Engagement and Satisfaction in OS Software Development:
The Impact of Job Characteristics

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Open source (OS) developers are contributing value to organizations and society as most contemporary organizations–including those that resisted their new way of developing software–now rely on the contributions of OS developers. This study examines the influence of job characteristics as drivers of engagement and satisfaction of developers in the OS environment. Using the job characteristics model (JCM) as the theoretical lens, we develop and assess a research model that examines engagement as a mediator in the relationship between job characteristics and satisfaction of OS developers. Findings indicate that several, but not all, job characteristics significantly influence the engagement of IS professionals working in Open-source software development (OSSD). The research contributes to the OS literature and extends our understanding of job characteristics, in the OSSD context. The study also provides new insight to organizations and individuals that are currently investing in OSSD or planning to do so soon.

Keywords: OS, software development, engagement, job characteristics, job satisfaction

INTRODUCTION

What job characteristics influence the satisfaction of open-source (OS) software developers (OSSD)? The previous research has a huge gap, as it has not focused on the engagement and satisfaction of these developers, even though OS developers have become mainstream across organizations. OS developers have evolved from being in an isolated world to being active participants in the organization. Beyond making public contributions, OS developers contribute to leading for-profit organizations as well, and renowned firms such as IBM, Google, and Microsoft are heavily involved in OSSD (Ho & Rai, 2017). As firms have moved beyond just using Linux and Linux-based technologies, to include a range of OS software in their products, OS developers have become sought-after workers (Florentine, 2013). Often, firms hire them instead of buying expensive licenses. Besides the broad range of firms, the organizations hiring OS developers include the who's who of the corporate world – such as Google, RedHat, HP, Dell, GM, Motorola, and Microsoft - a firm traditionally considered hostile to the OS movement (Vaughan-Nichols, 2013). The demand for OS Developers is increasing. 74% of hiring managers are looking for skilled OS developers and 65% of them identify an increase in hiring for OS talent to be more than any other part of their business, according to a survey of OS Jobs by the Linux Foundation (Linux, 2016). The idea of open-

source software development has influenced open-source development in many non-IS fields such as agricultural biotechnology (Adenle 2012) and electricity (Dall-Orsoletta 2022). Naturally, understanding the OSSD phenomenon remains an important topic for research (Sutanto et al., 2020).

The developers are a mainstay of both private and public institutions. Broader public contributions manifest as developers contribute to various government organizations such as the US Department of Defense (August et al., 2018). Similarly, Data.gov–a US government-sponsored website that makes thousands of datasets available to the general public–has been using GitHub as an OSSD platform for its OS applications (Data.gov, 2025). Because of the importance of OS developers to software development, the relationship between job characteristics and satisfaction for OS developers is an important, unexamined relationship. In comparison, previous research has examined how the characteristics of the job influence proprietary developers, little previous research focuses on OS developers. The two types of developers are markedly different, as borne in previous research. Specifically, OS developers have distinct motivations, such as altruism (Hars & Ou, 2002; Rafaeli & Ariel, 2008; von Krogh et al., 2012) or OSSD project attractiveness (Santos et al., 2013) or socialization experience (Carillo et al., 2017) or commitment to OSSD community (Maruping et el., 2019) or ties in the OSSD community (Peng et al., 2013). Practitioners work to underline the differences as well. According to the Global Spotlight 2023 report learning, fulfilling technology needs, creating career opportunities, a sense of responsibility towards the OS community, and enjoyment topped the list of factors that influence developers' contribution to OS software development (Linux Foundation 2023). Similarly, a survey of 678 OS developers conducted by The Boston Consulting Group (BCG) revealed that for a large majority, OS is a job, even though the motivations they work with are similar to that of the research community, as they desire to learn and seek respect through their code (Koch, 2003).

Because they may be intrinsically driven to contribute, previous research has presumed that developer satisfaction is an exogenous concept. Therefore, little previous research has focused on the satisfaction of OS software developers. Research in proprietary settings has linked job characteristics with developer satisfaction. Often, the job characteristics model (JCM) has been used as a theoretical lens to understand various facets of an information systems (IS) professional's job and to examine how these characteristics influence work outcomes in the proprietary software development (PSD) environment (Bala & Venkatesh,2013; Goldstein & Rockart, 1984; Igbaria et al., 1994; Morris & Venkatesh, 2010; Trip et al., 2016). Job characteristics have been found to differently influence job satisfaction in various contexts, such as in industrial and service organizations (Hackman & Oldham, 1976), in educational institutions (Daryanto, 2014), and in the hospitality and tourism sector (Zhao et al., 2016). It is unclear which characteristics influence OS software developers' satisfaction

