EFFECTS OF THE STARTUP ENVIRONMENT ON TECHNOLOGY EXTRAPOLATED FROM THE EFFECTS EXERTED ON STARTUP ENGINEERS AND MANAGERS

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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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APPEARANCE MODIFIER FOR REMOTE DIGITAL VIDEO COMMUNICATION AND HOW THE STARTUP ENVIRONMENT INFLUENCES ENGINEERS PRODUCTS, PRACTICES, AND ETHICAL DESIGN

At the time of the technical project's beginning most communication was facilitated online due to the COVID-19 pandemic. However, the trend of remote working has not been confined to the pandemic. Global Workplace Analytics found that between 2005 and 2018 there was an increase of 173% in regular remote working (Lister 2020). It is estimated that approximately 56% of all jobs could eventually be made remote (Lister 2020). Despite the convenience of working at home, there remains a bias towards appearance. The digital workplace presents new difficulties towards individual presentation. The most prominent one being a reliance on webcams and lighting to represent the physical appearance of people as well as makeup, clothes, and other cosmetic products.

The physical appearance of a person has been correlated with greater social and professional opportunities. Often a favorable preference is shown to more attractive people by managers compared to lesser attractive people (Leibu 2014). Zoom Video Communications acknowledges the priority of aesthetic video presentation and has released guidelines intended to improve the user's appearance online. In it specifies the guidelines of proper face lighting, "in such a way that it sits above you and points just above your head. You do not want the majority of the light to hit you, but you want just enough to make your face a bit more brilliant on-screen" (Zoom Video Conferences 2020).

The Automated Ring Light is a device designed to provide the user consistent optimal lighting by directly illuminating the users face as they move around the workstation. The device is positioned above the monitor allowing the actuating ring light a downward projection to user's face. This light is moved by two AC stepper motors that respond to the haptic movement of the user's head. This allowed the ring light to move both horizontally and along a vertical axis of rotation. In the age of online video conferences, this device presents the user as their best to their co-workers, clients, and business partners.

The STS research paper is an exploration of how the startup environment effects the technology developed in it. Despite their initial size, the technology created by startups have far reaching effects that at times drastically change how society operates and communicates with each other. In the early 2000s alone the rise of social media platforms created by seemingly humble startup's revolutionized how society spreads and processes information. Companies like Facebook, Twitter, Instagram, and Snapchat all originated from early startups that has had drastic disruptive effect on society (Ghezzi et al. 2016). Startups are everywhere and exist in many professional fields that range from development of biomedical technology to global logistics. All of these widely influential products or services were not developed initially in a stable corporate environment. Rather they were formed in a volatile startup environment with unique and intense pressures in it.

To what extent is a startup environment different to a corporate one? As outlined by Stayton et al. startup environments are subjected to short deadlines, significant financial stress, and high organizational tension. From these challenges, a startup environment experiences a drastic increase of the amount of work performed in a short time period (Stayton et al. 2016). In order to meet this high intensity workload, employees are expected to work beyond the typical nine to five workdays through overtime (Salamzadeh 2015). What causes this significant workload is the vulnerable financial situation startups exist in. Due to a limited number of finances, often generated from investors or personal investment by employees, startups have considerably more financial risk compared to more established private corporations (Salamzadeh

2015). This limited amount of capital creates a pressure to iterate as fast as possible on a product's development until it is profitable (Stayton et al. 2016).

The foundation present in an early startup including work culture, organizational structure, and work standards often persist after a startup graduates to an emergent organization (Brattström 2019). Therefore, the negative effects of the technology inflicted during the early stages of a startup, caused from performance impacts on engineers, may persist in an established organization and potentially carry on to effect entire groups of people. This includes effects created by the accelerated development cycle, the speed-oriented methodology behind the developed technology, and how a team approaches problems during design (Brattström 2019). All of these effects imprint themselves on technology that carry on beyond its initial creation. It is this principle that is the focus and merit of this research paper.

In order to indirectly relate the negative impacts of the intense startup environment on the technology, this paper is divided into three sections. First the extent of common challenges present in a startup environment are established. These challenges are then outlined in order to generalize a shared workplace environment present in nearly all startups. Thereafter from these challenges an exploration of their effects on engineers' performance, health, and team cohesion are established. From the negative impacts on engineers, research relating these impacts on engineers with their respective work be created. From these three bodies of research an indirect relation between the startup environment and negative impacts on technology are established.

However, it is not enough to create this link through research. To develop an understanding of how a startup environment itself negatively influences technology two ethical frameworks are utilized. The first is Arnold Pacey's Triangle of Technology Practice. Arnold Pacey's Triangle of Technology Practice is a framework used to develop an understanding of how the environment present in an organization effects the technology. In addition, to better understand the common groups present behind these influences Social Construction of Technology (SCOT) is utilized in order to develop an outline of which common groups influence the technology and in what way. While Pacey's Triangle will analyze the environment, Social Construction of Technology (SCOT) will analyze the greater ecosystem that this environment exists in.

Additional inspiration behind this research paper was a culmination of personal experiences relating to startups by the author. Based on past experience in early-stage startups it was evident that the intense startup environment left little room for active ethical or moral decisions relating to the developed technology. Often short deadlines and product performance were prioritized in an effort to create a profitable product as soon as possible. This in turn effected the technology as errors or issues stubbornly persisted in development resulting in frequent poor-quality patchworks. It is from this culmination of experience that this paper is created and structured this way. Questions regarding how and to what extent the startup environment effects technology are answered. Additional clarifying questions relating to what manner these effects are and common threads present in them are answered as well. It is the hope of this research paper to begin a dialogue on how the startup environment effects the greater society we live in every day and provide motivation for further future research.

COMMON TENSIONS AND CHARACTERISTICS PRESENT IN A STARTUP ENVIRONMENT

Modern day startups when compared to established private companies have stark differences that relate to a differing workplace environment and the different stakeholders involved with the organization. These differences have impacts on the performance of engineers and the work culture they participate in, which result in direct effects on the development of the product they are producing. Presented by Stayton et al. is a collection of common patterns and challenges that are intrinsic to a startup environment. In this paper created by Stayton et al. four tech-startups were studied that each had varying locations in the United States and products being produced in different markets. Interviews among all levels of management and employees were performed in order to generate a holistic evaluation of the entire organization. Common patterns or views present in all startups interviewed were analyzed and outlined.

