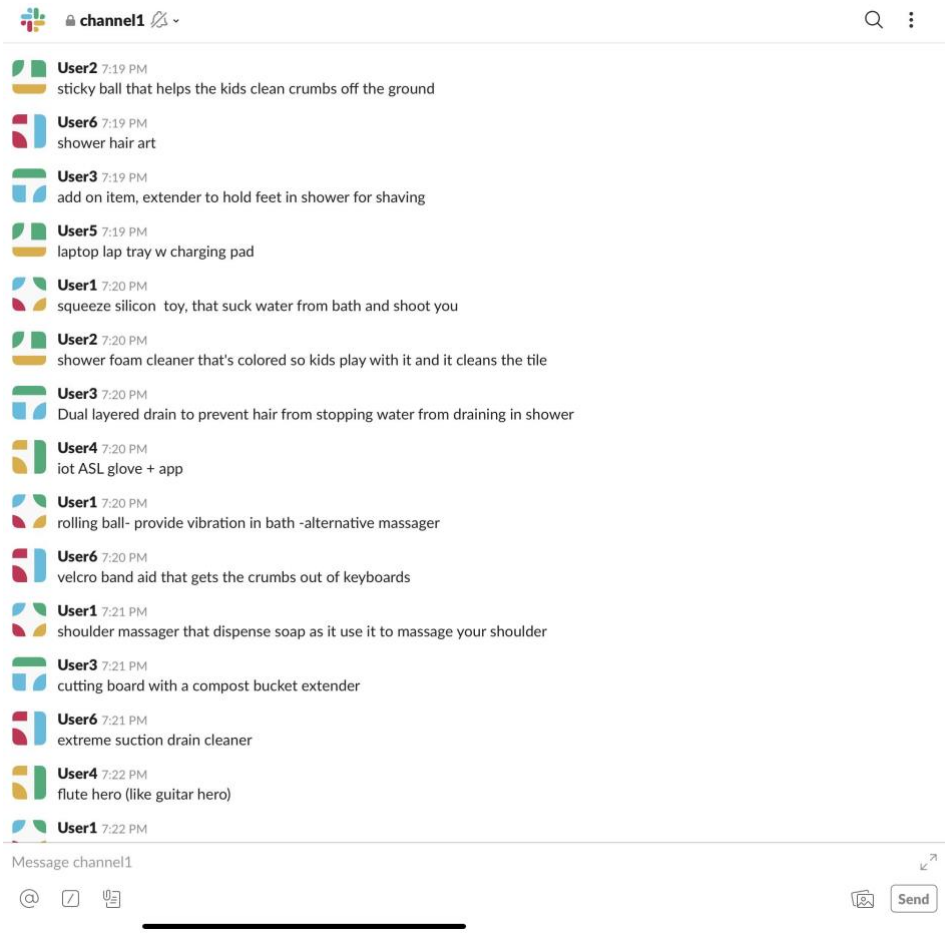


Figure 8: Slack channel of ideas from one of the groups showing anonymous user names

3.4.2 *Sketches of generated ideas*: Sketches were kept as physical copies for data analysis. Following the idea generation session, the sketches were scanned for records and for further analysis.

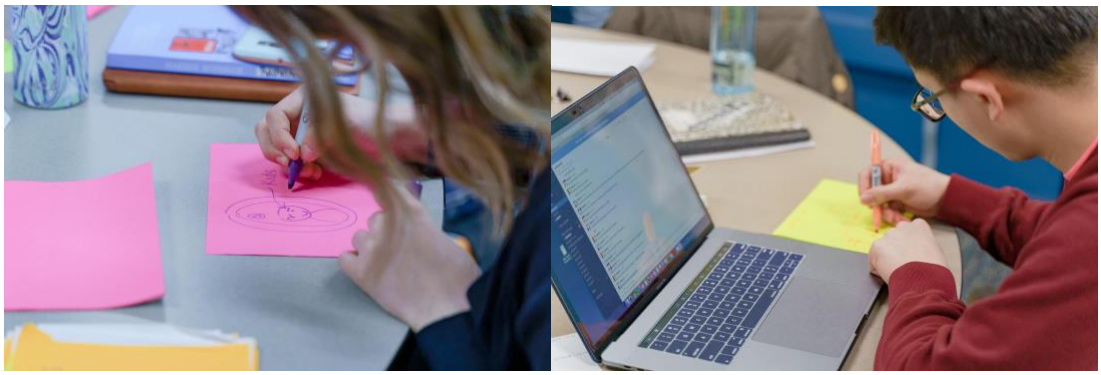


Figure 9: (left)A traditional brainstorming group participant sketching ideas as they generate them, (right) A Slack group participant sketching ideas from the Slack channel after completing the idea generation portion

3.4.3 *Idea Ratings by experts*

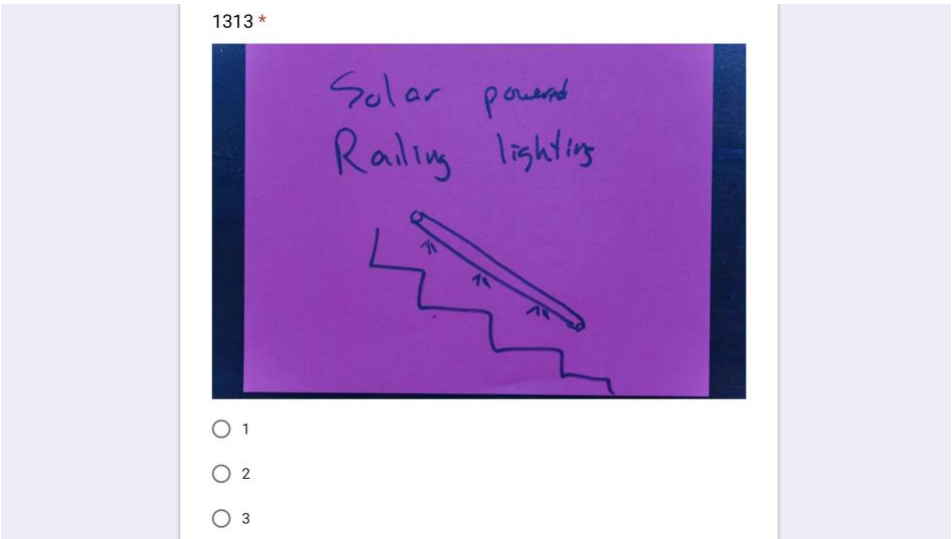


Figure 10: Snapshot of the Google form sent to reviewers

All ideas that were sketched during the study where digitized for online evaluation by expert reviewers. Both raters had experience evaluating product ideas. As product design

is a multidisciplinary field, the industry is composed of both engineering and design experts. One of the raters was an engineer and another was a graphic designer. Graphic designers are trained to focus on evaluating the visual such as the use of space, clarity of image, and concept communication. Engineers are trained as problem solvers and builders, evaluating most things based on feasibility, practicality, and function.

A collaborative practice evaluation was done with the two idea raters, with hopes of strengthening inter-rater reliability. They went through 50 idea ratings together and agreed upon criteria for each of the three rating levels (1, 2, and 3). Following the collaborative practice evaluation and determined criteria, idea raters were sent a Google form with scans of the remaining ideas to be evaluated. This portion was done individually, and the instructions for the form included a note of the discussed criteria from the collaborative practice evaluation. The order of the ideas was randomized for both raters and the ideas were coded for analysis. Criteria agreed upon by the two raters was as follows:

- *high-quality, Rating of 3:* The idea is original. The rater is able to immediately understand the idea and the function is clear.
- *Moderate Quality, Rating of 2:* The idea is easily understandable but not necessarily creative. The idea has redeeming qualities or workable flaws.
- *Low Quality, Rating of 1:* The idea function or concept is unclear. The idea is unoriginal or clearly already exists. The idea is an unnecessary adjustment to an existing idea. The idea is a random non-useful combination of components.

