ONTARIO SOCIETY OF PROFESSIONAL ENGINEERS

BARRIERS IN NEW ENGINEERING AND TECHNOLOGY JOBS:

THE UNEVEN IMPACT OF WORKING-AT-HOME ON RECENT GRADUATES, WOMEN, AND NEWCOMERS

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Abstract

A review of existing literature on the impacts of remote working with an emphasis on how they may affect the field of engineering in general, and the demographics of recent graduates, women, and newcomers in particular.

Research by

PRISM ECONOMICS AND ANALYSIS

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Executive Summary

This literature review explores the findings of empirical studies on the potential impacts, both positive and negative, of continuing or expanding working-from-home policies. The particular focus of this review is on the effects of working-from-home on engineering and technology professionals. Where available, the review takes note of how working-from-home may have different significance for women engineers, recently arrived internationally educated engineering professionals, and recent engineering and technology graduates.

Recent surveys find that there is broad employee support for a significant expansion of working-from-home policies. However, this may conflict with the interests of many of the organizations that employ engineering and technology professionals. Although not conclusive, an important inference from the literature is that engineering may be ill-suited to a large-scale shift toward working-from-home. That being said, there are several confounding factors that point to the need for caution before drawing strong conclusions. As well, there are significant gaps in research into the effects of remote working, especially in relation to engineering and technology work.

Recent Survey Findings

Recent surveys find that remote working is exceptionally popular among the general population. Although limited, there is some survey data indicating that this trend also holds among engineers. The same surveys report that those working remotely feel they are more productive than they were previously, but also that they are working a greater number of hours each week. These are self-reported findings which should be treated with caution. Recent surveys do not find any significant gender differences, although this may be because gender issues were not the focus. Not surprisingly, recent surveys also find that there is unequal access to the necessary resources to work remotely. The recent surveys do not explore the consequences of this unequal access, nor do they provide detailed insight into its incidence.

Remote Working: Success Factors

The literature on remote working generally finds that success in engineering work, particularly when that work is undertaken in a group or team-oriented context, is facilitated by consistent contact that allows for 'rich' communication. Rich communication encourages more effective teams through the freer exchange of ideas and the transfer of knowledge and expertise between members. There is a significant body of research which suggests that online communication is a suboptimal means of achieving these goals and may hamper the establishment and maintenance of high performing project teams. The preference of many engineering professionals to continue working from home, at least part of the week may run counter to the preferences of engineering employers if these assessments of the importance of rich communication prove to be largely correct.

Potential Benefits of Working-from-Home

An expansion of working-from-home policies may be associated with a number of benefits for engineers, both in general, and for women, recently arrived internationally educated engineering professionals, and recent engineering and technology graduates. The literature suggests that potential benefits may include: more career opportunities, superior work-life balance, reduced commuting time, and improved mental health.

Potential Drawbacks of Working-from-Home

The literature also suggests that an expansion or continuation of working-from-home practices may be associated with drawbacks. Among the most prominent potential drawbacks are: fewer and/or inferior mentorship opportunities, more intense competition for entry level positions, poorer work-life balance owing to an increase in working hours, reduced promotion opportunities, poorer overall engineering outcomes, and reduced integration of different identities into engineering workplaces.

Gaps in the Literature

The current empirical literature has serious gaps. In the main, this literature does not specifically address engineering workplaces or engineering and technology professionals. This is an especially serious gap because there are distinct characteristics of engineering workplaces that may make them either more or less suitable for continuing or expanding working-from-home arrangements. The current literature also focuses on overall averages. Some of the literature does not distinguish the potentially different effects of working-from-home on women, recently arrived internationally educated engineering professionals or recent engineering and technology graduates. Almost all of the literature is based on respondent's self-reported impressions. Employer perspectives are largely missing. The literature on remotely connected teams examines this process in the context of working from offices. This is not necessarily the same as connecting team members who are working from their residences. The literature does not explore the implications of working-from-home for career progression, although there are suggestions that professionals who choose to work from home may reduce their promotion prospects. The recent literature does not explore how the expansion or continuation of working-from-home affects the skills needed by leaders and managers. Lastly, the literature does not consider how engineering employers and engineering professionals can mitigate the potentially negative effects of working from home or maximize the potential benefits to both employers and employees.

Conclusion

A review of the existing literature should not be taken as a conclusive or definitive statement on the likely impacts of an expansion of working-from-home policies. The studies cited in this review are often narrow in their scope, with much of the data collected under circumstances that may be transitory or overly influenced by self-reporting biases. While on the balance, it can be inferred from the literature that, for engineering work, there are likely to be more negative than positive consequences associated with working-from-home, this conclusion should be viewed as tentative. There are significant gaps in the empirical literature, especially in relation to engineering work and the potentially different effects of working-from-home on women engineers, recently arrived internationally educated engineering professionals, and recent engineering and technology graduates.

Empirical Research on Remote Working and Working-from Home

Overview

Surveys and research conducted during the COVID-19 pandemic indicate an overwhelming desire among workers for greater access to remote working and working-from-home options in the future. These studies have also shown favourable reports regarding productivity among employees who have worked from home during the pandemic. However, past research and existing concerns about the durability and validity of these findings provide reasons to be cautious when attempting to generalise these findings to the post-pandemic world, or to the engineering profession specifically.