Stayton et al. found that there was a common motivation for speed among all levels of the organization. Speed relating to product design especially was created from the tensions between temporal and financial resource dynamics that frequently plague startups (Stayton et al. 2016). All employees and executives present in the startup work at accelerated pace in order to generate revenue before the organization runs out of funds. Entrepreneurs in particular in early stages of the startup, in absence of angel investors, may sometimes fund the startup through their own savings or money generated from friends or family. This results in significant financial pressure as startup team members developing a particular technology may run out of personal savings used to sustain themselves before a product enters a market. A lack of available capital in a startup furthermore encourages conservative spending on resources in order to maximize the amount of time they have to produce a product (Stayton et al. 2016).

Financial pressure present in a startup compounds the strain put on human resources. Stayton et al. finds that increased personal risk from startup team members results in significant workload intensity intending to resolve financial risk. Team members will work longer and faster with the intention of bringing a product to market. Significant stress noticeably results in a dropout rate of employees, which can further compound workload intensity. Stayton et al. remarks that escalating pressure on human resources can quickly take a toll on the performance and health of startup team members in the form of burnout as they are physical limits of how many hours a team member can tolerate.

Brattström reaches expresses a similar observation in a paper detailing the team dynamics of early startups. Brattström reports that financial stress results in quick successive change to the products a startup produces. These fast incremental changes are performed with the intention to rapidly improve the marketability of these products (Brattström 2019). Pressure to bring a product to market can strain team commitment wherein challenges of task demands and interpersonal differences began to surface. Setbacks including delayed development timelines, unexpectedly low sales, and difficulty in attracting investors further creates conflict in startup teams (Brattström 2019). In addition, the division of responsibility and rewards, in the form of equity, can provoke conflict if the perception of fairness among a team member is damaged.

From these research papers, an understanding of the startup environment is established as well as the conflicts and challenges that persist in it. Startup environments experience significant workloads which arise from financial stress as a dwindling amount of scarce funds encourages fast development cycles in attempt to make a product marketable. A common culture that persists through these startups is oriented to rapid development in order to reduce the risk each team member takes in order to participate in the startup. However, there lacks an understanding about how these challenges directly influence the product they are creating. Technology itself has effects on relevant stakeholders that can persist far beyond the intended utility it was created for (Bijker 2015).

While most startups fail, many do eventually succeed resulting in a product or service that is widely used among a large user base. Brattström presents the example of FedEx, which was nearly about to go bankrupt but survived through the startup's persistence (Brattström 2019). The design of these massively impactful products or services is created in a startup environment that experiences significant workload, financial, and interpersonal strain. As a result, these products or services may exert a negative influence on relevant stakeholders that may go unfixed in an attempt to focus purely on the marketability of the product or service. It is this impact the startup environment has on the produced technology that this research paper will explore.

FRAMEWORKS FOR UNDERSTANDING

In order to better understand how the startup environment influences the technology they produce; Arnold Pacey's Triangle of Technology Practice (1983, November) is used to develop an organized understanding of technology practice. As shown in Figure 1 on page 8, Pacey's Triangle has three aspects that compose technology practice.

Figure 1: Arnold Pacey's Triangle of Technology Practice: Shown in this figure is Pacey's concept of technology practice applied to the startup environment. This graph is the culmination of research analyzed in this paper. The parts of this graph are expanded upon further in this paper (Ferraro 2021).

The parts that compose Pacey's Triangle of Technology Practice are cultural, organizational, and technical aspects that influence the relevant technology. Pacey (1983) defines the cultural aspect as involving the ideological aspects of technology, ideas, and values that the people who influence the technology have (p. 5). This culminates into a shared culture that is present in an organization that the engineers as well as the managers participate in. Pacey (1983) describes this as, "the engineers' way of thinking" (p. 10) and what composes it. As outlined by Pacey (1983) organizational aspect relates to the structure of the organization along with what directly influences the organization. This includes the administrative structure and the public policy an organization has. It also includes the effects separate organizations or stakeholders have with the primary organization (p. 5). Finally, the technical aspect as described by Pacey (1983) contains all the accessible knowledge that is available as well as the innate skill individuals in the organization possess. Additionally, the technical aspect includes any available resources or tools needed to design, develop, and construct the relevant technology (p. 6).

Another tool that is used to conceptualize the unique influences that is exerted on technology in a startup environment, is the Social Construction of Technology (SCOT) framework. In essence it is a framework that is based on the mutual influence technology has on relevant stakeholders and the inverse effects stakeholders have on said technology. Created in the mid-1980s it is based on the argument that technology is the outcome of negotiations between several social groups rather than a product of technological determinism. These social groups can include but not limited to investors, engineers, managers, and users (Bijker 2015). Often during case studies in which Social Construction of Technology is applied a diagram composed of all relevant stakeholders involved with the technology is outlined. Shown in Figure 2 below is a diagram showcasing the relevant stakeholders that commonly appear in the cited research papers. These papers mainly relations found in Stayton et al., Brattström, and Vakkuri et al. which is reproduced in the figure below.