3.5 *Measures*

3.5.1 *Quantity of Ideas Measures*

All measures were gathered independently for each group:

- The average quantity of ideas generated per person
- The average quantity of ideas generated total
- The average quantity of ideas sketched per person for online groups only
- The average quantity of ideas sketched total for online groups only
- The average % of ideas sketched per person for online groups only
- The average % of ideas sketched total for online groups only

3.5.2 *Quality of Ideas Measures*

Quality of ideas measures involved participant's and rater's evaluation of the ideas with different methods. These measures were used to record data on participant evaluation of ideas. All measures were gathered independently for each group:

- The percentage of the total votes placed on session-generated ideas, by group
- The quantity of session-generated ideas added to the Pugh chart, by group
- The quantity of session-generated ideas in the top 5 or 6, by group

The following measures were used to record data on expert evaluation of ideas. All measures were gathered independently for each group:

- The average of expert reviewer scores, by group
- The quantity of ideas rated as high-quality by expert reviewers, by group

3.5.3 *Building Upon Ideas Measures*

To operationalize a measure for building upon ideas, threads were measured as ideas with a common word, used with the same meaning in different ideas. Examples of thread concepts include things such as “dog” or “humidifier. ” These themes were termed “Threads.” For example, a thread of ideas for the word “dog” might include the ideas “dog boots, dog collar, dog walker.” All the ideas use the thread concept word directly. All measures for building upon ideas were gathered independently for each group:

1. Total number of threads
2. The number of ideas in each thread
3. The number of threads that an idea contributes to

IV RESULTS

4.1 *Quantity of Ideas*

4.1.1 *Quantity of Ideas Generated: Slack versus Traditional Brainstorming*

Online groups averaged 54.8 ideas generated per group. Traditional groups averaged 43.1 ideas generated per group. Online groups’ average number of ideas generated differed reliably from the traditional groups’ average (difference=11.7 ideas generated, $t(11)=2.29$, $p<0.05$). Even if the high performing online 2 group that generated 77 ideas, 18 more than any other group, is removed from the traditional group average, online groups still averaged approximately 8 more ideas generated than traditional brainstorming groups, $t(10)=2.13$, $p<0.05$. Online groups averaged 2 more ideas

generated per person than traditional brainstorming groups during the idea generation session, t(11)=2.45, p<0.05.

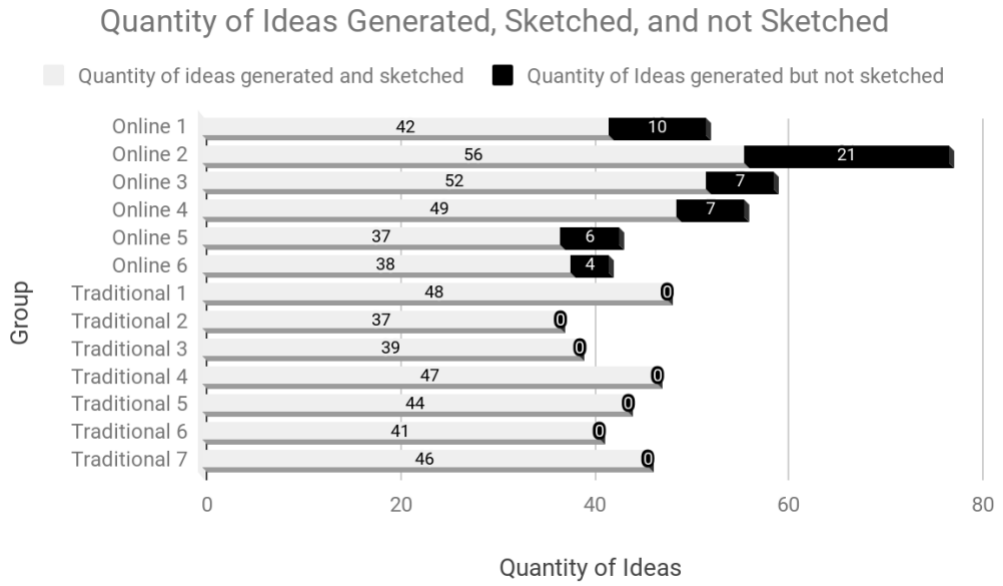


Figure 11: Chart showing the quantity of ideas generated and sketched by groups

4.1.2 *Quantity of Ideas Sketched: Slack vs. Traditional Brainstorming*

As shown in Figure 11 above, while online groups clearly generated more ideas, they were not able to sketch them all. Online groups averaged 45.7 ideas sketched per group. Traditional groups averaged 43.1 ideas sketched per group. Online groups' average number of ideas sketched did not differ reliably from the traditional groups' average (difference=2.6 ideas sketched, t(11)=0.74, p>0.05). Online groups averaged 0.4 more ideas sketched per person than traditional brainstorming groups, t(11)=0.66, p>0.05.

4.1.3 *Quantity of Ideas: Slack versus Traditional Brainstorming Summary*

Online groups were only able to sketch to an average of 84.3 % of the ideas they generated.

Group Size	Group	Ideas sketched	Ideas generated	Ideas Sketched (per person)	Ideas Generated (per person)	% of Ideas Sketched
5	Online 1	42	52	8.4	10.4	80.8
6	Online 2	56	**77**	9.3	12.8	72.7
6	Online 3	52	59	8.7	9.8	88.1
6	Online 4	49	56	8.2	9.3	87.5
6	Online 5	37	43	6.2	7.2	86.0
6	Online 6	38	42	6.3	7.0	90.5
6	Traditional 1	48	48	8.0	8.0	100
5	Traditional 2	37	37	7.4	7.4	100
6	Traditional 3	39	39	6.5	6.5	100
6	Traditional 4	47	47	7.8	7.8	100
6	Traditional 5	44	44	7.3	7.3	100
6	Traditional 6	41	41	6.8	6.8	100
6	Traditional 7	46	46	7.7	7.7	100
35	*Online Avg.*	45.7	54.8	7.8	9.4	**84.3**
41	*Traditional Avg.*	43.1	43.1	7.4	7.4	100.0

Table 1: Idea quantity Table

4.2 *Idea Quality*

4.2.1 *Participant Idea Rating results for total votes, Pugh chart worthy ideas, and top ideas*

Votes: Both online groups and traditional brainstorming groups used approximately 20% of their votes on average on session-generated ideas and approximately 80% on ideas generated prior to this study. Online groups averaged 14.5 votes on session generated

ideas compared to 15.1 for traditional groups. This was not a reliable difference in votes (difference=0.6 votes on session generated ideas, t(11)=0.24, p>0.05). See Figure 12 for the full data set comparison. When the traditional group 1 outlier was removed, the average for traditional groups increased to 17.2, t(11)=1.54, p>0.05.

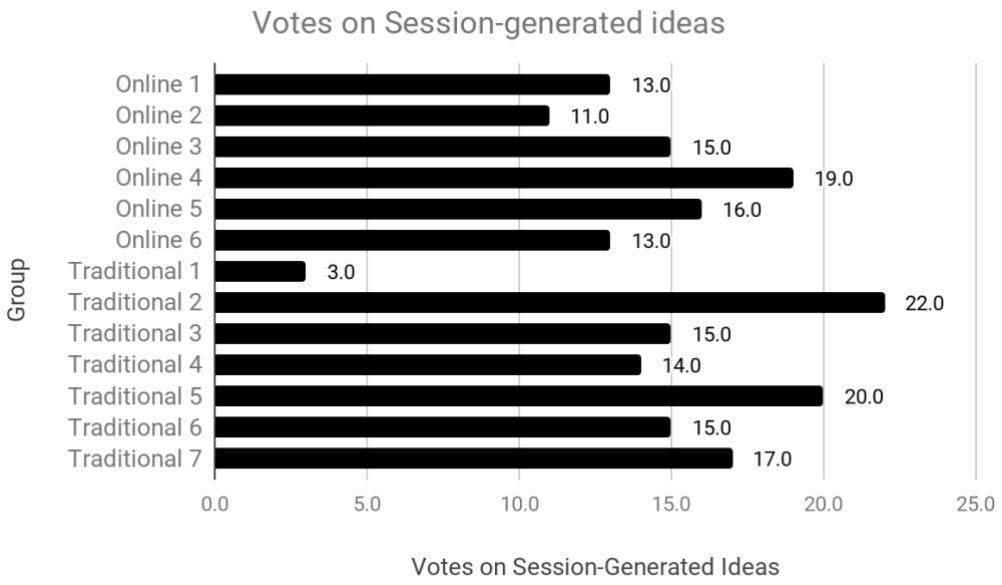


Figure 12: Chart showing the number of voting dots on ideas generated during the session

Pugh Chart Worthy Ideas: The average number of session-generated ideas included as Pugh chart worthy ideas for Online groups was 1.7 compared to 1.6 for traditional brainstorming groups. This was not a reliable difference (difference=0.1 ideas, t(11)=0.14, p>0.05). See Figure 13.