Because no systematic assessment of the characteristics of jobs done by OS developers has been undertaken in previous research, our research addresses a crucial gap, as we examine the characteristics of a job that enhances the engagement and satisfaction of OS developers. Specifically, we examine the mediating role of engagement between job characteristics and satisfaction of OS software developers. We propose our hypotheses based on the job characteristic model (Hackman & Oldham, 1980) identifying the influence of five job characteristics on developer engagement and satisfaction in the OS context. We test the proposed model using a survey study design, seeking responses from IS professionals working on various OSSD projects that serve educational, gaming, communication, and several other industries. The results support the central assertion that job characteristics drive the level of engagement of IS professionals in the OSSD environment. However, our study unravels differences across various job characteristics in how they engage developers and lead to their eventual job satisfaction.

Academically, our research contributes to the broader OS research focused on understanding and leveraging the potential of OS software developers. Developer engagement is an important outcome for the OS community, as practitioners and researchers struggle to unravel how to engage these developers on OS projects. As a software development paradigm, the OS software community faces adverse outcomes due to the lack of voluntary participation affecting many OSSD projects (Fang & Neufeld, 2009). The interest in developer participation and engagement is increasing as OS communities grow exponentially. Indeed, engagement is crucial in the OS community because it relates to performance. Roberts et al. (2006) found

that IS professionals' participation is positively related to their performance in OSSD projects. Not surprisingly, how to increase voluntary participation has emerged as an important question for IS researchers (Ho & Rai, 2017). While the focus on participation is increasing, there is little understanding of the ways OS software projects may enhance developer engagement and satisfaction. Our research contributes to the growing literature in the domain, as we differentiate the effects of various job characteristics.

THEORETICAL FOUNDATIONS

Job Characteristics and Job Satisfaction in OS Software Development

OS workers are breaking the stereotypes regarding a job. Traditional thinking may underline that a job requires a paid position. However, OS workers, much like scientific communities, identify themselves with their job, contributing even without getting paid. Their motivations for doing so are well documented (Alam & Campbell, 2017; Bagozzi & Dholakia, 2006; Hars & Ou, 2002; Maruping et al., 2019; Roberts et al., 2006). Other individuals identify themselves with their job or role (foreman, supervisor, engineer, etc.) deriving motivation from its unique character or impact, without deliberately thinking about compensation. Indeed, the ethos of jobs followed by OS are not inconsistent with the broader conceptualization of the job.

According to the dictionary, a job may be defined in one of three ways: a) a regular remunerative position b) a specific duty, role, or function, and c) something has to be done, a task (Merrium-Webster, 2019). Because a job may be conceptualized differently and delinked with the compensatory aspect, we use a more generalized definition to conceptualize the work of OS developers, as the vast majority of them give their time, talent, and energy to complete projects that do not provide any direct and/or immediate financial payment.

The conceptualization is academically rigorous as well. Scholarly research has studied jobs focusing on their various aspects, dimensions, or attributes. For example, studies have focused on better job design, job experience, or performance. The concepts examined in these studies often lack any financial aspects associated with the job. For instance, Turner and Lawrence (1965) studied six attributes of a job–variety, autonomy, required interaction, optional interaction, knowledge and skill required, and responsibility. Similarly, Hackman and Lawler (1971) used variety, autonomy, task identity, and feedback as the core dimensions to describe a job. Conceptualizing jobs based on the individual role and task of an OS developer, we argue that when an IS professional uses their capabilities to perform a task (or group of tasks) that fulfills their role(s) (e.g., developer, tester) in an OS IS development project, their participation in the project constitutes as a job. It is imperative to note that the definition does not presume that a financial renumeration is involved.

Using their conceptualization, we identify five characteristics of an OS software developer's job, by adapting the definitions of the five JCM constructs from Hackman and Oldham (1980) and being informed by Morris and Venkatesh (2010) who apply the JCM constructs in the IS context (see Appendix A for few studies in the IS literature using the job characteristics model). *Task significance* is defined as the IS professional's perception of how significant the OS project is to society or an organization. *Task identity* is defined as the part of the OS project the IS professional has been involved with. *Skill variety* is defined as the variation in a skillset utilized by the IS professional to accomplish their task in the OS project. *Autonomy* is defined as the degree of freedom the IS professional enjoys in deciding how to accomplish their task in the OS project. *Feedback* is defined as the extent of information provided by the OS software project itself that helps the IS professional determine the quality of their input in the project.