Findings In-Depth

Statistical data gathered immediately prior to and during the COVID-19 pandemic provides the bulk of the insights relating to the shift towards remote working and working-from-home as widespread and normal means of doing business. The following sections will call attention to the findings which are most relevant to the areas of interest of this study. They will also identify where information gathered may be lacking or impeded by factors beyond the scope or capacity of the research being referenced.

Remote Working vs. Working-from-Home

For the purposes of this paper a necessary distinction must be drawn between the terms "remote working" and "working-from-home". These and other terms such as: "teleworking" are often used interchangeably both in common discourse and in research. This is because of a lack of a clearly defined terminology for the field. Distinctions are important for ensuring that information is understandable and the limitations of the applicability of knowledge is clearly communicated. Therefore, for the purposes of this study, "working-from-home" will specifically refer to the phenomenon of a worker performing their duties from the home rather than a centrally located office. "Remote working" will be used to refer to any situation in which a worker is performing duties from a location other than a central work location and is facilitated through the use of electronic communication. Throughout this paper, insights drawn from research on remote working may be applied to working-from-home if there is sufficient overlap or similarity in the topic of discussion.

Popularity of Working-from-Home

Statistics Canada recently released a report detailing their findings on the productivity and personal preferences of people new to working-from-home during the COVID-19 pandemic. This study found overwhelming support for greater access to working-from-home options (Mehdi and Morissette, 2021). A significant majority (80%) would prefer to spend at least half of their working time at home. Among that group, a large portion (39%) would prefer to work *most* or *all* of their time at home (Mehdi and Morissette, 2021). A similar poll conducted by the Pew Research Center corroborated these findings. Among a geographically representative sample of 10,322 American adults more than half of respondents (54%) wished to continue working from home in some capacity after the pandemic has ended (Parker et al., 2020).

There is some evidence to suggest that these results will also generalize to those in the engineering profession. Terminal.io, a remote team working and recruiting platform, conducted an online survey of 1,108 engineers across North and South America. It was found that 76% of those surveyed would prefer to work at least half of their hours remotely following the pandemic. They also found that 29% would prefer that working remotely full-time become a permanent change (Terminal.io, 2021).

Potential Issues

The above findings paint an optimistic image of the trend towards a greater emphasis on working-from-home in the post-pandemic world. However, it is important to consider them in context and address their limitations before coming to any conclusions.

Firstly, the Statistics Canada study which offers the most positive view of a continuation of COVID era working-from-home practices bases its measures of productivity on self-reports from employees. Findings of increased productivity among teleworkers are broadly borne out by previous meta-analytic research both in terms of supervisor ratings and, in some instances, objective measures (Gajendran and Harrison, 2007, Gajendran et al., 2015). There are, however, a number of issues with regards to these findings which may call into questions their reliability and their usefulness in generalizing to future contexts.

Definitions of productivity are a recurring problem with remote working and working-from-home research. This is due to a necessary distinction between total output and output as a function of a given period of time. In the case of the former there is strong evidence that total output increases among remote workers, but this must be considered in conjunction with the evidence that those working from home report taking fewer days off (including days when they are sick) and report working longer hours (Montruil and Lippel, 2003). This state of affairs appears to have held true, or potentially even accelerated during the COVID pandemic. One recent survey by ADP in conjunction with Angus Reid found the proportion of remote workers reporting an increase in worked hours had doubled when compared to the previous year (ADP, 2021). Statistics Canada has worked to address this issue by asking respondents to rank productivity on a per-hour basis rather than in abstract or total terms. This is an important step in making research into working-from-home more consistent and valid but does not wholly eliminate potential issues with interpreting their findings. For example: both Pew Research Center and Statistics Canada note that a lack of access to childcare may have contributed to lower overall productivity, which could mean that resulting productivity gains are actually understated (Mehdi and Morissette, 2021, Parker et al., 2020). However, there is also the possibility that the closure of other businesses and sources of recreation may have contributed to an increase in overall productivity by denying various forms of leisure as alternatives to work. Employees may also have an incentive to be dishonest in discussions about their self reported productivity. Those wishing to maintain a working arrangement that was previously a privilege may choose to overstate their productivity to continue working-from-home (Mann and Holdsworth, 2003, Allen, Golden and Shockley, 2015).

There are also issues relating to the extent to which results taken from the general population are likely to apply to the engineering profession specifically. Engineering work, especially when conducted as part of a team, has been found to be hampered by remote

working outside of specific circumstances. Current research suggests that outside of highly individualized working conditions, remote working is generally harmful to the innovative and productive potential of engineering and design (Chamakiotis, Dekoninck, and Panteli, 2013). This runs directly counter to the findings of surveys discussed above and their assertions of enhanced overall productivity. Engineers operate in a field that requires advanced education and substantial cognitive abilities. It is not a stretch to believe that the challenges facing engineers while working-from-home differ from those experienced by the general population. As a result, the survey findings likely do not map perfectly to the circumstances of engineers and technologists.