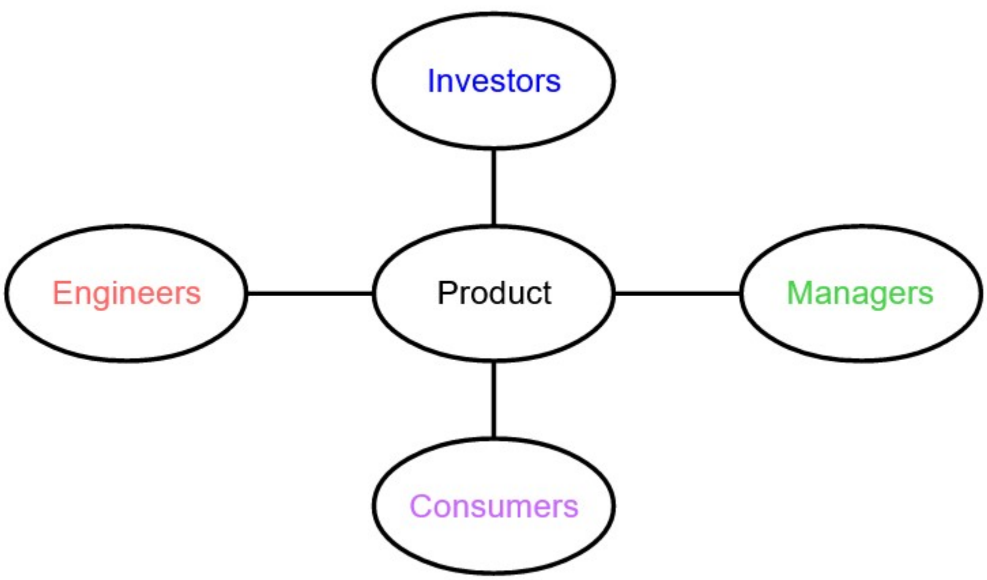

Figure 2: Diagram of Relevant Stakeholders for Startup Organizations: This is a diagram showcasing common stakeholders or groups that interact and influence the product developed in startup environments. These stakeholders include investors, managers, consumers, and engineers (Ferraro 2021).

As presented in Figure 2 on page 9 is a web of the social groups that have a noticeable influence on the technology that the startup produces. It should be noted that the impacts that these groups have on the product may direct or indirect. An example of an indirect influence exerted on a technology is the pressure from managers and investors exerted on engineers to quickly develop a product (Stayton et al. 2016). While these social groups do have direct effects on the product, the overwork of engineers caused from this pressure nonetheless does exert an effect that could possibly not be present in absence of these social groups.

THE EFFECTS ON STARTUP ENVIRONMENT ON ENGINEERS

The effects of the startup environment on engineers can be divided by the three aspects of Pacey's Triangle of Technology Practice. This section focuses on how the organizational, cultural, and technological aspects that compose the technology practice of a startup affect the engineers present in it. These effects on engineers are related using existing studies of the effects of overtime hours in similar workplace environments. These findings are then compared to the studies describing the environment of startups outlined in the previous section. Additionally, studies regarding the cultural effects on engineers and engineering design are discussed.

ORGANIZATIONAL ASPECT

The organization of startups are a direct response to the challenges and conflicts present in them. As explored by Stayton et al. a dwindling amount of financial resources creates significant tension between time and human resources. This in turn results in long hours and cases of burnout present among team members (Stayton et al. 2016). An increase of overtime hours present in an organization has shown to have significant effects on the performance of employees. Nishikitani et al. presents a study performed in 2005 wherein 304 software engineers in Japan analyzed the effects of excessive work and job strain with negative physical and mental health affects (Nishikitani et al. 2005). Nishikitani et al. shows that overtime work results in significant association of higher Hamilton Depression Scale (HDS) scores and Profile of Mood State (POMS) anger-hostility scores. The Hamilton Depression Scale is a 17-item questionnaire used to assess depression with physician present, while the Profile of Mood State is an established metric among the Japanese population to quantify mood states (Nishikitani et al. 2005, p. 624). Shown in Figure 3 on page 12 is a diagram showcasing the probability values of each of these variables relating with overwork.

Figure 3: Correlation Coefficients of Exposure Variables: This is a collection of correlation coefficients found in Nishikitani et al. study regarding relating overtime work with negative scores on Hamilton Depression Scale and Profile of Mood State. These findings show significant association with sleep duration and job strain with these same variables (Nishikitani et al. 2005).

Nishikitani et al. also showed that sleep duration and job strain are associated with similar effects on Profile of Mood State tension-anxiety and anger-hostility. However, it was not statistically determined that sleep deprivation or job-strain were associated with overtime hours. Nishikitani et al. shows that this lack of correlation may be due to the fact the difference in the two groups studied did not differ enough in overtime hours. The control, or employees with reduced overtime hours, among the 20 days of work in the month still contributed approximately one hour or less overtime hours each day on average (Nishikitani et al. 2005). Nishikitani et al. cites a paper made by Kageyama et al. in which short sleep duration is closely associated with overtime work (Kageyama et al. 2001).

Nishikitani et al. also cites Nakata et al. in which sleep problems were shown to be prevalent among white collar workers that work overtime hours. Nakata et al. shows that white-collar workers working longer than 10 hours per day, resulting in a cumulative of 40 hour a month of overtime work, have only 6 hours of sleep or less a day. These effects result a perceived higher level of stress and a lower quality of life (Nakata et al. 2000). Among those surveyed approximately 26% of workers possessed one of the four sleep problems. These include taking more than 30 minutes to fall asleep, awakening during sleep, early morning awakening, and excessive daytime sleepiness (Nakata et al. 2000). Present in Kageyama et al. is a study that also correlates overtime work with Sleep Length on Weekdays (SLW) and Sleep Debt on Weekdays (SDW) (Kageyama et al. 2001) .

This increased aggression or frustration present in overtime groups as studied by Nishikitani et al. matches with an observation mentioned in Brattström’s paper. When a startup begins to undergo the bulk of its work after initially forming, which often has significant workload intensity, interpersonal differences begin to surface resulting in conflict. This results in a series of unproductive conflicts that may result in significant distractions. These conflicts may result in team divorces compounding additional strain or difficulties experienced by a startup team (Brattström 2019). Additionally, these findings by Nishikitani et al. relate with Stayton et al. study of challenges present in startups. Stayton et al. describes the phenomenon on how escalating pressure on human resources may reduce the performance and health of team members in a startup environment.

CULTURAL ASPECT

The culture of a startup remains distinct from other workplace environments. The demands and challenges present in a startup result in a unique culture that is designed intentionally or unintentionally to cope with these stressors. Brattström presents an overview of the culture and characteristics present in a startup team. In order to maintain team cohesion in absence of legal, financial, or benefit incentives, startup’s develop a shared identity and common emotions that cultivates a team comradery (Brattström 2019). This foundation of a startup’s culture persists long after the early stages of a startup. The set of values present in the initial founding team has a strong impact on the values imprinted on the emergent organization. This persistence of initial conditions that carry on from early in the startup also notably applies to structural qualities of the startup as well (Brattström 2019). This persistence in structure results in the roles and the relationships between them to continue onwards into the new organization.