Relatedly, to conceptualize *job satisfaction*, we rely on well-established conceptualizations that have been highlighted in the psychological, organizational behavior, and IS literature. Specifically, we adapt our definition from previous IS (Morris & Venkatesh, 2010; Tripp et al., 2016) and engagement literature (Rich et al., 2010). *Job satisfaction* in OSSD refers to the degree of positive emotional response generated by an IS professional's assessment of the experience gained due to their role(s) in the OS project.

Job Engagement in OS Software

Job engagement is an important antecedent to satisfaction because engagement plays a crucial role in the OS community. Other reasons – such as those relative to financial rewards – may not be as relevant to the OSSD contributors. In the previous research, various individual and project-related factors have been found to influence engagement. Works examining the relationship between individual factors and engagement underline the influence of various intrinsic and extrinsic motivations (Alam & Campbell, 2017; Hars & Ou, 2002; Hertel et al., 2003). Across developer collaboration, ties have also significantly influenced the IS professional's decision to join a new OSSD project (Hahn et al., 2008). Besides personal attributes and aspirations, project attributes have been found to drive OS software developer participation. Notably, project attributes such as quality control and project type have been found to influence continued voluntary participation (Ho & Rai, 2017). However, ironically, while the OS software developers are most motivated by the nature of the job itself, what job characteristics drive their engagement and satisfaction is a research question that has largely been ignored in previous research.

Job engagement in OS development refers to the physical, cognitive, and emotional investment made by a participant in performing the task or group of tasks in the OS project that serves their or her role in the project. Engagement encapsulates the deep relationship between an individual's self and work at physical, emotional, and cognitive levels (Rich et al., 2010). The idea of engagement in the workplace was first conceptualized as personal engagement and disengagement by Kahn (1990). Since then engagement has been used in management and organizational behavior to explain the relationship between a person and their role at work (Saks & Gruman, 2014). Also, as a construct, engagement manifests in different forms across the organization, including employee engagement (Anthony-McMann et al., 2017), work engagement (Halbesleben, 2010), job engagement (Rich et al., 2010; Saks, 2006), unraveling the relationship between a person and their or her role at work.

Our conceptualization of job engagement is guided by Kahn (1990) who referred to engagement as "the harnessing of organization members' selves to their work roles; in engagement, people employ and express themselves physically, cognitively, and emotionally during role performances" (p.694). Thereby, our conceptualization is that of a psychological construct that demonstrates a deep relationship of an individual with their or her work. Also, our conceptualization is different from participation in the OS software projects, which is a behavioral construct measured by the amount of direct contribution (e.g., number of lines of code or number of bugs reported). By focusing on job engagement, we unravel the relationship (physical, emotional, and cognitive) between an OSSD project and the role(s) played by the IS professional working on the project, going beyond mere participation.

Research Model

We build a research model to examine the effects of various job characteristics on engagement and to assess if engagement mediates the relationship of these characteristics with job satisfaction (See Figure 1).

We argue that job satisfaction is greater for OS software Developers engaged with the job, as they contribute their physical, cognitive, and emotional energies. OS software context offers many options to contribute. Unlike IS professionals working in the proprietary environment, the majority of the OSSD contributors are not constrained by a contractual obligation (Seidel & Steward, 2011; Robles & Gonzalez-Barahona, 2006) or are not motivated by financial incentives (Roberts et al., 2006). Hence, satisfaction may not arise unless one engages energies–physical, cognitive, emotion– as work outcomes may suffer. Indeed, engagement impacts work outcomes positively. Kahn (1992) proposed that both individual and organizational outcomes are influenced by employee engagement. Subsequent research found engagement influences various individual outcomes, including job satisfaction (Saks, 2006). Therefore, we argue that job engagement mediates the relationship between job characteristics and job satisfaction in OS projects. Hence, below we propose five mediating hypotheses for the five job characteristics.