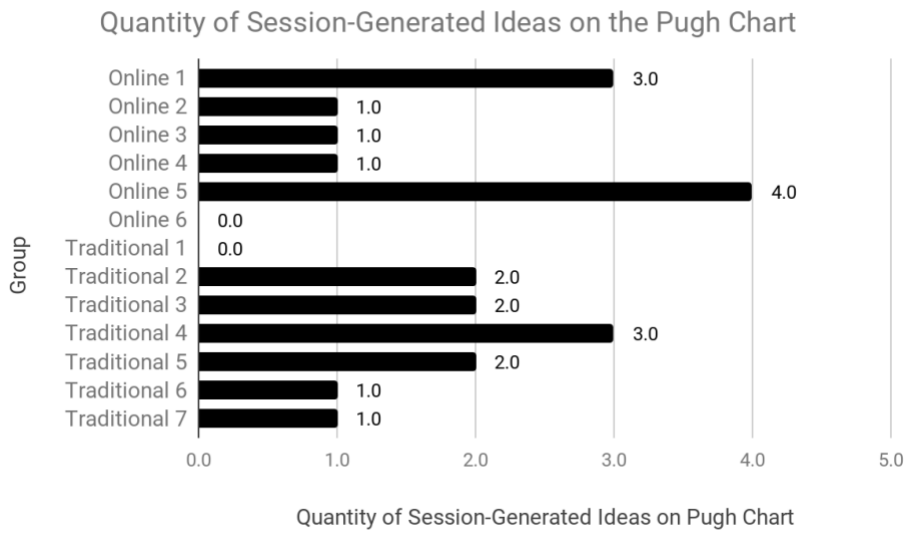


Figure 13: Chart showing the number of session-generated ideas selected by each group for the Pugh chart

Top ideas: The average number of session-generated ideas in the top 5/6 for Online groups was 0.8 compared to 0.6 for traditional brainstorming groups. This was not a reliable difference (difference=0.2, $t(11)=0.73$, $p>0.05$). See Figure 14.

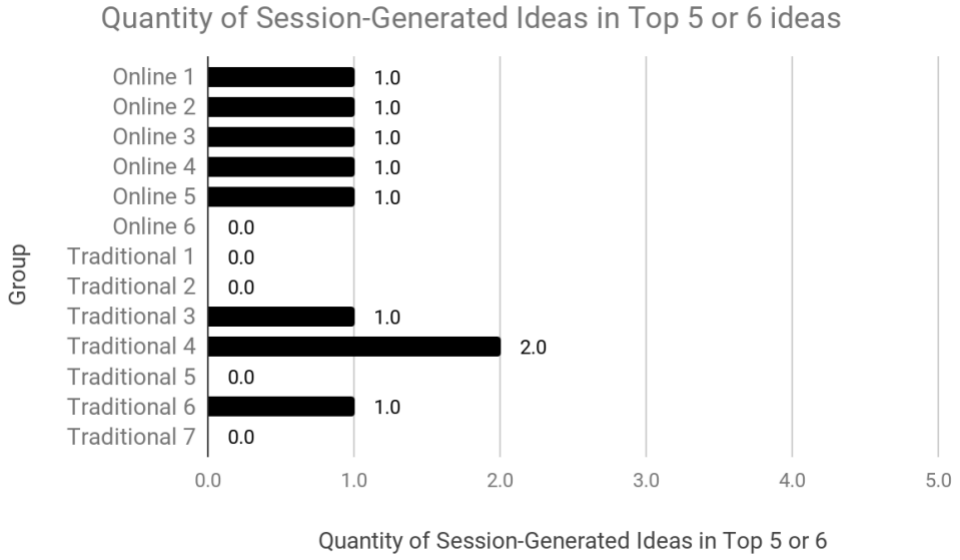


Figure 14: Chart showing the number of session-generated ideas selected as top 5 or top 6 by each group

4.3 *Expert Idea Rating*

The table shows the inter-rater reliability scores for the idea quality ratings. The two product experts, one an engineer and one a designer rated the ideas on a scale from 1 (lower quality) to 3 (higher quality).

4.3.1 *Inter-rater reliability*

For the full 576 session-generated ideas rated, the raters had an agreement percentage of 54%. The inter-rater reliability cohen's kappa value was 0.18.

- An idea was given an overall rating of 3 if it received either 2 3s or a 3 and a 2 as ratings.
- An idea was given an overall rating of 2 if it received 2 2s or a 2 and a 1 as ratings.
- An idea was given an overall rating of 1 if it received 2 1s as ratings.

INTER-RATER-RELIABILITY

		RATER 2			
		1	2	3	TOTAL
RATER 1	1	206	55	0	261
	2	145	98	5	248
	3	0	60	7	67
	TOTAL	351	213	12	576
	AGREEMENT	206	98	7	311

% AGREEMENT	54.0
COHEN'S KAPPA	0.18

Table 2: Inter-rater reliability calculation

4.3.2 *Expert Idea Rating Results*

For the individual ratings of the rater 1, online groups averaged 6.67 ideas rated as high-quality and traditional brainstorming groups averaged 5.14 ideas rated as high-quality. The difference was not reliable for rater 1 alone (difference=1.53 ideas rated high-quality, $t(11)=1.65$, $p>0.05$). For the individual ratings of the rater 2, online groups averaged 1.5 ideas rated as high-quality and traditional brainstorming groups averaged 0.43 ideas rated as high-quality. The difference was also not reliable for rater 2 alone (difference=1.07 ideas rated high-quality, $t(11)=1.46$, $p>0.05$). For the combined ratings of the two experts, online groups averaged 6.8 ideas rated as high-quality in contrast to only 3.6 ideas rated as high-quality in traditional brainstorming groups. The difference for the combined ratings was reliable (difference=3.2 ideas, $t(11)=3.61$, $p<0.05$). On a per-person level, this translated to 1.2 ideas for Slack and 0.6 ideas for traditional brainstorming groups. See Figure 15.

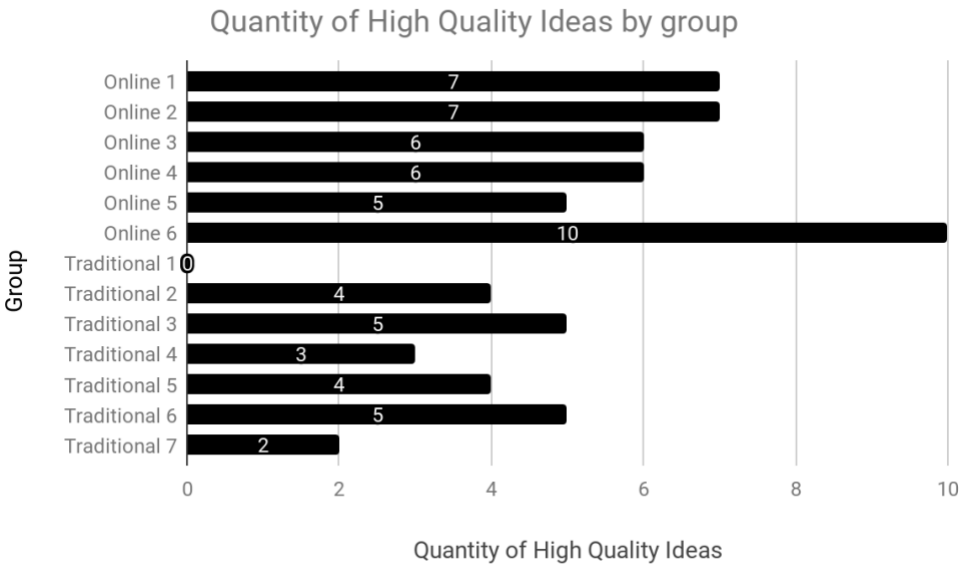


Figure 15: Chart showing the number of high-quality ideas by group as rated by experts

4.3.3 *Slack individual participant high-quality ideas as measured by experts*

Online participants' usage of anonymous logins allowed tracking of where ideas came from by user but not individual. Only 4 participants online generated more than 2 high-quality ideas as rated by experts. 14 participants generated no high-quality ideas, while the remaining 20 participants as measured by experts contributed either 1 or 2 high-quality ideas. 61% of online participants generated at least 1 high-quality idea.