The context of this culture that shared among startups and its effects on engineering design is explored by Vakkuri et al in their study on ethical design in software startups. Vakkuri et al. examines startups that produce products containing artificial intelligence and examines how Accountability, Responsibility and Transparency (ART) principles are ignored among the engineers. Accountability, Responsibility, and Transparency principles, created by Dignum, were used as the ethical framework to categorize the specific negligence found in startups studied. Vakkuri et al. however simplifies this framework to a more practical approach by utilizing a breakdown of artificial intelligence ethics also outlined by Dignum. These are examining how integration of ethical reasoning is included in the artificial intelligence system, use of regulatory and engineering methods supporting integration of artificial intelligence ethics, and adherence to professional standards relating to artificial intelligence ethics (Vakkuri et al. 2020, p. 199).

The result of this analysis is produced in below in Figure 4 on page 15 wherein a collection of Vakkuri et al. findings are presented. This table represents the primary empirical conclusions. It should be noted that empirical validation shown in the table does not imply other novel findings weren't empirically generated, but rather certain findings were additionally validated through existing literature.

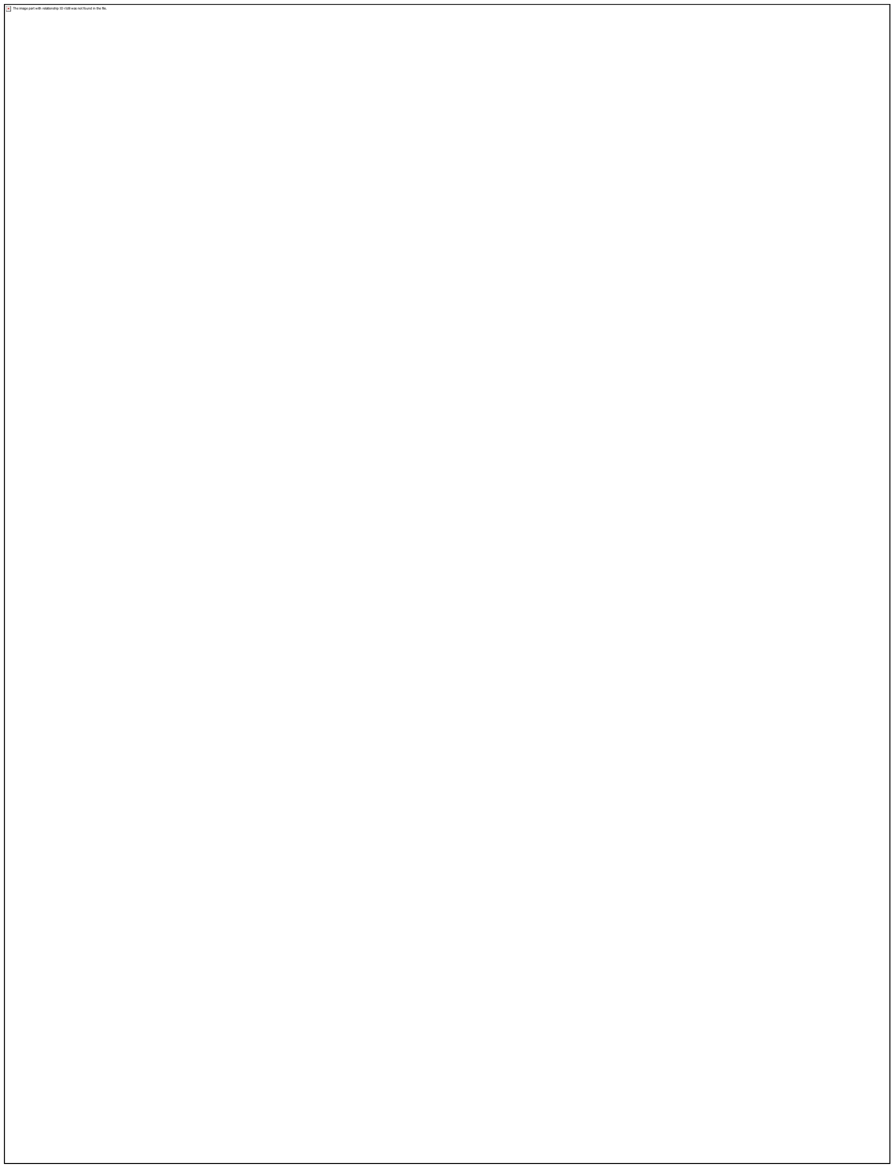

Figure 4: Empirical Findings from Startup's Surveyed: This is a collection of Primary Empirical Conclusions (PECs) found by Vakkuri et al. In it are the observations found in the startups studied. These findings are additionally classified whether they are validated by past studies, novel to this research, or contradicts past studies (Vakkuri et al. 2020).

As shown in Figure 4 several findings of how ethics are handled in a startup environment are shown. The novel insights found by Vakkuri et al. study all relate to how ethical guidelines or frameworks in a startup-environment are neglected. In particular, Vakkuri et al. notes that developers feel more responsibility to practical problems relating to the development of the product. While some developers may express ethical concerns, these are ultimately unaddressed in pursuit of more practical immediate problems. Any concerns developers did have on the possible effects on the users were only related to tangible physical effects rather than non-tangible negative effects such as stress. The extent of neglect relating to the possible effects on stakeholders was extensive as none of the startups studied discussed hypothetical effects of the system on users outside of practical interactions of it. The extent of the developer's explicit responsibility seemed to be unclear as well (Vakkuri et al. 2020, p. 206).

The responsibility that was understood by developers related to the expectations found in their roles. With their goal in developing quality software, resulting in a quality product, was considered their responsibility as professionals. However, the definition of this quality was again based on the testing present in only a laboratory setting. Another insight that conflicts with conventional development is the lack of discussion regarding misuse and error scenarios beyond the future operational life of the system in the field. Future use of the system is not prioritized, rather immediate operation in favor of prototype iteration (Vakkuri et al. 2020, p. 206).