Finally, it bears considering that the broadness of recent survey findings may not accurately depict the experiences of women engineers, recently arrived internationally educated engineering professionals, and recent engineering and technology graduates. While trends among workers new to working-from-home and/or remote working in the general population offer a high-altitude view, the changes undergone over the course of the pandemic likely have not been borne evenly across all groups of the population.

While the implications of these findings will be discussed in greater detail in later sections, data collected by the Future Skills Centre indicates that there exist pronounced gaps in online access among 'equity seeking groups' (Saba et al., 2021). Among their findings are that members of such groups appear to be less likely than the general population to have access to the requisite infrastructure and equipment to make working-from-home viable (Saba et al., 2021). Gaps in "digital skills" between groups, and the costs of a move toward working-from-home may also have different impacts on women engineers, recently arrived internationally educated engineering professionals, and recent engineering and technology graduates. (Ng et al., 2021, Saba et al., 2021, Future Skills Centre, 2021).

Factors Which Contribute to the Success of Engineering Teams

Overview

A robust body of academic and practical research has distilled the primary factors which contribute to success in the field of engineering, particularly with regards to working as part of a group or team. Existing literature emphasises the importance of building and maintaining trust among team members, enabling communication high in richness and clarity, the aligning of incentives, and group commitment. Richness of communication refers to the number of different methods through which a medium can communicate meaning. A high richness medium (like face-to-face interaction) has many channels (hand gestures, tone, eye contact, facial expression) while a low richness medium (like text messaging) has few (written text). Current research also suggests that these factors may be under threat in an environment in which working-from-home is dramatically expanded.

Findings In-Depth

The factors which most contribute to the success of engineering projects have been a topic of interest among researchers for decades. Literature on the best practices for remote working and working-from-home has been growing steadily since the concepts were first introduced as a possibility. The sections below will distill some of the most significant and relevant findings and provide explanations about how some aspects may interact or conflict.

Ideal Conditions and Potential Conflicts

Research has consistently found that a cohesive team environment which maximizes communication and trust is a vital part of ensuring high performance in engineering teams (Olson et al., 2008, Jordan and Adams, 2016, Thamhain and Wileman, 1987). In a large-scale study of academic literature Olson et al. developed what have become accepted factors which facilitate success in collaborative STEM environments. Through their research, this group found that the establishment of "common ground", defined as mutual knowledge and a shared set of beliefs and assumptions, in combination with "collaboration readiness", defined as the motivation to collaborate, a willingness to trust one another, feelings of empowerment, and the alignment of goals, were among the most important factors in determining team success (Olson et al., 2008). Preliminary research also found that these qualities, with minimal modification, were also primary drivers of STEM success in the private sector (Cherian and Olson, 2007). Other factors commonly cited include strong and effective leadership, proper experience and skills, sufficient resources, planning, rewards, autonomy, and technical capacity (Thamhain and Wileman, 1987). If engineers and organizations anticipate a move towards more working-from-home arrangements, it is vital that they take into account the reduction in efficacy of these and other key components of traditional working arrangements when developing their policies.

One such component is clear and concise communication, which has been found to be key in fostering and enhancing innovation in engineering teams (Olson et al., 2008, Jordan and Adams, 2016, Thamhain and Wileman, 1987). It is also believed to be among the most

likely casualties in a shift toward working-from-home arrangements. This is attributed to a reduction in the "richness" of communication between team members. "Communication richness" is defined as the number of channels through which information can be communicated (Wu et al., 2008). Online communication is severely limited when compared to face-to-face interaction, lacking in ostensibly minor nuances such as the ability to maintain eye contact, the presence of even slight delays in discussions, difficulty in communicating tonality, or the supplementing of statements through the use of gestures. This theory has been lent credence as research on the connection between the richness of a given communication medium and the productivity of those who make use of it has grown. Among the most notable developments in this field of research has been a study conducted by the Massachusetts Institute of Technology (M.I.T.). In their study, I.D. badges were used to monitor the richness of in-person discussions at high tech firms. This information was then compared to discussions conducted electronically, with the productivity of participants then compared between the two groups (Wu et al., 2008). Their findings indicated that face-to-face interactions were associated with higher efficacy in the completion of complex tasks (Wu et al., 2008). These findings should be taken with a grain of salt given that the alternative method of virtual communication being studied was email. However, additional research appears to support the underlying claims of a connection between richness of communication medium and productivity in complex tasks even when higher fidelity mediums are used (Utrianen, 2017, Sroka, 2018).

Compounding issues of communication are the potential effects of remote work or working-from-home on the establishment and maintenance of trust among engineers. Trust serves as an essential foundation for the free exchange of information and is especially important when performing complex tasks which require the involvement of multiple parties (Thamhain and Wileman, 1987). Existing literature suggests that face-to-face interaction remains the most efficient way for groups to establish trust among their members (Allen, Golden, and Shockley, 2015). The ready transfer of information serves a vital role in the context of complex engineering projects. Efficient information transfer helps reduce the duplication of effort, propagates new ideas and efficiencies, and better integrates the contributions of team members (Allen, Golden, and Shockley, 2015).