4.4 *Building Upon Ideas*

The results from building upon ideas were examined with respect to the number of threads, the number of unique threads, and the length of threads. Evaluation of idea threads was based on the title of the idea given by the participants. Online groups averaged 27.3 threads per group. Traditional groups averaged 15.7 threads per group. The

average number of threads per group differs reliably between the two conditions (difference=11.6 threads, $t(11)=3.35$, $p<0.05$).

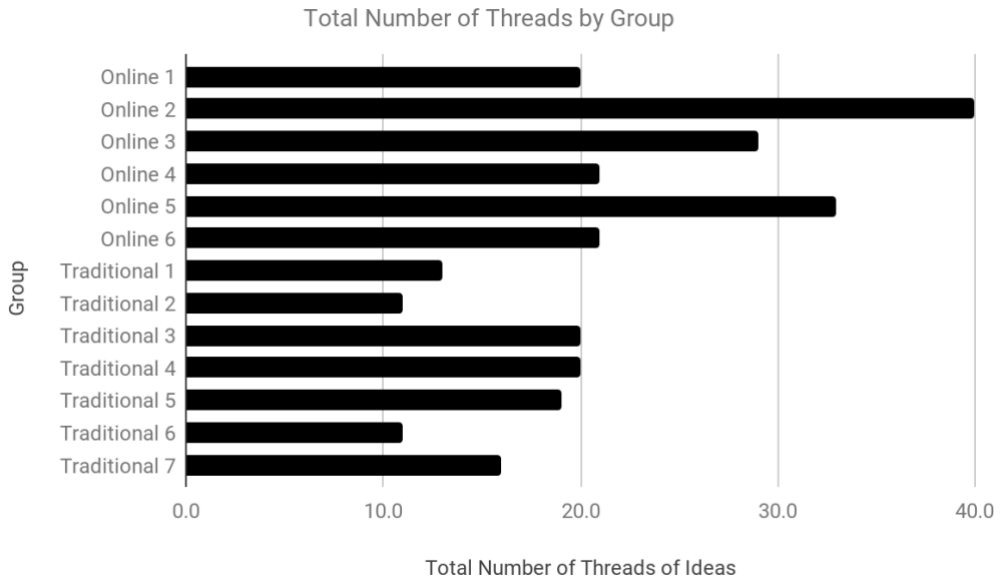


Figure 16: Total number of threads of ideas per group

4.4.1 *Threads*

The relationship between the total number of idea threads and the number of ideas generated had a moderate correlation coefficient of R=0.65. The Pearson (R) result is significant at a 0.05 significance level. See Figure 17.

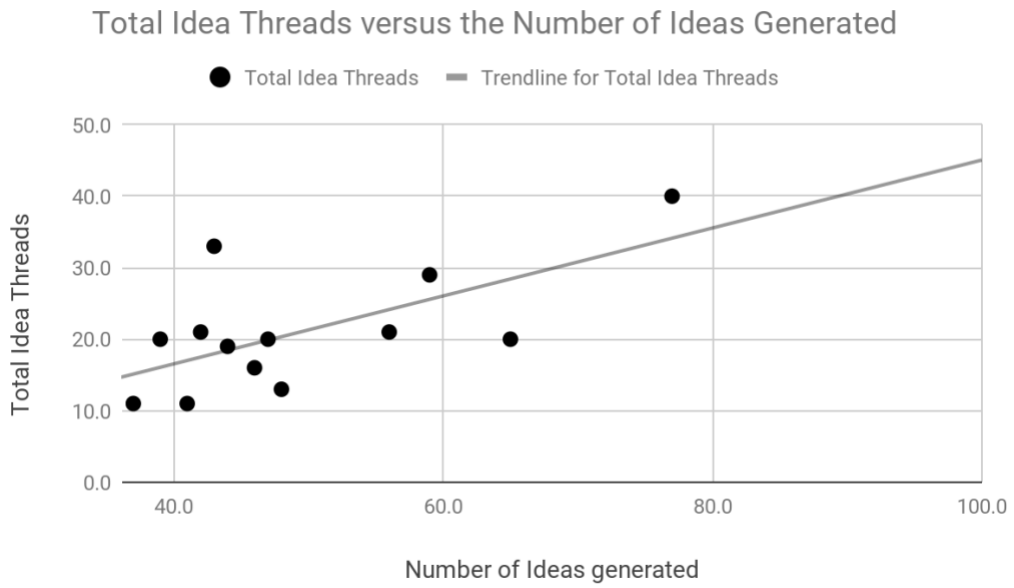


Figure 17: Chart showing the total number of threads versus total ideas generated

The relationship between total threads and the number of high-quality ideas yields a correlation coefficient of R= 0.401. The Pearson (R) result is non-significant at a 0.05 significance level. See Figure 18.

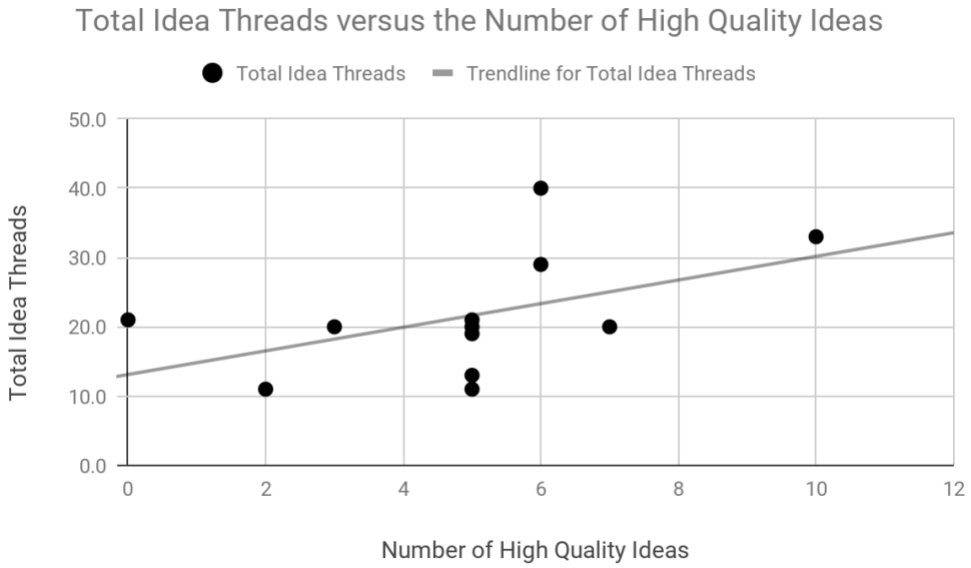


Figure 18: Chart showing the total number of threads versus the number of high-quality ideas

Figure 19 shows the breakdown of the threads for each group by the percentage of common threads and the percentage of unique threads. Common threads represent those that appear in multiple groups. Online groups averaged 12 unique threads per group. Traditional groups averaged 6 unique threads per group. Online groups had a reliable difference in an average number of unique threads from traditional brainstorming groups (difference=6, $t(11)=2.04$, $p<0.05$), though this data was influenced by the higher total average number of threads. Only 1 out of 6 online groups had fewer than 7 unique threads while 5 out of 7 traditional brainstorming groups had fewer than 7. However, as a percentage of total threads, online groups averaged only 6% more unique threads than traditional brainstorming groups, $t(11)=0.73$, $p>0.05$.