However, there are notable limitations present in Vakkuri et al. research that is addressed in the paper. Due to the lack of established research many of the novel claims found have not been explored in other existing research. Vakkuri et al. expresses that due to the technology used in the products, artificial intelligence, is only recently emerging in startup environments that certain findings cannot be confirmed through existing research. In addition, Vakkuri et al. is a case study of multiple startups, which Vakkuri et al. addresses as having difficulty towards generalizing results. Vakkuri et al. paper was published in 2020, and many of the subjects explored in the research are also novel besides the evaluation of artificial intelligence ethics. Studies of ethical accountability in startups and how it relates to engineering design is a novel avenue of research.

However, another insight into the culture present in startups is explored by Steverson. In a paper presented by Steverson discusses that startups may mislead or hide the negative results or lacking reputation to potential stakeholders. This concept of legitimacy lies is the phenomenon wherein an entrepreneurs or team members intentionally misrepresent facts temporarily in order to reduce risk in the early stages of startups. Steverson shows that this phenomenon is based by two principles. The first is that entrepreneurs, as a group, are uniquely encouraged to lie and the second is that entrepreneurs stand to likely gain from that lie. Through this lie the financial stress, as pointed out by Stayton et al., is at conflict with limited temporal resources. A direct response to reduce this financial tension is to attract investors or partners that can provide funding (Steverson 2013).

Steverson expands on this phenomenon and clarifies that entrepreneurs are often less concerned about long-term trust or consequences. It is understood that without lying there may not be long term survival. Steverson explores that this phenomenon also manifests in less explicit or clear ways. Due to the uncertainty present in startups entrepreneurs may not know relevant information to give a definite evaluation of their status on performance. Though this level of uncertainty is understood and said to be the norm between investors and entrepreneurs. Mature firms often adapt methods to compensate for overly optimistic estimates of performance. However, this awareness of uncertainty is still consciously omitted in favor of long-term survival as well (Steverson 2013).

TECHNOLOGY ASPECT

As touched upon in Stayton et al. resources in early startups are usually scarce. A lack of funding results in priority to conserve resources in order to reduce the risk of the startup failing (Stayton et al. 2016). This conservation of resources is manifestation of the lean startup methodology often used in many emerging startups. Presented by Ghezzi is a detailed description regarding lean startup approaches and methods to generating fast and cheap heuristics in startups. Due to the uncertainty in startups many entrepreneurs create unexpected contingencies and plans to develop with limited resources. Often this conservation in resources, frequently used in especially digital startups, results in bootstrapping available technology while continually attempting to make a marketable product. Value present in tech startups is through simplifying complex technological potential and transforming it to a strategic benefit in performance (Ghezzi 2020). In this respect, technology is a means to an end and only another resource to manage in a startup.

EFFECTS ON ENGINEERING DESIGN

In the previous section the effects on engineers from the startup environment were outlined based on which aspect present in Arnold Pacey's Triangle of Technology Practice it fell under. However, in the previous section there was not any direct correlations relating to the effects on engineers to the technology they develop. Present in this section is a collection of research papers which correlate the negative effects on engineers with impacts on the technology or work they produce. This will complete the indirect relation between the startup environment and the effects it has on the technology produced in this environment.

ORGANIZATIONAL ASPECT

Overtime work and burnout has is a common conflict present in startups as shown by Stayton et al., and the resulting effects of the overtime are outlined by Nishikitani et al. in their study. As presented by Nishikitani et al. excessive overtime work cause a variety of negative physical and mental effects that manifest as higher scores in depression as well as tension or anxiety (Nishikitani et al. 2005). Excessive overtime work presented by Kageyama et al. is also associated with an increase of sleep deprivation as well as excessive sleeping on the weekends to make up for sleep deprivation (Kageyama et al. 2001).

These findings were as well expressed in a paper by Olson et al. in which overtime hours were again associated with sleep deprivation. However, this was only a partial observation present in the paper presented by Olson et al. Olson et al. examines a body of evidence relating to the effects of improperly managing a project timeline on the design of software systems and the performance of software engineers. In Olson et al. identifies that the effects of overtime work on software engineers results in noticeable negative effect on the quality of the work produced. Sustained overtime can produce fatigue that results in propagating errors that overall reduces the productivity of the sleep-deprived employee. Increasing amounts of overtime hours are associated with continued diminishing quality of a software engineer's performance. These effects are then carried over to the negatively affect the workload wherein poor performance can manifest in short-term or long-term effects on the project. These effects therein compound existing time pressure (Olson et al. 2015).

In addition, the cognitive effects present in employees becomes significant. Mental fatigue gradually increases from overwork which in turn impairs work engagement, work quality, and productivity. The ability to sustain focus will in turn be impaired as attention declines from fatigue. Overlooking errors, missing instructions, and losing progress with work may results during the design or development of a product. Olson et al. notes that a software engineer's capacity for innovation reduces as the work is reduced to completing an arduous task. This reduces team cohesion as when sleep quality is damaged from overtime hours people become irritable, impatient, and easily frustrated. This in turn damages the nuance present in a task as developers reduce complexity in order to resolve the source of strain. These frustrations are carried over to interpersonal conflicts which then damage the schedule or scope of a project (Olson et al. 2015).

However, Olson et al. expresses that these negative effects on the product not only manifest on an individual level but a team level as well. Olson et al. examines existing research on the effects of team performance when subjected to excessive overtime and fatigue. The negative effects from diminished quality redirect the goals of teams away from the main project activities. In addition, a divide between separate divisions working the same project may develop a distrust or frustration with one another. An example of a possible division between two separate sub-teams is employees assigned to quality assurance and those assigned to development. Even discussions of defects themselves continue to add to task pressure and individual stress on a team. The culmination of these negative influences may result in a critical delay in a project, which may be financially dangerous for startups.

Putkonen presents a simulation model designed to model the continued effects of fatigue and overwork on the quality to finish a task. Through the simulation model significant delays similar to those described by Olson et al. manifested as fatigued compounded. Time pressure present in the model was shown to increase when time remaining on the project was dwarfed with the time required to finish individual tasks. The errors that accumulate from time pressure in the model are thus shown to create a compounding pressure on employees. These were referred to as loops due to how errors generated from each loop fed back into the time pressure exerted on software engineers. The negative performance loops that arose from the model include overtime, fatigue, diminishing work-engagement, and lack of innovation loops (Putkonen 2009).