The above best practices are also important in aiding higher order group functions such as maintaining an alignment of interests among team members, and commitment to the group (Thamhain and Wileman, 1987). Given that these factors tend to coalesce and be maintained under conditions of high trust between team members, it is possible that they too will be threatened by a move towards more working-from-home, and as a result, undermine the functioning of the team more generally.

Although framed primarily in terms of aiding in the functioning of team members, the high-performance factors mentioned above are also relevant to management and leadership.

Those heading teams are most effective when they are familiar with the needs of their subordinates. They also benefit from being knowledgeable on how best to allocate talent and time among projects. These skills are highly contingent on the ability of those in charge to connect with those whom they oversee. Managers are most able to facilitate the success of their engineering teams by demonstrating their commitment to the teams' interests rather

than their own and by demonstrating that they are deserving of trust (Olson et al., 2008). Due to the same factors discussed previously, managers may find greater difficulty in performing their duties to their maximum potential in a virtual working space. Implied support can be found for this thesis in research conducted by the Future Skills Centre, which found that managers were among those most likely to rate their experience transitioning to remote working poorly (Saba, Bezu, and Haider, 2021). While ratings from managers eventually rose to levels similar to those of other respondent groups, whether or not managers *in engineering* are a part of that trend remains an open question.

Complicating Factors

Consideration should also be paid to the extent to which best practices in engineering potentially conflict with those of working-from-home. Although engineering literature indicates that an environment which fosters frequent and unencumbered contact is best for achieving optimal results, it is widely believed that the opposite is most conducive to success when working remotely. Remote working literature has found, with a great deal of consistency, that remote workers are at their best when their tasks are minimally interdependent and highly compartmentalised (Cherian and Olson, 2007). This owes to factors previously discussed relating to difficulty in transmitting information through less rich media. Additional difficulties brought about by a reduction in both formal and informal contact likely also play a part.

Moreover, aspects which have been found to be both desired by remote workers and conducive to their success run afoul of the qualities found in successful engineering teams. For example, increased autonomy, commonly cited as a benefit of remote working, may undermine the development of trust in the workplace. As will be discussed in later sections, other aspects associated with positive working-from-home performance such as compartmentalized work and little interdependence may also weaken overall engineering team performance (Cherian and Olson, 2007). It is therefore important for employers and employees to consider not only how remote working and engineering can be optimised individually, but also how best to reconcile their competing demands.

Potential Benefits of Working-from-Home

Overview

Surveys referenced in Section 1 in combination with a review of current literature suggests that there are likely to be benefits experienced by both engineers in general, and women engineers, recently arrived internationally educated engineering professionals or recent engineering and technology graduates *in particular. These and other groups may benefit from greater flexibility in working conditions, wider organisational access, increased feelings of autonomy, increased satisfaction, reduced personal costs, and superior work-life balance.*

Findings In-Depth

Previous research on the subjects of remote working and working-from-home in combination with recent survey data offers ideas of how workers may benefit from a shift to more working-from-home. Details on how the empirical research and supporting evidence suggest a permanent shift may benefit engineers are provided below.

Career Prospects

First among potential benefits of a greater emphasis on working-from-home is expanded access to career opportunities. Growth in working-from-home has the obvious implication of divorcing employment prospects from a geographic location. This could open up access to a wider variety of employment options than were available in the past.

Among women in engineering this state of affairs may, for instance, aid in eliminating the "trailing spouse" phenomenon. This refers to a situation in which partners, but more often women, compromise their careers in service of the other's through relocation (Harris, 2002). In a similar vein, increased working-from-home could also serve to encourage accommodation for engineering professionals with young children. This is particularly relevant for women engineers who more often bear greater responsibilities for young children. Changing roles or organisations can be immensely difficult for those with families. The need to relocate and reorient various obligations is a strain that is often felt most acutely by women, who are often ascribed the greatest responsibility for familial affairs. Working-from-home becoming more common may drastically reduce the disruptions felt by those seeking working conditions which better suit their personal circumstances. This change could serve to shift leverage towards employees, particularly those in desirable groups for recruitment and retention. This may, in turn, lead to firms better tailoring their accommodation practices to the preferences of such individuals. Overall, it is possible that working-from-home, especially a maximal interpretation of it, could decease the likelihood of women in engineering being made to choose between family and career.

In the case of recently arrived internationally educated engineering professionals expanded access to potential employers may reduce the imbalance between their employment outcomes and those of native-born Canadians (Crossman, Hou, and Picot, 2021). It may also encourage better economic outcomes among this group by expanding the

geographic options available to them. Data suggests that new immigrants are overwhelmingly drawn towards the largest Canadian cities, all of which are currently gripped by pronounced affordability issues (Vézina and René Houle, 2017, Klachkin, Stillo, and Davenport, 2021). Remote working options may allow for greater choice in work location among recently arrived internationally educated engineering professionals and thus bolster economic outcomes among them. Superior economic outcomes may be compounded by reductions in often overlooked costs relating to transportation, necessary office-wear, and other incidental expenditures.