FIGURE 1
RESEARCH MODEL
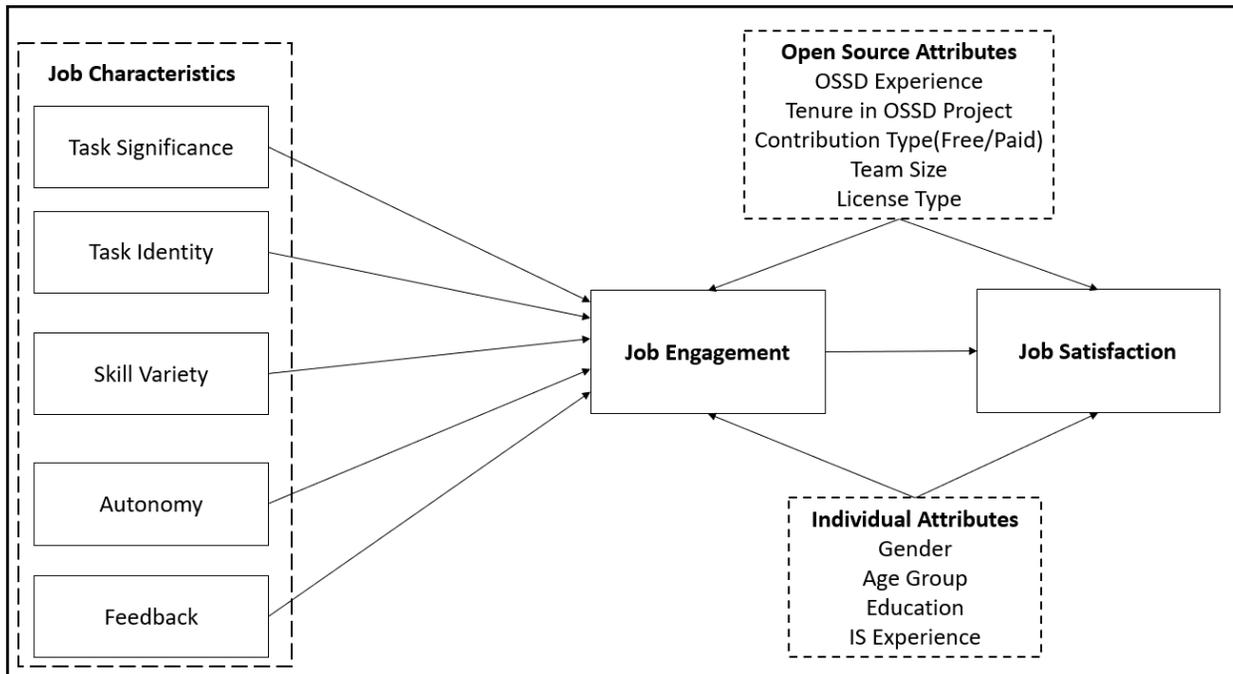
We argue that five characteristics of the job influence the developers' engagement that leads to greater satisfaction. Previous research has found job characteristics as an antecedent to employee engagement (Christian et al.,2011; Crawford et al., 2010; Saks, 2006). Christian et al. (2011) argue that when job characteristics allow for a person to invest more "energy and personal resources" they will be more engaged in that job. Saks (2006) argues that positive job characteristics tend to positively impact job engagement. We underline that job characteristics differently influence engagement and thereby, satisfaction.

Task Significance of the OSSD Project
Task significance of an OS software project to the IS professional enhances their engagement, positively influencing satisfaction. The OS domain is full of opportunities. For instance, Linux Foundation and SourceForge have thousands of OS projects developers can choose from to contribute. Because IS professionals voluntarily choose the task(s) they want to accomplish in OS software projects, individuals may choose only the task(s) that they perceive to be significant. Voluntary contributions imply that many individuals start contributing but never apply themselves to the task(s) because they are not engaged. Their attitude is reflected in numerous OS projects in which developers discontinue their contribution before they complete their tasks in those projects (Fang & Neufeld, 2009). However, that attitude will change if a developer perceives that the task(s) related to their job in the OS project significantly impacts others, especially when that perception is shared by the OS community they belong to.

Maruping et al. (2019) argue that a developer's commitment to the specific OS community influences their code contribution. OS software developers find it rewarding to contribute to OSSD projects that thousands of people use (White, 2018). Kahn (1992) points out that being able to make important contributions leads to engagement. So, when an IS professional finds an opportunity to contribute to an OS software project, they will look for a task in that project that the OS community perceives as significant, and consequently, they will be more engaged. While developers may continue to participate for other reasons, such as reputations and others, we argue that the task significance of the job is a stronger predictor of engagement as the engaged IS professional feels satisfied. Hence, we hypothesize:

H1: *Task significance associated with the role(s) of an OS software professional will positively influence their job engagement and engagement will mediate the impact of task significance on their job satisfaction.*

Task Identity of the OSSD Project

Most OSSD projects are developed by a very small group of developers or individual developers. Visiting any OSSD platform's website will demonstrate that single contributors develop most OS software projects. The idea of "lone wolf" is often applied to OS software developers (Anthes, 2005). While some argue that lone wolf is not quite an appropriate term, the general notion that OS software developers tend to work alone is apparent, as many projects are often initiated and managed by solo developers. Their tendency among OS software programmers indicates that they care about how much of a complete task they, task identity, have in an OSSD project. Task identity is related to the psychological ownership of a task in the sense that the higher the task identity higher the feeling of ownership. The psychological ownership theory well illustrates the feeling of ownership.