In another research paper created by Barnes the effects of sleep deprivation are explored among teams. Barnes cites the merit of this study by presenting a series of case studies in which sleep deprivation were associated with significant engineer disasters such as Chernobyl and Three Mile Island. Barnes explores that team decision accuracy may be impaired by sleep deprivation, however depending on the task structure the impact of this may vary from marginal to extreme. With team structures that have weak horizontal stability, or the lack of other team members working in parallel on a task, are significantly affected. Due to the low amount of team members in a startup, multiple responsibilities may be distributed among startup members (Brattström 2019). For startups individual responsibilities may have low horizontal stability; meaning a lack of mutual accountability may be present for critical tasks. Therefore, these critical contributions that are crucial to operation may be missing or significantly hindered without other team members there to maintain accountability (Barnes 2009).

As part of the methodology present in the lean startup model as shown by Ghezzi these financial pressures and time pressures in turn cause an incentive to bring a product to market. This results in frequent pivots, or drastic changes in a products scope, which is a direct response with consumer feedback. The technology in a lean startup is a utility which value is based on its success in consumer trials. The organizational structure of many startups is built around this principle. Any negative impacts of the product are only explored through product risk which is only addressed if consumer trials demand or generate complaints present in feedback (Ghezzi 2020).

CULTURAL ASPECT

The negative effects on engineers as a result of culture that was explored through Vakkuri et al. does manifest on negative impacts on the product produced by a startup. In a paper presented by Van Gorp et al. presents a series of case studies in which different design methods present in different companies were used in the creation of their respective products. Common findings between these design methods include interesting insights into engineering design as a whole. For example, in all companies, despite the professional standards or codes that apply, employees approach to design was only based on regulatory and role requirements. Similar to the observation shown in Vakkuri et al. responsibilities were based on the role each employee or did not possess. Van Gorp et al. notes that in absence of regulatory frameworks or explicit responsibilities, ethical decisions, which relate to safety and sustainability, were only based on internal design norms. These norms were the culmination of the engineer's experience. At times this reliance on norms resulted in neglecting other important qualities present in the product (Van Gorp et al. 2008).

Van Gorp et al. presents an example in which a trailer produced by a company neglected traffic safety in favor of structural reliability of the trailer. This was based on the norms that were the culmination of the engineer's specific experience, which was only with structural reliability. In absence of another engineer specializing in traffic safety these concerns were ultimately neglected as it wasn't perceived to be the duty of the engineers present. This relates to finding presented in Vakkuri et al. as in absence of experience or professional norms important design concerns relating to engineering ethics were neglected.

TECHNICAL ASPECT

Shown by Stayton et al. was that startup environments have a lack of resources that they can draw upon when developing a product or technology. This encourages a frequent reuse of resources to compensate with a scarcity of resources (Stayton et al. 2016). Ultimately this results in a series of solutions that can be described as bootstrapping, which involve a mentality of do-whatever-it-takes in order to meet project deadlines. While resource conserving does mange to reduce the time taken in development if managed properly, decision making behind technology is made so progress can be achieved as quick as possible (Stayton et al. 2016). This results in a technological product that is produced with an intention to provide strict utility for startup growth.

As shown in Olson et al. present in organizations that have significant overwork and short deadlines are prone to excessive technical errors that plague development. This finding is as well corroborated by Barnes et al. that sleep deprivation caused by overwork results in an excess of errors. In attempt to resolve these errors decision making is impacted among team members, which results in a lack of innovation or diligence present in reactionary solutions. This lack of diligence in reactionary can be considered merely as patchwork solutions in an attempt to resolve a persistent issue (Barnes 2009).

FRAMEWORK ANALYSIS

Based on the research accumulated from the previous sections, a series of common patterns relating to each aspect of Arnold Pacey's Triangle of Technology Practice are defined. These patterns present are explained separately using previous research to support their findings. This completes the analysis of technology practice, through strictly defining how and to what extent parts of the startup environment effects the technology produced in them. Thereafter common groups effecting the startup are explored using Social Construction of Technology (SCOT) framework.

ORGANIZATIONAL ASPECT

Shown in Figure 5 on page 24 is a collection of common findings present in the accumulated research. These findings concluded that the organizational aspect of startup environments had a variety of structural elements common in all cited research. These included short development cycles, reduced financial resources, significant overwork, pressure for marketability of the technology, and interpersonal team conflicts.

Figure 5: Triangle of Technology Practice Organizational Aspect: This is a highlight that is used as a visual tool meant to assist the reader in this section. In this figure a focus is put on the findings relating to the organizational aspect of technology practice in a startup environment (Ferraro 2021).

Present in all research, a startup environment was characterized by short development cycles and reduced amount of financial funding as shown in Stayton et al. as well as with Ghezzi and Brattström. The result of both lacking financial resources and short development cycles was an excess of overtime work as described by Stayton et al. as well as from Brattström. The effects of the overwork on the health of engineers, which included excess anxiety, stress, and sleep deprivation were shown by Nishikitani et al. as well as by Kageyama et al. respectively. Sleep deprivation was linked with a lack of innovation or critical thinking present in solutions as shown by Barnes. Olson et al. additionally found that this overwork also caused an excess of errors present in the technology, and a diminishing effect on team-based decisions (Olson et al. 2015). Pressure for marketability is structurally implemented in the organization of a startup as marketability is the crucial objective in lean startup methodology (Ghezzi 2020). Olson et al. as well as Brattström showed from the significant stress present in startup development cycles may cause interpersonal conflict ultimately resulting in team friction.

CULTURAL ASPECT

Synthesized from the previous sections is a collection of common patterns that relate to the cultural aspect of technology practice in startup environments. Shown in Figure 6, the conclusion was that the cultural aspect of startup environments included an undefined responsibility among engineers, ethical decisions were based only through experience, and common in design was a strict focus on the mere utility of the developed technology.

Figure 6: Triangle of Technology Practice Cultural Aspect: This is a highlight that is used as a visual tool meant to assist the reader in this section. In this figure a focus is put on the findings relating to the cultural aspect of technology practice in a startup environment (Ferraro 2021).