Among recent engineering and technology graduates and new entrants to the field the prospect of a wider employment market likely also holds appeal. The chance for greater exploration of opportunities and the potential for better alignment between skills and desired careers are likely to prove highly desirable. A recent survey of engineers and technology workers conducted by Terminal.io found that, among Canadian respondents, 67% would prefer to work for a tech company located in the United States. Within this group 39% expressed no interest in living in the U.S. (Terminal.io, 2021). A similar sentiment was found in a study conducted by the University of Toronto in conjunction with Brock University. This study found that among STEM graduates in Canada there was an overwhelming preference to work for foreign, especially American, companies (Spicer, Olmstead, and Goodman, 2018). If legal barriers and concerns relating to location-based pay can be addressed, full working-from-home may result in more Canadian engineers and technology professionals gaining access to their preferred employers without the need to relocate.

Workplace Equity

Working-from-home may contribute to a more equitable workplace, although the research on this is both mixed and sparse. There is some cause to believe that remote working conditions may reduce or eliminate biases in discussion among members of different identity groups (Bhappu, Griffith, and Northcraft, 1997). The basis for this is the view that online communication reduces the salience of demographic characteristics compared to in-person interactions. If correct, this could benefit both women engineers and engineers from visible minority backgrounds.

The largest equity benefit for women may be the provision of more flexible working options which promote greater work-life balance. (Chung and Van der Lippe, 2018). Flexible working arrangements including working-from-home are a key method of keeping women, especially those in complex or human-capital-intensive jobs, engaged with their careers and their organisations (Chung and van der Lippe, 2018). This premise is somewhat supported by current survey data such as the COVID specific data collected by Pew Research. This data showed that 49% of respondents felt they had gained greater flexibility in their work, and that 39% reported a higher degree of work-life balance (Parker et al., 2020).

Working remotely can also facilitate better balance between family and professional commitments by promoting fluidity in working hours with respect the often-erratic demands of family life, especially during new motherhood (Fuller and Hirsch, 2018). These benefits have the potential to increase retention of female engineers while also enhancing their long-term professional prospects (Fuller and Hirsch, 2018). Tentative support for this idea may be

intuited from findings which indicate that women are generally as or more likely to have positive impressions of working from home and are similarly likely to make use of the option as compared to men (Ng et al., 2021).

Mental Health

Mental health benefits of working-from-home are difficult to quantify owing to the challenge of isolating a single factor in the determination of an individual's mental health. Nevertheless, there is a consensus in the research literature that the absence of a commute, the reduction in exposure to office politics, and bolstered feelings of autonomy have a positive impact on the mental health (Mann and Holdsworth, 2003, Terminal.io, 2021). While all engineering and technology professionals may experience improved mental health from working-from-home, these benefits may be greater for women engineers and recently arrived internationally educated engineering professionals. Recent immigrants are significantly less likely to avail themselves of mental health services (Derr, 2017).

Potential Drawbacks of Working-from-Home

Overview

There is evidence to suggest that engineering work may be adversely affected by a pronounced shift to working-from-home. There is reason to believe that a shift to working-from-home could reduce promotion prospects, exacerbate work-life balance issues, increase inequality in the engineering and technology professions, reduce opportunities for mentorship and put downward pressure on earnings, especially for entry-level jobs.

Findings In-Depth

A thorough examination of existing literature on the subject of remote working has yielded a number of potential negative outcomes which should raise significant concerns regarding how the practice may impact perceptions of employment equity in the field of engineering. Such potential drawbacks are detailed below.

Mentorship and Networking

Mentorship has long been known to be an important part of accelerating people's growth and development both in general and specifically in the engineering space (National Academies of Sciences, Engineering, and Medicine, 2019). A move toward a greater or total working-from-home regime may have a negative impact on mentorship. This could be due to the limited opportunities for informal and spontaneous interaction via online media when compared to face-to-face interactions. Reductions in the development of trust and communication more generally as a consequence of heavily electronic exchanges may also reduce its efficacy (McReynolds et al., 2020).

Mentorship can be of particular benefit to women engineers, recently arrived internationally educated engineering professionals, and recent engineering and technology graduates. Women in STEM are believed to benefit significantly from mentorship opportunities, particularly with regards to career progression, retention, and development (Saxena, Geiselman, and Zhang, 2019). The paucity of women in STEM fields is said to make mentorship particularly important. Mentorship can act as a means of addressing under-representation and aid in understanding the aspects of a workplace's culture which can be perceived by women as unwelcoming (Saxena, Geiselman, and Zhang, 2019).

Mentorship in the workplace offers new immigrants the chance to learn the nuances and unspoken cultural norms which govern Canadian workplaces (Lai, Shankar, and Khalema, 2017). This benefit likewise may be compromised or lost in a shift toward more working-from-home. The workplace acts as a location through which natural English language training can occur. It can also work as a facilitator for acculturation and social integration. Some recent immigrants may find their integration more drawn out. They may also have less opportunity for advancement than would otherwise be the case (Ng et al., 2021).

Among recent graduates, mentorship serves as a well documented means of accelerating their professional development (Malmgren, Ottino, and Amaral, 2010). Loss of access to this opportunity, or even a simple reduction in its efficacy may have a negative impact on those entering the engineering field. Given current demographic trends, the transfer of knowledge to younger generations in the workplace is crucial, as those with the most experience are likely to begin retiring *en masse* in the near future (C4SE, 2015). Ensuring that mentorship is strengthened, rather than weakened, is therefore important to maintaining the calibre of Canada's pool of engineering talent.