Psychological ownership refers to an individual's feeling about owning a part or whole of something without legal or formal ownership of that object (Karahanna et al., 2015). Having a bigger possession can lead to a positive effect and vice versa (Formanek, 1991). Higher task identity means a greater sense of accomplishment because the person involved sees a task from the beginning to the end (Turner and Lawrence, 1965). Task identity is important in an OSSD project because it impacts an IS professional's sense of ownership of that task and positively impacts their job engagement in the OSSD project. Conversely, if they have a lower level of task identity, they will be less engaged, which ultimately leads to lower job satisfaction. Hence, we hypothesize:

H2: *Task identity associated with the role(s) of an OS software professional will positively influence their job engagement and engagement will mediate the impact of the task identity on satisfaction.*

Skill Variety in the OSSD Project

OS software projects are quite diverse and provide a unique opportunity for IS professionals to develop and demonstrate their skillset. OSSD provides an opportunity to showcase an IS professional's skillset to potential clients and has been documented as one of the prime motivations for participation in OSSD projects (Hars & Ou, 2002; Lerner & Tirole, 2002; von Hippel & von Krogh, 2003). Further, OSSD provides opportunities to learn and display new skills. OSSD platforms (e.g., GitHub) suggest that OS software projects help to grow new skills. OSSD not only provides an IS professional the ability to pick a project in an area of expertise that is interesting and beneficial to the person, but it also provides an easy transition point for new entrants as previous code sets are readily available to newcomers for review.

As suggested by contemporary research, many organizations are becoming interested in OSSD (Ho & Rai, 2017). Therefore, skill variety of tasks is an important driver, engaging IS professionals in the OS environment, and OS software professionals that are highly engaged in contributing their knowledge, time, and effort, realize higher levels of satisfaction. That is:

H3: *Their degree of skill variety required to perform the task(s) associated with the role(s) of an OS software professional will lead to a higher level of job engagement of the professional, and engagement will mediate the impact of skill variety on satisfaction.*

Autonomy in the OSSD Project

Unlike other job characteristics, autonomy in the OSSD project will not influence engagement. Autonomy is the cornerstone of OSSD and is often assumed by default. Unlike the proprietary environment, where people have some contractual obligation and possibly have serious career ramifications on abandoning a project, IS professionals are not bound by any contractual obligation in the OS environment (Seidel & Steward, 2011; Robles & Gonzalez-Barahona, 2006). Therefore, IS professionals in the OSSD projects enjoy quite a high degree of autonomy because they can always leave the project if they cannot perform the task in their way. Researchers have found that 80% of OS projects are terminated because

participants left the projects during development (Fang & Nuefeld, 2009), which motivated Ho and Rai (2017) to examine factors that affect continuation participation amongst volunteers.

Because IS professionals expect a high level of autonomy in OS projects, we argue that an IS professional may simply leave the project if they do not enjoy a high level of autonomy; but a high level of autonomy will not make any significant difference in their or her level of job engagement. We also argue that due to the expectation of a high level of autonomy in OS projects, autonomy will positively impact job satisfaction in OS projects as it has been found in the proprietary environment (Tripp et al., 2016; Morris & Venkatesh, 2010) but job engagement will not mediate the impact of autonomy. Hence, we hypothesize:

H4: The level of autonomy in an OS software project will not significantly impact the job engagement of the IS professional working on the project and thereby job engagement will not mediate the relationship between autonomy and job satisfaction in OS projects.

Feedback From the OSSD Project

Feedback in the OSSD project represents whether an IS professional can understand how they perform in the OS project from completing their task(s). Such feedback from completing task(s) is important in OS projects because OS projects lack the formal feedback process from other actors (e.g., supervisors). Organizations are built on structures that are designed to provide feedback through various types of coordination to facilitate the most efficient production, and IS are built to help coordination (Gurbaxani & Whang, 1991). So, feedback in the proprietary environment is much more structured and driven by others rather than the task itself. On the other hand, feedback from others in the OSSD projects is much less organized and formal. For instance, code acceptance by project administration is used as an indicator of performance in OS software projects (Ho & Rai, 2017; Roberts et al., 2006; Hertel et al., 2003) but because an IS professional does not have a contractual obligation, they may not be very receptive to criticism from a project owner or other team members.