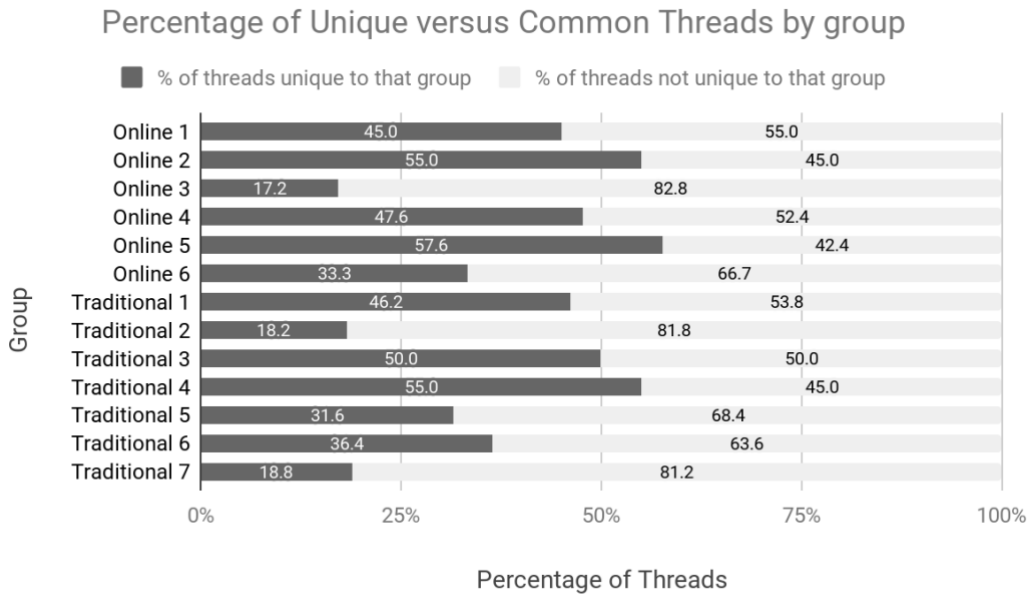


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Figure 19: Chart showing the percentage of unique and common threads by group

4.4.2 *Length of Threads*

Thread Length						
Group Size	Group	Ideas Generated	Total Idea Threads	% Threads with Only 2 Ideas	% Threads with 3+ Ideas	% Threads with 4+ Ideas
5	Online 1	52	20.0	40.0	60.0	25.0
6	Online 2	77	40.0	40.0	60.0	12.5
6	Online 3	59	29.0	55.2	44.8	20.7
6	Online 4	56	21.0	61.1	38.9	22.2
6	Online 5	43	33.0	75.8	24.2	9.1
6	Online 6	42	21.0	61.9	38.1	19.0
6	Traditional 1	48	13.0	84.6	15.4	15.4
5	Traditional 2	37	11.0	63.6	36.4	9.1
6	Traditional 3	39	20.0	70.0	30.0	5.0
6	Traditional 4	47	20.0	60.0	40.0	10.0
6	Traditional 5	44	19.0	68.4	31.6	15.8
6	Traditional 6	41	11.0	81.8	18.2	18.2
6	Traditional 7	46	16.0	75.0	25.0	12.5
35	*Online Avg.*	54.83	**27.33**	55.67	44.33	18.08
41	*Traditional Avg.*	43.14	**15.71**	71.91	28.09	12.29

Table 3: Thread lengths by group

Table 3 shows the breakdown of threads by length. The metrics were designed to show minimum, slightly above average, and well above average performance thread lengths from left to right. The average thread length for online groups was 2.66 ideas. Average thread length for traditional groups was 2.48 ideas. The average thread length differed reliably between the two conditions (difference=0.18 ideas, $t(11)=2.11$, $p<0.05$). The

percentages of 2-idea threads, 3 or more idea threads, and 4 or more idea threads can further illuminate the differences in the depth of idea building occurring in the threads.

The relationship between average thread length and total ideas generated, shown in Figure 20, has a moderate to high correlation coefficient of R=0.71, p<0.05. With the outlier (77 ideas generated) removed, the correlation is still moderate at R=0.68, p<0.05.

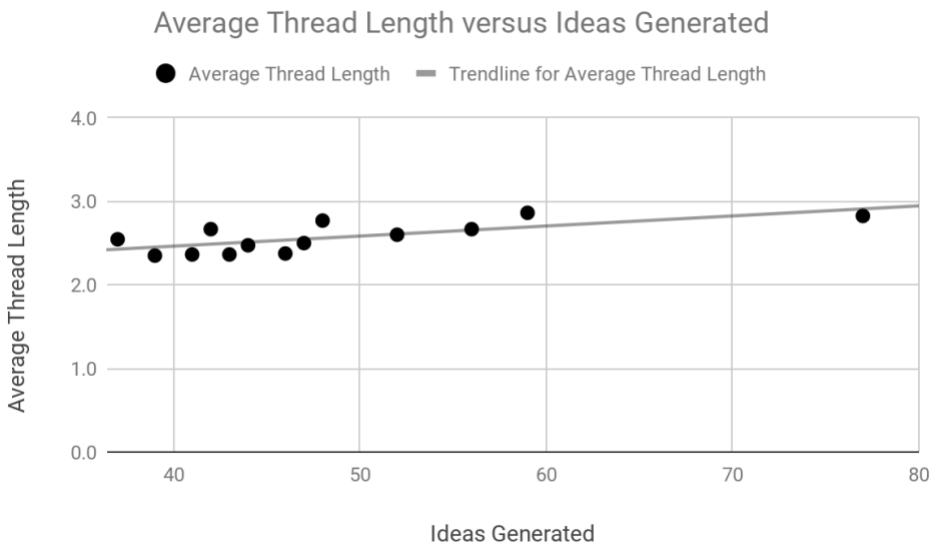

Figure 20: Chart showing the relationship between average thread length and total ideas generated

The relationship between average thread length and the number of high-quality ideas, shown in Figure 21, has a weak correlation coefficient of R=0.22, p>0.05.

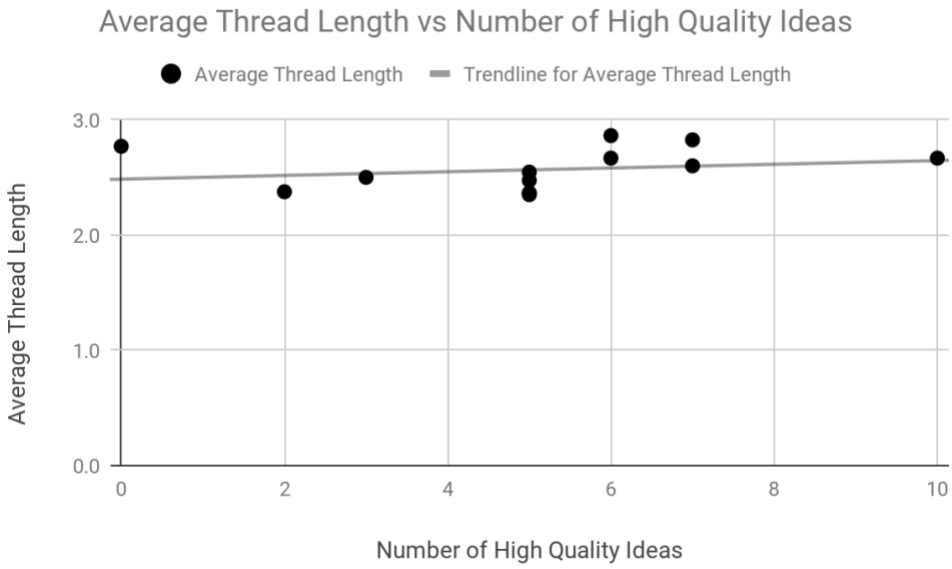

Figure 21: Chart showing the relationship between average thread length and quantity of high-quality ideas

4.4.3 *Idea inclusion in threads*

The percentage of ideas with at least one thread showed a clear advantage for online groups with an average of 78.5% compared to 53.6% for traditional brainstorming groups, $t(11)=3.71$, $p<0.05$. Observing Figure 22, we see that online groups had a smaller proportion of ideas with 0 or only 1 thread. Online groups also had significantly higher percentages of ideas with 2 or more threads, $t(11)=4.64$, $p<0.05$.