An issue similar to reduced mentorship opportunities is the question of how networking is likely to be affected by the move to more working-from-home. The literature suggests that participation in informal professional networks is important for professional development and learning about new opportunities (Bartol and Zang, 2007). Women and newcomers are often thought to be at a disadvantage in building or joining networks. This is because professional networks tend to be shaped by commonality of traits and shared interests. In some environments this can inadvertently have the effect of excluding or leaving out some women engineers and newcomers. (Forret, 2006, Xu and Martin, 2011, Chekwa, 2018).

There is not current research on the extent to which working-from-home affects network formation and participation. However, the loss of informal, face-to-face interactions presumably mitigates against building or being part of a professional network. The consequences of reduced professional networking opportunities are negative for all engineers, but especially for women engineers, recently arrived internationally educated engineering professionals, and recent engineering and technology graduates.

Potential Labour Market Effects

As remote work grows so also does employer access to previously untapped talent. If an employer adopts a fully remote working or working-from-home model, rather than a hybrid model, that employer is no longer restricted to its immediate geographic area when recruiting. This has two potential consequences. First, for an employer, severing location from recruitment widens the potential recruitment pool. Second, and conversely, for engineering and technology professionals who are willing to work remotely, the same severing of location from recruitment may expand employment opportunities. It is too early to say how these potential changes in the engineering labour market will work out or whether they will primarily benefit employers or jobseekers.

Increased competition for jobs, if it turns out to be a consequence of a shift to working-from-home, may spur the common HR practice of raising the bar for new hires. This is most evident when employers set a three-to-five-year experience requirement for new hires. "Experience Inflation" can be particularly challenging for recent graduates and for newcomers (whose non-Canadian experience is often discounted).

In a survey conducted by TalentWorks in 2018 it was found that the proportion of "entry level" positions requiring at least 3 years of prior experience stood at 61% (Chakrabarti, 2018). These findings are supported by a report released by VerveResearch, in which it was found that as many as 93% of entry level engineering positions required previous experience (Salton, 2021). If a significant number of employers use remote working to take advantage of a wider

talent pool and then raise experience requirements for new hires, it is possible that many more recent graduates will find themselves challenged when attempting to start their careers.

More broadly, the expansion of the talent pool to which employers have access as a consequence of greater emphasis on working-from-home may put downward pressure on wages. Companies such as Facebook have already begun to endorse ideas such as adjusting wages to an employee's place of residence (Gilchrist, 2020). It is not surprising that, in their survey, Terminal.io found that location-based pay was unpopular among engineers (Terminal.io, 2021). Location based pay is controversial precisely because it forces employees to choose between compensation and working-from-home. One of the most important things for companies to determine going forward will likely be the extent to which working-from-home and compensation are valued by current and prospective employees. Striking a balance between these factors may prove to be one of the defining aspects of employee-employer relations for the next several years.

Work-Life Balance Issues

Women have been singled out in past remote working literature for the impact that working-from-home has on their work-life balance (Ibarra, Gillard, and Chamorro-Premuzic, 2020). While the potential gains for women in the form of increased work flexibility and greater work-life balance have already been discussed, existing scholarship is sharply divided on whether or not this will be the ultimate outcome. It is believed that as a result of expectations within society of a need for women to fulfill both domestic and professional functions, that there is a strong possibility that working-from-home will actually *increase* the overall burden in their working lives (Ibarra, Gillard, and Chamorro-Premuzic, 2020). This may actually result in greater overall work-family conflict while also expanding the career and earnings gap between men and women in engineering.

This possibility has been broached by previous researchers who have argued that remote working arrangements and flexible work designs are treated differently between men and women. Men, it is said, use remote and flexible work arrangements to expand their spheres of work while women use them to better balance domestic and professional obligations (Lott and Chung, 2016, Future Skills Centre, 2021). This may explain why many organizations which implement more flexible working arrangements still fail to increase the share of women in upper-level management positions (Jones, 2019).

A continuation of this observation can be found in a very small-scale study of the experience of software engineers working during the pandemic. It was found that most of the efforts to accommodate the transition to working-from-home did not address the specific needs of female employees. While ergonomic and technological accommodations were made, there was little acknowledgement of the needs typically associated with women such as childcare, meal preparation, or cleaning services (Machado et al., 2020). This issue may be compounded by the previously cited observation that those working from home tend to put in longer hours.

Career marginalisation can be a consequence of reduced ability to advocate for oneself. A lack of presence in the office can affect one's influence over resource allocation and assignments, as well as reduce access to informal networks (Haddon and Lewis, 1994, Mann

and Holdsworth, 2003). There is a risk that women will feel pressured to opt for remote working arrangements to better balance their family obligations, but by doing so they will reduce their prospects for advancement. There is already some anecdotal evidence to suggest that those who choose to work from home will be at a disadvantage. At time of writing JPMorgan Chase CEO Jamie Dimon and CEO of WeWork Sandeep Mathrani, have made statements emphasising their preference for employees to work in the office. They add that they view a commitment to do so as a sign of personal and professional ambition (Wells, 2021). There is also some historic evidence of this tension among companies with innovation-based ambitions. Some notable examples have included Yahoo and IBM, both of which had robust remote working policies in place, only to have them retired, arguing that the dearth of in person contact had negatively impacted their innovative potential (Sroka, 2018). Similar concerns have also been voiced by Patrick Pichette, former CEO of Google (now Alphabet), who has noted that he prefers that employees work in the same location as often as is possible (Sroka, 2018).