However, developers in OSSD take the initiative to enhance an existing code, sometimes for their use, and rely on the project's performance to determine their success in contributing to the OS project. Their feedback from actual work will be more valuable and constructive to the IS professional than the criticism (even when it is constructive) they may receive from other team members. Because feedback provided by actual work is more salient in OSSD projects, we argue that when an OS software project provides better feedback, the IS professional working on the project is more engaged and therefore, will be more satisfied. Hence, we hypothesize:

H5: A higher level of feedback from an OS project will lead to a higher level of job engagement of the IS professional contributing to the project and job engagement will mediate the impact of feedback on job satisfaction in OSSD projects.

RESEARCH METHODOLOGY

Study Design

The survey was posted on Amazon Mechanical Turk (AMT). Online crowdsourcing markets (e.g., AMT) have recently emerged as a viable alternative source for research participants (Steelman et al., 2014). While the AMT was used as a marketing tool to reach potential respondents, the survey itself was hosted in the Qualtrics server. AMT directed interested IS professionals to an anonymous link hosted by Qualtrics. Several conditions were implemented to achieve quality responses. First, the survey on AMT was designed to be marketed to only IS professionals. To ensure that the survey was marketed to the right people, the study used the AMT category 'Job Function – Information Technology' as a requirement. Second, in addition to AMT's professional category, further screening in the survey was included. The screening included the following questions: "Are you an information system or technology professional? Are you currently participating or recently participated in one or more OS development of IS projects?" The questions also included a highlighted note: "A potential participant of their survey must be an IS or

technology professional who is currently contributing or has contributed to one or more OSSD project(s). Hence, answering NO to their question will terminate the survey." The survey automatically moved to the end for a participant who answered negatively to any of these questions. If a participant indeed answered 'no' to these questions they received a note of appreciation and an explanation for the abrupt termination. The note was as follows: "THANK YOU for your time and effort in completing this survey. We sincerely appreciate your contribution to our research. If you have reached this point only after the first one or two questions, you have answered 'no' to any of the first two questions. As we mentioned in our disclosure, a potential participant must be an IS or information technology professional who is currently participating or has recently participated in one or more OSSD project(s). Hence, answering NO to these questions has terminated the survey for you. In any event, we appreciate your interest." Third, as Steelman et al. (2014) suggested, the AMT was instructed to only include U.S.-based participants. Respondents were paid $5 for a fully completed survey. Each respondent who reached the end of the survey was provided a random seven-digit code that they would provide to AMT to receive the payment from AMT. The respondents had four hours to complete the survey. The clock would start when a respondent chose to respond in the AMT system and the clock would end when a respondent provided the random code they receive from the Qualtrics survey.

Participants

We received a total of 330 responses. These 330 respondents reached the end of the survey and provided the code to AMT to collect their payments. However, only 165 responses were included in the final analysis of their paper. Responses were excluded from the final analysis for partial answers and lack of useful details. First, the responses that did not include answers for the three focal variables (job characteristics, engagement, and job satisfaction) were deemed incomplete and excluded from the analysis. Most of the responses that were excluded fell into their first category. Second, responses that appeared to provide vague, unrelated, or meaningless answers were deemed as answers that lacked useful details. For instance, one response mentioned "music player" as the project description. Another example is a response that mentioned "A front-end JavaScript framework" as the project description. Since these responses failed to provide a good description of the OS project, concluded they were not reliable enough for our study. Approximately twenty-two percent of the respondents were female, and the remaining were male. The lack of female participants in our sample reflects the fact that fewer female developers are currently contributing to the OSS domain (Frluckaj et al. 2022). The highest number of respondents were between 31 and 40 years old (approximately 46%) followed by respondents between 21 and 30 years (approximately 41%). One respondent did not answer the age group or the gender question. A more detailed demographic data is provided in Table 1. The following table about the demographics indicates that, as per their sample, mostly younger professionals who are early in their career and in their 20s and 30s are involved more heavily in OS development than those who are in their 40s and 50s whereas, according to DATAUSA, the IS professionals are mostly in their early 40s. This diversion in the OSS workforce from the MIS workforce trend is expected given that younger MIS professionals have more to gain from their contribution to the OSS domain.