Present in Vakkuri et al. is a series of empirical conclusions that relate to the culture present in startups. Found in Vakkuri et al. was a lack of defined responsibility among engineers, in which the responsibilities only related to their specific roles. Vakkuri et al. also found that ethical decisions were only implemented through the experience present in the engineers rather specific guidelines (Vakkuri et al. 2020, p. 206). These findings were corroborated by Van Gorp et al. as in absence ethical guidelines or frameworks the technology produced was only constrained by regulatory, requirement specifications, or job roles (Van Gorp et al. 2008).

Finally, present in the cultural part of technology practice in startup environments is a strict focus on utility of technology itself. This is contrasted to viewing the technology as a complex social tool that affects stakeholders. Found in Vakkuri et al. was that developers felt mostly responsible towards tackling problems relating to development, such as minimizing errors, and meeting project goals (Vakkuri et al. 2020, p. 206). While ethical concerns are expressed little is done during development to address these concerns (Vakkuri et al. 2020, p. 206). This utility of technology was also expressed by Ghezzi in which technology was described as a utility that is used to generate value (Ghezzi 2020).

TECHNICAL ASPECT

Shown in Figure 7 on page 27 is a variety of common patterns present in the technical aspect of startup environments. Found among startups was a scarce lack of resources, frequent reuse of existing tools or technical solutions, solutions that were bootstrapped to meet deadlines, patchwork solutions that were made under significant time pressure, an excess of technical errors present in the technology.

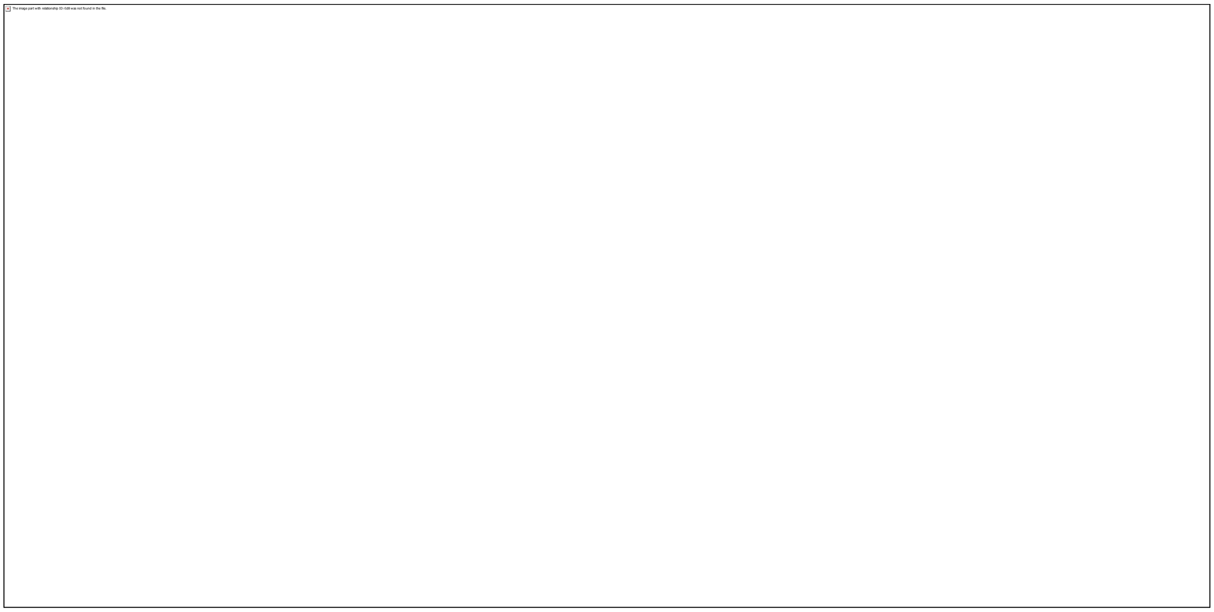

Figure 7: Triangle of Technology Practice Technical Aspect: This is a highlight that is used as a visual tool meant to assist the reader in this section. In this figure a focus is put on the findings relating to the technical aspect of technology practice in a startup environment (Ferraro 2021).

Stayton et al. shows that the technology produced by startups utilizes a minimal amount of technical resources available. Reusing resources and bootstrap solutions are employed to meet project deadlines which is as well shown in Stayton et al. (Stayton et al. 2016). Present in this technology is an excess of patchwork solutions meant to resolve strenuous errors that arise from development. These patchwork solutions especially happen when symptoms of sleep deprivation arise from overwork which is shown in Barnes et al. (Barnes et al. 2009). At times from these bare solutions technical errors may continue to arise resulting in a technology that is plagued with excessive errors throughout development (Olson et al. 2015).

SOCIAL CONSTRUCTION OF TECHNOLOGY

Shown in Figure 8 on page 28 is an analysis of the primary social groups that effect the startup environment. It is composed of definite groups that exist inside and outside the startup. With the investors and consumers effecting the technology externally and the product managers and engineers effecting the technology internally in a startup. Team member roles and responsibilities can be blended together or shared in an early-startup's team and thus blur the line between engineers and managers. However, there nonetheless exists some semblance of hierarchy present in a startup that warrants their division. Wherein the top of the hierarchy is usually held by the founding members of a startup (Brattström 2019).

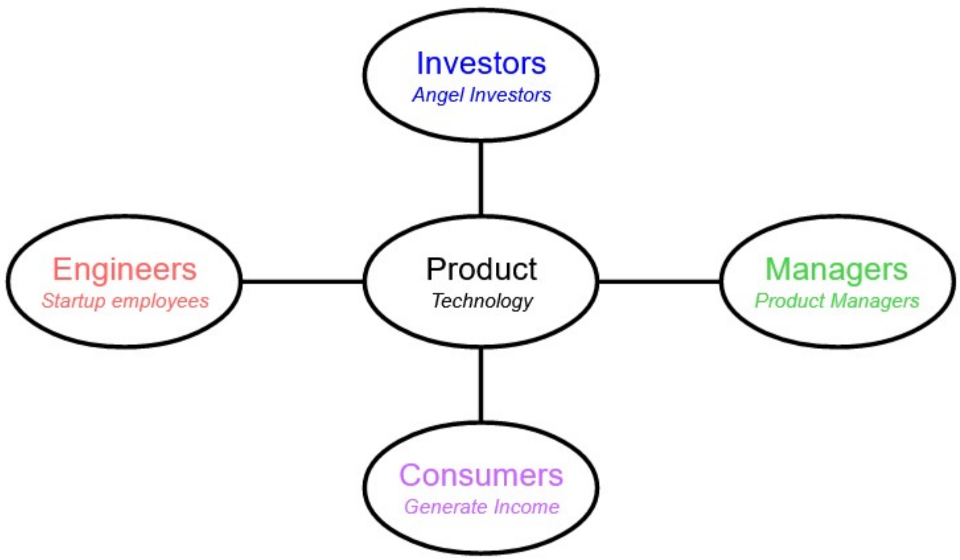

Figure 8: Diagram of Relevant Stakeholders for Startup Organizations with Description: This is a diagram showcasing common stakeholders or groups that interact and influence the product developed in startup environments. This figure is repeated as a tool for the reader (Ferraro 2021).