Despite the potential for working-from-home to exacerbate gender issues, it is worth noting that neither Pew Research nor Statistics Canada found significant gender differences in their surveys (Mehdi and Morissette, 2021, Parker et al., 2020). These findings run counter to what would be expected. Studies conducted for the Future Skills Centre found that working-from-home does not appear to reduce the challenge many women face when trying to balance family and workplace obligations. (Future Skills Centre, 2021). While findings made while schools and daycare centres were closed should be treated with caution, there is some evidence to suggest that this is a persistent issue. A pre-pandemic study on how remote working affects well-being found that working-from-home was associated with less happiness for parents (Song and Gao, 2020). The idea that these issues are independent of the pandemic is strengthened by additional research conducted for the Future Skills Centre. In one survey 62% of respondents agreed with the statement "When I work from home, I feel like I am working all the time and never have time for myself or my family." (Future Skills Centre, 2021). Though far from conclusive, this implies that at least some of the issue may relate specifically to the act of working from home rather than pandemic specific changes. It is also possible that the increased workload is a function of the pandemic and will be reduced as people acclimate to their new working arrangements, though this has not yet been reflected in any relevant polling or survey data.

Remote Work and Career Progression

Among the most common concerns raised by the remote working and working-from-home literature is the extent to which working remotely affects career progression prospects. The belief that working away from the office negatively impacts one's potential for upward mobility is so common that it has become something of a truism among the general population (Allen, 2001). Research by the Future Skills Centre throughout the pandemic found that as workers transitioned to working from home, this concern was especially acute among women, immigrants and younger workers. Among immigrants, 44% worried that working from home would negatively impact their careers, a rate which rose to 60% when considering only recent immigrants (Future Skills Centre, 2021). This concern is also especially prevalent among young workers, 56% of whom fear a negative impact on their careers (Future Skills Centre,

2021). Curiously, women were less concerned about this potential impact. Only 32% of women expressed a concern that working-from-home might adversely affect career advancement prospects. (Future Skills Centre, 2021).

The evidence on whether working remotely adversely affects career prospects is decidedly mixed. One study finds that women who work from home or work remotely can expect fewer opportunities for promotion and lower overall earnings growth (Glass, 2004). On the other hand, a second study finds a net positive correlation between telecommuting and wages for women (Weeden, 2005). A meta-analytic report conducted by Gajendran and Harrison found there was no statistically significant correlation between telecommuting status and perceptions of career prospects (Gajendran and Harrison, 2007).

Brain Drain

From a broader, social perspective there is also the potential for remote working to accelerate what has already been characterised within Canada as the "Brain Drain" of STEM talent. As has been touched upon in previous sections, there appears to be an enormous portion of the engineering population which would prefer to work for United States based companies rather than those in Canada (Terminal.io, 2021). A previous research project conducted on behalf of the federal government by a partnership of Brock University and the University of Toronto describes in stark terms the reality that, within STEM circles, Canada is often seen as a suboptimal choice among practitioners, especially younger ones (Spicer, Olmstead, and Goodman, 2018).

Equitable Access to Opportunity

In discussing potential benefits of remote working, it was mentioned that some researchers have suggested that remote working may increase equitable access to opportunity by moving a greater proportion of interactions to electronic exchanges (Bhappu, Griffith, and Northcraft, 1997). However, there are alternative perspectives.

In a case study conducted as part of the European Global Product Realization, a large-scale design competition, it was found that a previously unexplored dimension of the team's remote working habits was the formation of "subgroups". The competing teams were comprised of individuals from a variety of backgrounds who were dispersed across a wide geographic area. It was observed that those individuals with commonalities that made communication easier were likely to form subgroups within the project. These subgroups, once established, tended to dominate discussions and exert greater influence on the direction of the project (Chamakiotis, Dekoninck, and Panteli, 2013). This raises the possibility that within teams composed of remotely-based members, an informal sub-group may emerge that unintentionally excludes or leaves out some members of the team. Women engineers and newcomers may be at greater risk of being left out.

Research into inclusiveness in remotely based engineering teams is limited and contradictory. No strong conclusions can be drawn. However, the experience employers have had with working-from-home may lead to an increase in remotely based teams. How this trend will affect inclusiveness in the engineering profession is an important issue.

When considering inclusivity decision makers should be aware of its historic drivers. Among the most commonly cited methods of encouraging integration of different groups is extended exposure to one another in combination with persistent interaction and cooperative interdependence (Gaertner et al., 1999). This method of reducing intergroup prejudice is explicitly threatened by the very nature of remote work. Existing research suggests that remote working arrangements are at their most efficacious when employees are given maximal autonomy, with their work being as compartmentalised and as lacking in interdependence as possible (Saba et al., 2021, Cherian and Olson, 2007). This is the antithesis of what conventional research suggests is the primary means to promote integration.