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TABLE 1
PARTICIPANTS' AGE AND SEX

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	Female	Male	Total
Below 20 years	0	1	1
Between 21 and 30 years	16	52	68
Between 31 and 40 years	18	57	75
Between 41 and 50 years		16	16
Above 50 years	2	2	4
Total	**36**	**128**	**164**

The respondents had an average of approximately eight years of experience in the development of IS and approximately six years of work experience in OS development of IS. 48% of respondents reported that they contribute to OS projects for free and payment. However, 31% reported that they only contribute for free while the remaining 21% contribute only for payment. The projects in our sample included both voluntary projects (106) that did not involve any payments and paid (59) projects. A large majority, approximately 39%, of the projects were initiated by a private individual or a group of individuals. 22% of projects were initiated by the platform organization, 22% by a non-profit other than the platform, and a for-profit organization initiated the remaining projects. 39 out of the 165 projects were designed for education, 19 for gaming, 45 for communication, 42 for utilities, and the rest did not fall into the four categories listed above. Even though the respondents mentioned various OS platforms they prefer to work with, the top five favorite platforms included GitHub, Linux, Kaggle, Sourceforge, and Oracle BeehiveOnline.

The respondents were involved in a wide variety of OS software projects hosted in various OSSD platforms that are compatible with operating systems such as Linux and Windows. The purpose for these projects included but was not limited to e-commerce, security enhancement, artificial intelligence, heatmap, internet bot, and crypto currency.

The host platforms for the projects include but are not limited to, well-known OSSD platforms such as GitHub, Sourceforge, and Linux. The respondents' roles ranged from developers performing different roles at the periphery or core.

A few projects are listed in Table 2 that were hosted in a variety of OS platforms and compatible with major operating systems, include both free and paid projects, and represent the major sectors – education, gaming, communication, and utilities.

Measures

The focal constructs of their study include the five based on the job characteristics model, job engagement, and job satisfaction. To measure the constructs in our study, we searched for appropriate and already validated scales in the existing literature. All of the measurement items used in their study were collected from existing literature to operationalize the constructs.

We used 15 measurements proposed by Hackman and Oldham (1980) in their job diagnostics survey (JDS) to measure *job characteristics*. However, because the context of the study is OS IS development, we used the JDS items modified by Morris and Venkatesh (2010) whose research on job characteristics was also conducted in the context of IS. Morris and Venkatesh (2010) modified the JDS survey to remove any reverse-coded items for better reliability and validity. *Job engagement* was measured using a five-item scale adapted from Saks (2006). In addition to covering the cognitive, emotional, and behavioral aspects of engagement, the items developed by Saks (2006) also specifically focused on job engagement concerning the work role played by an employee (Anthony-McMann et al., 2017). We believe the measurement items' focus on the engagement related to work, which Saks (2006) argued to be different from organization engagement, makes the items more relevant to our study of the influence of job characteristics on job engagement and job satisfaction. Finally, *job satisfaction* was measured using three items adapted originally from Jansseen (2001) but modified by Morris and Venkatesh (2010). Like the use of items for job characteristics, contextual relevance was the logic for using the modified items from Morris and Venkatesh (2010) for measuring job satisfaction.

We included several individual and project-related variables in our study to control for alternative explanations. We controlled for individual attributes–gender, age, and education that are important in many studies that investigated job characteristics, engagement, job satisfaction, and other related constructs in the context of IS (Anthony-McMann et al., 2017; Ho & Rai, 2017; Morris & Venkatesh, 2010; Rich et al., 2010; Saks, 2006). Gender was coded as a binary code: female or male. Education was measured in years of formal education. The respondents were divided into five age groups: 20 and younger, 21 to 30, 31 to 40, 41 to 50, and over 50. We also controlled for OS project-related attributes that have been identified as important factors in OS literature–type of project license, contribution type, IS experience, OSSD experience, and tenure in a project (Ho & Rai,2017; Setia et al., 2012). The respondents were given four choices for license type: Berkeley Software Definition, General Public, Lesser General public, and others.

Contribution type was measured as a binary variable using free = 1 and paid = 0. Tenure in a project was measured in the number of years in which months were converted into years.

TABLE 2
BRIEF DESCRIPTION OF A FEW OSSD PROJECTS INCLUDED IN THE STUDY SAMPLE

Brief project description	Contribution Type	Host Platform	Compatible OS	Role(s) of the respondent
E-commerce functionalities with advanced custom features	Free	GitHub	Linux, Windows	Peripheral Developer
Develop software to meet the organization's new privacy standards	Paid	Sourceforge		Active Developer
Speech recognition software provides gamers the ability to give voice commands to interact with games.	Free	GitHub	Linux	Active Developer, Documenter
Facilitate sharing study materials for exams.	Free	GitHub	Windows	Core member
Manage organization assets, especially making asset retirement decisions	Paid	Linux	Linux	Core member
Monitor Cryptocurrency rates online in real-time.	Free	Bitbucket	Ubuntu	Peripheral developer, Bug fixer, documenter
Their project is for farmers and other agriculture workers in New Zealand and Australia to get weather data, data used for determining when to spray their crops.	Paid	Linux	Linux	Peripheral Developer
Help type 1 diabetics get open access to the data from their glucose meters and share it over the internet.	Free	Nightscout	Linux	Architect, but reporter
A musical ear and interval training program.	Free	Sourceforge	Linux	Bug fixer, bug reporter, and documenter
Restrict Application - it is a powerful parental control software that can easily block adult content.	Free	Sourceforge	Windows	bug fixer