The finances present in a startup can be generated through two means. The first is personal investment by startup team members or their family members. The second is through angel investors as expressed by Stayton et al. (Stayton et al. 2016). As a result, present in Figure 8 these investors are outlined as a social group affecting a startup's technology. These investors have stake within the startup organization as they are risking capital by investing into them. Pressure to perform by these investors, in order to reduce the financial risk the investors are undertaking, is exerted onto startup (Steverson 2013). In addition, the reputation of a startup is built through interactions with investors or potential business partners. This provides a pressure on the startup to perform or produce results in line with investor expectations (Steverson 2013).

This financial pressure is frequently communicated and enforced by the product managers present in a startup, which warrants their inclusion in outline presented in Figure 8 on page 28. Present in Ghezzi is a breakdown of lean startup methodologies found in most startups. Product managers serve as an integral role in a startup team in which technical goals, project deadlines, and technical issues are resolved by promoting team cohesion. Project managers encourage adherence to schedule and coordinate strategies for marketability of the produced technology (Ghezzi 2020).

In order to alleviate the financial pressure in a startup, marketability to the consumers is used to begin generating income. This income is seen as the primary goal present in startups in order to avoid relying on dwindling funds generated from investors or from startup member's investment through personal finances (Ghezzi 2020). The financial incentives posed by consumers results in the implementation of rapid design cycles. These rapid design cycles are a part of the popular lean startup methodology which focuses on fast iterations on the product in attempt to sustain the growth of the startup (Ghezzi 2020). This principle is what most startup models are based and has seen frequent use in recent decades (Ghezzi 2020). Therefore, due to the strong incentive posed by consumer interests, this social group was explicitly defined in Figure 8 on page 28.

Finally, the most crucial and biggest effect present on the technology are the engineers that develop it. While financial pressure is exerted by external investors and communicated through product managers, engineers ultimately produce the technology in a startup. Common pressures that are exerted on engineers include overwork and short deadlines (Stayton et al.

2016). The effects from overwork include a lack of quality present on an individual and team basis as presented by Olson et al. (Olson et al. 2015). Shown by Barnes is an analysis of negative effects relating to sleep deprivation on individual and teams of engineers. These effects include a lack of innovation and from overwork and critical errors that may cause significant impact to a project or technology. Due to their direct influence on technology caused from external pressures they are included as a group in Figure 8 on page 28.

SUMMATION

Based on the analysis framed through Arnold Pacey's Triangle of Technology Practice an indirect link between the startup environment and negative effects on the technology produced were established. The extent of the negative influence that a startup environment exerts on the technology encompasses the organization, culture, and technical resources. The organization of a startup is oriented to short development cycles, a lack of reduce funding, and significant overtime work that is inflicted on employees. From this financial pressure, management present in a startup additionally encourages marketability rather than prioritizing ethical design in the relevant technology. This incentive for marketability is reinforced by the culture of a startup in which a prioritization of utility is persistent among engineers. Explicit responsibilities relating to ethical design remain undefined or unclear which ultimately results in ethics only being accounted for based on personal subjective experience.

These pressures in turn effect the resources available for the technology as well as the quality of the technology itself. Lacking financial funding contributes to a lack of resources. In response to this lack of resources existing tools or work may be reused encouraging patchwork or temporary solutions. Significant overtime pressure present from financial stress reduces the quality of the work produced by engineers. Often errors accumulate due to sleep deprivation or stress imposed on the engineers. These mistakes, which manifest on a team level as well as individual, further compound the strain present in the development cycle. The excess in personal tension and anxiety may even cause interpersonal conflict among a team and reduce the quality of the design solutions.

The relevance of this resource is reinforced by Brattström. Present in Brattström paper is a finding that the culture or organizational structure present in a startup may persist beyond the early stages of the startup (Brattström 2019). It is possible that many of the outlined effects on the technology in an early-startup environment can carry over to the emergent organization. The design errors inflicted on the technology as well as the focus on marketability over ethical design can damage or negatively impact relevant stakeholders. The effects from a startup environment detailed in this paper may not be constrained to the small scale usually seen in startups, but instead effect a much larger scale. This gives merit to future studies as currently there is little established research of the effects of the startup environment on engineering design.

FUTURE RESEARCH AND LIMITATIONS

However, there are limitations present in this research paper. All of these effects on technology found in this paper are only indirectly proven. There is a lack of data directly correlating several relationships found in this paper. For example, financial stress has not been found by data to correlate with errors or negligence in designing technology. Instead, the effects of financial stress were only outlined which included significant overwork and short deadlines. Thereafter a relation was established between overwork and technological development. Studies relating to the effects of overwork on the quality, error rate, and lack of innovation on a technology were used to supplement lacking existing research. It is recommended that future studies test the validity of these indirect relations expressed in this paper through direct correlation in data. The intention of this paper is to begin a dialogue and inspire further research on this topic as there is very little established research available.

Additional potential research avenues can include performing a series of case studies in which the effects of startup products are evaluated on stakeholders using an ethical framework. An example of a framework that may work well in these potential case studies is Value-Sensitive Design (VSD). This ethical framework would be ideal as it focuses on the impacts and benefits on values held by multiple groups. Showing unintentional negative affects on stakeholder's values from a startup's product may create enough evidence to encourage further research on this topic. Another benefit to utilizing Value-Sensitive Design may be achieving a better understanding on specific negative aspects present in the development of startup products. As this paper only touched upon broad negative effects relating to quality or ethical accountability in these products.

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