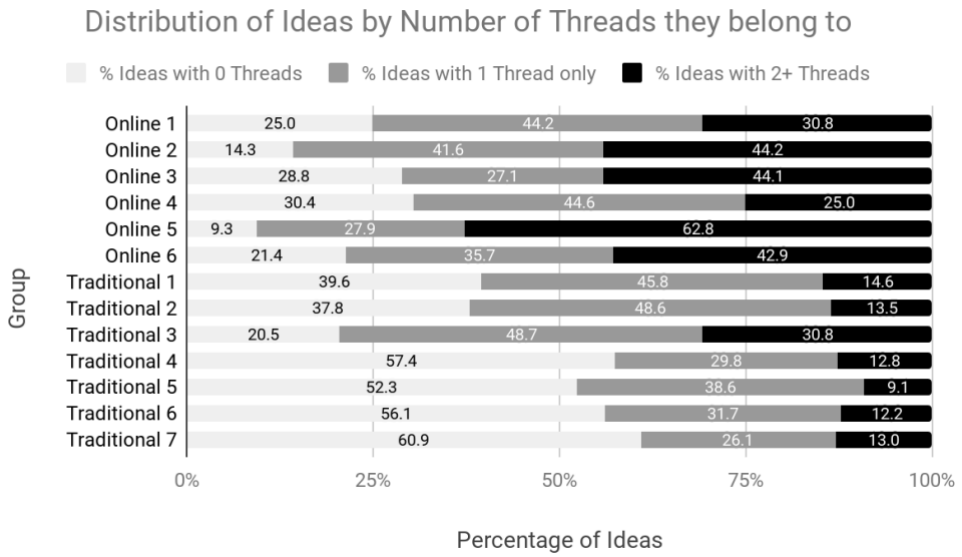

Figure 22: Chart showing the distribution of ideas by group and by the number of threads the idea contributes to

4.5 *Survey Results*

The overall average comfort level developing ideas was 4.04 out of 5. The overall average comfort level sketching ideas was 3.78 out of 5. The overall average number of ESL (English as a second language) participants per group was 0.85. No group had more than 2 ESL participants. The overall average on the introvert to extrovert scale was exactly 2 on a scale of 1 to 3, indicating balance overall between introverts and extroverts in the study.

Group	Ideas Generated	Ideas Sketched	Comfort Level Developing Ideas (1-5)	Comfort Level Sketching Ideas (1-5)	Number of ESL Participants	Introvert to Extrovert Spectrum (1-3)
Online 1	52	42	3.4	4.0	1	1.8
Online 2	77	56	4.2	4.3	1	2.8
Online 3	59	52	4.8	4.0	2	2.0
Online 4	56	49	4.7	3.8	1	1.5
Online 5	43	37	4.0	4.0	0	2.0

Online 6	42	38	4.2	4.0	0	2.0
Traditional 1	48	46	4.0	3.8	2	2.2
Traditional 2	37	41	3.0	3.2	1	2.0
Traditional 3	39	44	4.3	3.7	1	1.8
Traditional 4	47	37	3.9	3.7	0	2.0
Traditional 5	44	48	3.9	3.7	0	2.2
Traditional 6	41	39	4.3	4.0	2	2.2
Traditional 7	46	47	3.8	3.0	0	1.5
Online Avg.	54.83	45.67	4.22	4.02	1	2.02
Traditional Avg.	43.14	43.14	3.89	3.59	1	1.98

Table 4: Survey results data by group

Online groups' average comfort ratings did not differ reliably from the traditional groups' average (difference=0.33 out of 5, $t(11)=1.26$, $p>0.05$). Online groups rated their average comfort level sketching ideas 0.43 points higher than traditional brainstorming groups, $t(11)=2.74$, $p<0.05$. There was no statistical difference in the average group introvert-extrovert rating for online groups compared to traditional brainstorming groups, $t(11)=0.16$, $p>0.05$. Online groups had a correlation coefficient of 0.56 between introvert/extrovert scale and the number of ideas generated per person, favoring more extroverted groups. However, this was not statistically significant for the number of online groups. The correlation coefficient of the introvert/extrovert scale and the number of ideas generated per person for traditional brainstorming groups is $R=0$. Online groups had a weak correlation coefficient of $R=0.14$, $p>0.05$, between introvert/extrovert scale and the number of high-quality ideas. Traditional brainstorming groups had a weak

correlation coefficient of R=0.15, p>0.05, between introvert/extrovert scale and the number of high-quality ideas.

4.5.1 *English As a Second Language Participants*

The correlation coefficient for the proportion of ESL participants versus ideas generated per person was weak at R=0.35, p>0.05. The correlation coefficient for the proportion of ESL participants versus the number of high-quality ideas was weak at R=0.34, p>0.05.

4.5.2 *Comfort Level Sketching Ideas*

The correlation coefficient for comfort level sketching ideas versus ideas sketched per person was weak at R=0.27, p>0.05.

4.5.3 *Comfort Level Developing Ideas*

The correlation coefficient for comfort level developing ideas versus ideas generated per person was weak at R=0.14, p>0.05.

V-DISCUSSION

5.1 *Summary of Results and Support for Hypotheses*

5.1.1 *Hypothesis 1: Online groups will generate and sketch more ideas than traditional brainstorming groups*

Online groups generated a statistically significant average of 11 more ideas than traditional brainstorming groups. Online groups also sketched a statistically insignificant

0.4 more ideas per person than traditional brainstorming groups. It is evident from the data that online groups did not have enough time to sketch all the ideas they generated, only 84.3 percent of their ideas on average. They did, however, have measurably more success in generating ideas than traditional brainstorming groups. One outlier online group generated 77 ideas, 18 more ideas than any other group. Nonetheless, removing this from the data for analysis still resulted in a statistically significant advantage in the number of ideas generated for online groups. Hypothesis 1 is partially supported as online groups generated more ideas and sketched more though the difference in sketched ideas was not statistically significant. Given more time to sketch ideas, the hypothesis may have been more strongly supported. However, further study is needed to see if the time increase would maintain the reliable difference in ideas generated between the two conditions.

One of the strengths of online idea generation is the reduction of "production blocking," when participants have to take turns sharing ideas (Nijstad & Stroebe, 2006). The findings of the study seem to agree with existing research that online idea generation reduces the effects of production blocking, as online groups generated ideas at a much faster pace than traditional brainstorming groups. Specifically, in Slack the continuous thread style and digital chat communication allowed multiple participants to send ideas simultaneously without having to wait for each other. It could also be the case that online groups generated more ideas simply because they did not have to sketch as they generated ideas.

5.1.2 *Participant Rating Hypothesis 2A: Online groups, as measured by participants in the session, will place more votes on their session-generated ideas, select more to be on the Pugh chart, and select more ideas to be in the top final ideas from the Pugh chart than traditional brainstorming groups.*

Hypothesis 2A is not supported as no statistically significant evidence was uncovered in support of participant selection differences. Online and traditional brainstorming groups used approximately the same percentage of their votes on session-generated ideas. The results for participant evaluation of ideas, selecting a top 12 ideas for the Pugh chart and a top 5 or 6 final ideas, yielded non-significant differences between online and traditional brainstorming groups.

Several factors could have contributed to the low number of session-generated ideas selected for the top 12 and top 5 or 6. Pre-session ideas could simply have contained many high-quality ideas, causing participants in both conditions to choose them over the session-generated ideas. It could also be the case that participants were biased by the increased time spent with the pre-session ideas prior to the in-class idea generation session. Group discussion and thinking may also have led to good ideas from the study idea generation session being tossed. Differences in pugh chart categories also likely contributed to differences in idea selection from the top 12 to the top 5 or 6.