Mental Health

Because the large-scale shift toward working-from-home has occurred as part of a response to a major pandemic and economic dislocation, separating out mental health impacts is difficult. For this reason, predictions of potential mental health impacts of increased working-from-home should be made with an emphasis on issues which are endemic to remote working as a whole rather than those that may have arisen as a result of recent circumstances.

In research conducted by the Future Skills Centre it was found that recent immigrants were among the most likely groups surveyed to believe that they cannot work from home and continue to be a "good parent" (Future Skills Centre, 2021). If working-from-home exacerbates issues of work-life balance rather than ameliorate them this may have negative repercussions for the mental health of those affected, most likely women with young children.

On a broader scale, feelings of isolation have been commonly reported among remote workers for several decades and are of serious concern due to their comorbidity with other mental health complications such as depression (Mann, Sandi, and Holdsworth, 2003).

Lack of Access to Necessary Infrastructure

Questions also remain with regards to how working-from-home may exclude groups from participation based on access to the necessary tools and infrastructure. The cost of high-quality internet access, the potential need to purchase the requisite equipment and the need to find a suitable working location may all serve to exclude some people from positions in the engineering field.

Countries such as Mexico, in recognition of this potential issue, mandate that employers compensate teleworking employees for internet and electricity costs (Lockton Global Compliance, 2021). Canadian provinces have yet to determine the extent to which employers are required to financially accommodate employees that are expected to work from home. It is common to find postings which now list a stable and highspeed internet connection as a precondition of employment. Presumably this stable and highspeed internet connection is to be maintained at the employee's expense. This is to say nothing of other unresolved issues such as the eligibility for work related expenses, zoning issues, tax and insurance implications and worker safety coverage conflicts.

Potential Areas of Future Research

Overview

The preceding review of research and current trends has provided a baseline understanding of some of the possible outcomes of the continued shift towards working-from-home in the engineering space. However, there are still many informational gaps which are not addressed in existing research. The following section identifies several areas in which better understanding may be of use to decision makers in the future.

The Impact of Working-From-Home on Engineering Teams

As has been discussed at length in previous sections, there are very real concerns over how working-from-home may affect the efficacy of engineers. While this report has provided a strong theoretical basis on which to make educated assumptions, there is still a great deal of information which can only be gleaned from real-world experience and observation. Areas of future research should focus on coming to tested, replicable, and definitive conclusions on whether or not engineering teams that work from home face measurable changes in: productivity, innovation, structure or security.

How Working-From-Home Affects Different Roles

The field of engineering is enormously diverse and complex. The sheer number of different roles and functions makes sweeping generalizations about how changes in the nature of work will impact them less than ideal.

Different functions are likely to be affected in different ways by a shift towards working-from-home. The complexity of organizations mean that employees are likely to be affected not only by changes to their own working conditions, but also changes in the working conditions of those around them. Engineers that do or do not work from home but rely on or regularly interact with others that do will still likely see changes in how they can fulfill their duties. Future research should focus on refining understandings of which roles are most and least amenable to a shift to working-from-home and expanding on how working-from-home in other areas of organisations may alter the roles and abilities of engineers.

How Partial and Total Working-From-Home Preferences Affect Careers

Similarly to questions of job efficacy, this paper's understanding of how working-from-home will impact career opportunities is highly theoretical. Survey data has focused overwhelmingly on personal perceptions rather than on observable results, and thus may be heavily influenced by biases and incomplete information. Future research should seek to document differential outcomes among those who choose to work from home as compared to those who do not. It should also take into account circumstances which influence such decisions, and the extent to which they are associated with membership to particular groups. As with the rest of this report, focus should be placed on women, recent engineering and

technology graduates, and internationally-educated engineering professionals that have arrived in the near past.

How Working-From-Home Affects Needed Skills

Firms that seek a to sustain a competitive advantage in the engineering space while also embracing a working-from-home framework will need to ensure employees have the skills to succeed in this new paradigm. Likewise, employees that wish to flourish in a world in which working-from-home is increasingly common will need to learn to adapt. The shift to working-from-home will impact not only the duties of the job itself, but also the management of those engaging in them. Future research should investigate the skills that allow for maximum efficacy both among workers and managers when working-from-home in the engineering space. It should also work to understand whether these skills are universal or apply to particular types of roles, organisations, or people.

How Working-From-Home Affects Recruitment and Retention

As mentioned earlier in this report, preferences for working-from-home as expressed by the general population and engineers are remarkably strong. At time of writing it seems extremely likely that the extent to which working-from-home options are made available will significantly impact an organisation's recruitment efforts. Likewise, the jobs that engineers are likely to consider will almost certainly be influenced by the availability of working-from-home options, or compensation in lieu of them. Future research should investigate the extent to which both employees and employers value working-from-home in recruitment and retention strategies. Effort should also be made to understand the dollar value that both parties place on working-from-home accommodations in salary negotiations and measures of turnover.

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