5.1.3 *Expert Rating Hypothesis 2B: Online groups will generate more high-quality ideas than traditional brainstorming groups measured by quantitative expert ratings of idea quality.*

The inter-rater reliability Cohen's kappa value of 0.18 is low, but considering the non-equiprobable nature of the 3 rating levels in combination with the subjective nature of creativity, this number is less alarming. It also can be easily discerned from the data that rater 2 was harsher in their rating of ideas. Raters agreed on only 7 ideas as definitive 3s, but 72 ideas received a 3 from at least 1 rater.

Online groups averaged a statistically significant 3.2 more high-quality ideas. Online groups outperformed traditional brainstorming groups in quantity of high-quality ideas generated on both the group and per-person levels. Hypothesis 2B is supported as online groups did generate more high-quality ideas as rated by experts. Online groups also generated more ideas and better ideas than traditional brainstorming groups, in support of the quantity-quality correlation mentioned in past studies (Adánez, 2005). The anonymity of online groups may also have made participants more likely to suggest more outlandish or taboo ideas, leading to more unique threads of ideas and more original ideas.

The inclusion of pre-session ideas as a factor in the selection process for participants' creativity ratings is a major difference that likely contributed to the lack of continuity between the results of hypotheses 2A and 2B. Student ratings of creativity likely did not match expert ratings of creativity for several reasons. Differences in criteria and process of selection is another major difference between the participant ratings and the expert ratings. The number of ideas evaluated is also significantly different for the groups compared to the two raters, with the raters evaluating 576 ideas and the groups choosing the top 12 ideas from numbers between 60 and 150 ideas. Additionally, the raters were

product design experts whereas the participants were students from a variety of disciplines that could generally be considered novices with respect to product design.

5.1.4 *Hypothesis 3A: Groups with more threads, or longer average thread length, will have more ideas.*

Online groups averaged a statistically significant 11.6 more threads generated than traditional brainstorming groups. They also averaged a statistically significant 0.18-idea longer average thread length than traditional brainstorming groups. There was a moderate, and statistically significant correlation of R=0.65 between total threads generated and the number of ideas generated. Average thread length had a statistically significant high correlation, R=0.71, with the total number of ideas generated. Hypothesis 3A is supported. Online groups not only generated more unique threads of ideas, showing the capacity to make non-obvious connections, but also more generated high-quality ideas as ranked by experts, showing the ability to synthesize the connections into creative concepts.

Online groups' ideas tended to skew more towards more connections to threads in contrast to fewer connections to threads in ideas of traditional brainstorming groups. This could be due to the greater number of ideas to create threads with. It could also be a function of the increased visibility of ideas in the Slack channel for online groups compared to ideas placed on the board for traditional groups. Traditional brainstorming groups placed all the ideas on the board as they were generated, but participants had to look at the board, and then their page to sketch. Online groups, in contrast, could both see

all the group ideas and generate ideas on the same page, so they did not need to look away from their page to gain inspiration or build upon ideas. Additionally, traditional groups were viewing ideas as sketches while generating ideas. Online groups were viewing ideas in text only while generating ideas.

5.1.5 *Threads and Quality of Ideas Hypothesis 3B: Groups with more threads, or longer average thread length, will have more high-quality ideas.*

Prior research says that creativity comes from one's ability to make non-obvious connections between unrelated things (Mednick, 1962). The relationships between average thread length or total number of idea threads and the number of high-quality ideas generated are weak correlations of R=0.22 and R=0.401. Hypothesis 3B is not supported as there is no statistically significant correlation between the number of high-quality ideas and the metrics for building upon ideas. The lack of reliable relationships between thread length, number of threads, and high-quality ideas illuminate a question of whether staying on a thread or starting a new thread is more important. The data would suggest total number of threads is more important, though neither correlation is strong. It could be that longer threads lead to more creative ideas, but it's just as likely that creating many threads and greater diversity of ideas leads to more high-quality ideas. Based on the correlation coefficients it's also possible that there is a negative relationship or no relationship at all between these metrics.

5.1.6 *Top Ideas and Threads Hypothesis 3C: Top ideas are more likely to be a part of threads.*

Hypothesis 3C was not supported. While higher-rated ideas on average belonged to a slightly greater number of threads according to the data, the result was not statistically significant.

5.1.8 *Secondary Survey Results Summary*

There was no discernible relationship between performance metrics and group proportion of ESL participants, between comfort sketching ideas and quantity sketched per person, or between comfort level developing ideas and quantity generated per person. Online groups did, however, report a statistically significant 0.43 points high average comfort level sketching ideas than traditional brainstorming groups. Task visibility was better in the pnline groups because of the centralized, automatic scrolling channel-style of the platform. According to past studies by Harkins & Petty (1982) and George (1992), task visibility decreases social loafing, so production differences between online and traditional brainstorming groups are influenced by this difference.

Based on engagement in building upon ideas within online groups it appears these effects have had their theorized effect. Similar to the findings of this study, past studies have found online groups to report greater satisfaction with participating in the activity through an online platform, while also being more productive in the study (DeRosa et. al, 2007). Online groups also rated their comfort level developing ideas an average of 0.33 points higher than traditional brainstorming groups, though this was not a statistically significant result. Online groups succeeded at all of the things Osborn (1953) feels the activity of idea generation requires. They succeeded at deferring judgment on ideas by generating a

lot without commenting on ideas in the channel. They succeeded in encouraging outlandish ideas, with online groups building upon more unique threads than traditional brainstorming groups. Finally, they succeeded at building upon the ideas of others by producing a greater number of threads and longer average threads than traditional brainstorming groups.

5.2 *Limitations of the study*

5.2.1 *Slack novelty effect? The similarity to social media?*

Slack is a relatively new platform and is not used with the frequency of social media platforms, particularly within the participant demographics. There is a possibility that the similarities of Slack to some social media platforms, or the novelty of the digital interface in comparison to traditional brainstorming, may have influenced performance. Online groups generated ideas and built upon ideas more extensively than traditional brainstorming groups, suggesting either increased motivation, advantageous skills for the task or minimized production blocking effects. Assuming approximately equivalent overall group skill levels, and understanding past literature suggests online idea generation reduces production blocking, increased motivation seems a possible justification for the superior performance on some metrics. It is unclear whether this is due to the novelty of the platform or similarity to social media. It remains a limitation of this study that motivation for participation is unclear and not discernible from the data.

5.2.2 *Engineer vs. designer ratings*

The expert idea ratings were done by product designers in two disciplines, design and engineering. A collaborative practice evaluation was done in hopes of increasing inter-rater reliability due to the representation of two different disciplines in product design. This was unsuccessful as the inter-rater reliability score was still low. Having defined criteria in advance instead of utilizing a collaborative practice evaluation may be more beneficial for future work utilizing raters with different backgrounds. The scale the raters agreed upon for high-quality, moderate quality, and low-quality ideas covered multiple metrics including clarity, creativity, and usefulness.

5.2.3 *Idea generating time and sketching time*

Another limitation of the study is that online groups generated ideas for 10 minutes then sketched ideas for 10 minutes, while traditional brainstorming groups simultaneously generated and sketched ideas for 20 minutes. While online groups clearly generated significantly more ideas than traditional brainstorming groups, it is difficult to discern if this difference was due to being online or due to the process of generating ideas before sketching in contrast to doing both simultaneously. However, as the difference in the number of sketched ideas is inconclusive, it appears that the difference does not impact the number of sketched ideas. This suggests participants may have spent approximately the same amount of time sketching ideas, but less time generating each idea in the online platform. More time should have been given overall as online groups clearly were not able to sketch all their ideas generated. A future study could provide more time for both sessions so that ideas are not left generated but un-sketched. Additionally, later ideas in the session tend to be more creative ideas. The ideas that online groups were unable to

sketch theoretically are those from later in the session as they started sketching their ideas from the beginning of the session first. It is possible that online groups had fewer of their best ideas make it to the expert evaluation stage because of this. This could yield an even greater difference in the number of high-quality ideas between the two conditions.

5.2.4 *Nominal idea generation versus interactive group idea generation*

It is important to note that most research on idea generation in groups still supports nominal idea generation as the more productive method. While this study presents findings that support the need for and feasibility of further research into interactive group idea generation, nominal idea generation remains a potentially more viable option.

5.2.5 *Group Size*

Studies have been conducted on group size comparisons for electronic and non-electric brainstorming that found larger groups in electronic brainstorming generated more unique ideas, though the same scaling effect was not seen in non-electronic groups (Gallupe et. al, 1992). Nonetheless, that study only examined groups up to 12 participants. The lack of group size comparison is a limitation of this study as it remains unclear what the ideal group size is for idea generation through Slack. It could be the case that smaller or larger teams than 5 or 6 ideate better online.

5.2.6 *Individual Contributions*

Due to study design flaws surrounding efforts to preserve anonymous data from participants, this study lacks analyzable data on individual contributions. Since the ideas

cannot be directly linked to participant responses to survey data the correlations between individual contributions and survey metrics cannot be analyzed. This also limits the study because individual contributions cannot be compared to group performance. It also cannot be determined if one or two members of each group may have dominated the idea generation session while others exhibited social loafing or free riding. Participant involvement could shed light on group size considerations as well, as phenomena like social loafing and free riding become more pronounced with increasing group size.

5.2.7 *Building upon ideas measures*

A more accurate measure of building upon ideas for the traditional brainstorming condition would be to have participants ideas numbered in order to maintain the chronological list of ideas for analysis. This would allow tracking of which ideas came first as with the online groups in this study. Another method that could increase the accuracy of the building upon ideas measure for both conditions would be to have the ideas clustered based on the most similar existing idea from the session to create threads during the session rather than examining them after. In the online groups, this could easily be done by encouraging participants to reply to ideas they are building upon creating a sub-thread rather than typing them in as new ideas. For traditional groups, this could be done by the facilitator as ideas are handed to them to post on the board. This would also allow participants to better visualize threads of ideas during the session itself. Future studies could utilize these methods for greater understanding of how building upon ideas differs between the two conditions.

VI-CONCLUSION

6.1 *Implications of Study*

The future of online communication and collaboration is unfolding before us. Social media platforms have reached numbers of active users in the billions. Previously dedicated social platforms like Facebook and Instagram are now integrating, adopting, and in some cases transitioning to more work, business, and productivity tools. Slack is an emerging platform with an interesting balance of social and work affordances. The platform is growing rapidly and becoming increasingly integrated into collaborative tasks, particularly in business, professional, and academic workspaces. This research presents a step towards understanding how these businesses, professional organizations, and schools can utilize the platform for creative-collaborative tasks as well.

It is hard to say the results of this study might apply to any other platforms as each online social platform presents different affordances, challenges, target users, and interface designs. So many factors could influence a difference in performance between two platforms like Pinterest and Twitter, and it is difficult to assert any one factor is responsible for a statistical difference. This study, however, creates a framework for which these platforms can be studied with comparisons to traditional brainstorming.

Online groups clearly generated more ideas than traditional brainstorming groups. The method of idea generating followed by sketching in contrast to simultaneously performing the tasks could explain this difference in quantity. The seamless visual

experience of generating ideas interactively online in comparison to traditional brainstorming may also contribute to the difference in quantity of ideas. It is worth noting as well that online groups did self-report a statistically significant, higher comfort level sketching ideas, which suggests the process was beneficial over sketching and generating at the same time. Online groups also generated more high-quality ideas than traditional brainstorming groups. The two biggest questions about online idea generation whether it could produce enough ideas, and whether it could produce high-quality ideas.

Online groups built upon ideas much more than traditional brainstorming groups. This is perhaps the largest performance difference from the study between the two conditions. Online groups generated more threads, had a longer average thread length, had more ideas that were apart of multiple threads, and generated more unique threads than traditional brainstorming groups. This is likely a product of the difference in the visibility of ideas and ease of concentration the Slack channel affords, with a continuous stream of ideas in text form, instead of announced ideas placed on a board.

For industry professionals and companies conducting idea generation internally for design purposes, this study shows it is possible to involve employees from remote locations and offices in idea generation through a digital platform like Slack. For external consumer-driven tasks, consumer involvement in idea generation can also be facilitated through a similar process.

6.2 *Future Work*

Slack and platforms like it present scaling capabilities to engage hundreds or even thousands in a single group. Intermediate steps need to be taken before scaling by powers of 10, but this study presents a good first look at online idea generation in Slack from 3 different means of evaluation. Scaling using a similar method would provide valuable insight into how scaling impacts the 3 performance metrics of quality, quantity, and threads of ideas. The question of whether group size matters in these scalable environments like Slack is also an interesting research question to consider for future group size studies. It could be that there is minimal change in the effectiveness of the ideation session with scaling. Future studies could also benefit from studying a larger sample size in terms of the number of groups in the dataset than that of this study. This would hopefully provide stronger data to make assertions about.

Removing the component of anonymity for future studies would also illuminate how social cognitive factors like gender bias and evaluation apprehension impact the study. This would also more closely replicate a real-world situation as social networks and online collaborative platforms often attach identifiers to users, sometimes including personal information. Seeing how these influence the sessions both in idea generation and evaluation could provide a more realistic understanding of real-world implications of idea generation in digital platforms.

Research has documented that it is more difficult for ideators to participate with prompts they do not understand (Luther & Bruckman, 2008). A research study comparing performance in Slack idea generation for ESL participants with different native languages

may be beneficial to understand if languages, and which languages influence performance in idea generation.

A potential benefit of idea generation in an online platform like Slack is the ability for participants to leave the platform to reference something and return to the session easily. The study of idea generation with an unconstrained timeline through Slack could shed light on whether this positively or negatively impacts the idea generation session overall. Additionally, research appears to support textual stimuli leading to more original solutions (Goldschmidt & Sever, 2011), so it is possible the ability to reference other things through the internet could increase creative output in the session. This structure also more closely resembles a real-world or industry context for digital idea generation as participants would like to be on an unconstrained timeline with the ability to leave the platform at any time during idea generation.

A study comparing the two idea-generating-then-sketching processes could shed light on whether sketching ideas becomes an impediment to the success of generating ideas in traditional brainstorming groups as well.

Future studies on other social-collaborative platforms like Pinterest, Reddit, Instagram present opportunities to examine differences in idea generation style in various platform interfaces and compare. Studies on the most established platforms make the most sense for long term applicability to other research with the longevity of the platforms.

Additionally, these studies could highlight common and unique platform features that influence idea generation.

English as a Second Language is another survey metric that could benefit from a study of individual performance in group idea generation. Many of the practical benefits in the scalability of platforms like Slack come from the ability to conduct idea generation with participants all over the world. Language becomes a focal consideration in this case and any data on the performance of second-language participants could be invaluable. The ability of participants to communicate their ideas effectively has great importance when it comes to the evaluation of said ideas. ESL (English as a second language) participants may have had their ideas misinterpreted because of cultural or language barriers with reviewers. This all depends on what language was the participant's first language and how they have learned English, or whatever language is used for communication in the idea generation session. Additionally, how the culture of their first language differs from that of the NSE (native speaker of English) participants matters.

Studies could be conducted with coded data to analyze individual performance next to group performance for all the participants. Differences in individual performance metrics could also be more directly compared to survey reporting results for other considerations of the study.

Finally, an interesting future study would also be a comparison of crowdsourced nominal idea generation through Amazon Mechanical Turk to Slack Team-based idea generation.

This comparison of nominal and interactive idea generation in prominent digital contexts could shed light on the future of idea generation online and how these established platforms may play a role in future ideation strategies.

6.3 *Final Conclusion*

In conclusion, the digital platform Slack is a viable option for idea generation in small groups online. Groups utilizing the platform not only create comparable results to traditional brainstorming groups, but they also exhibited enhanced performance in the area of building upon ideas. In situations where iterating or building upon ideas is an essential or desired outcome, Slack could be considered a more ideal option than traditional brainstorming for effectiveness.

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