The items were unchanged if they fit our context. However, some of the items were slightly modified to fit the context of OS development. For instance, the question "In general, how significant or important

is your job? That is, are the results of your work likely to significantly affect the lives or well-being of other people?", was modified by adding the phrase 'in the OS project' at the end of the first sentence. Another example of such modification was made to the item, "How much variety is there in your job? That is, to what extent does the job require you to do many different things at work, using a variety of your skills and talents?" by replacing 'at work' in the second sentence with 'in the OS project'. Participants provided their responses to measurement items for all of the focal constructs using Likert-type scales with anchors (1) strongly disagree to (7) strongly agree. Table 3 includes the modifications made to the measurement items for job characteristics. The crossed-off words or phrases were removed or modified. The words and phrases in *italics* are the additions and modifications for the OS environment questionnaire. Measurement items for job engagement and job satisfaction are provided in appendix B.

TABLE 3
MODIFIED MEASUREMENT ITEMS FOR JOB CHARACTERISTICS

Job Characteristics
Task Significance   • In general, how significant or important is your job *in the OS project*? That is, are the results of your work likely to significantly affect the lives or well-being of other people?   • Their job is one where a lot of other people can be affected by how well the work gets done.   • The job itself is very significant and important in the broader scheme of things.
Task Identity   • To what extent does your job *in the OS project* involve doing a "whole" and identifiable piece of work? That is, is the job a complete piece of work that has an obvious beginning and end? Or is it only a small part of the overall piece of work, which is finished by other people or by automatic machines?   • The job provides me the chance to completely finish the pieces of work I begin.   • The job is arranged so that I can do an entire piece of work from beginning to end.
Skill Variety   • How much variety is there in your job? That is, to what extent does the job require you to do many different things ~~at work~~ *in the OS project,* using a variety of your skills and talents?   • The job requires me to use a number of complex or high-level skills.   • The job is complex and nonrepetitive.
Autonomy   • How much autonomy is there in your job? That is, to what extent does your job *in the OS project* permit you to decide on your own how to go about doing the work?   • The job gives me considerable opportunity for independence and freedom in how I do the work.   • The job gives me a chance to use my personal initiative and judgment in carrying out the work.
Feedback   • To what extent does doing the job itself provide you with information about your work performance? That is, does the actual work *in the OS project* itself provide clues about how well you are doing—aside from any "feedback" ~~coworkers or supervisors~~ codevelopers or team members may provide?   • Just doing the work required by the job provides many chances for me to figure out how well I am doing.   • After I finish a job, I know whether I performed well.

Empirical Analysis

Following standard practice, we first tested the reliability and validity of various scales and then tested our proposed research model using the data collected about the OSSD projects.

Measurement Model Evaluation

To evaluate the measurement model, we tested the reliability and validity of the scales used in our study. For testing the reliability of the measures, we used Cronbach's Alpha. Cronbach Alphas were as follows: task significance (0.77), task identity (0.71), skill variety (0.69), autonomy (0.82), feedback (0.72), job engagement (0.74), and job satisfaction (0.82). Given that all of the Cronbach Alphas were 0.7 or above, we concluded that all scales were reliable. To assess the convergent and discriminant validity of the survey items a confirmatory factor analysis was conducted on the focal variables using principal components to see if items were loading on the desired variables. Varimax rotation with Kaiser Normalization was used to achieve optimum loading of the items. The rotation converged in seven iterations and converged on seven factors. We used the Kaiser-Meyer-Olkin (KMO) sampling adequacy test to measure sampling adequacy. The KMO test score of 0.85 which is between 0.8 and 1 indicated, according to Cerny and Kaiser (1977), that the sampling was adequate for the factor analysis. Bartlett's test of sphericity indicates that (Chi-Square =1966.584, $p < 0.005$) the dataset is appropriate for factor analysis (Bartlett, 1950).

All of the item's communality was above 0.5. The factor analysis showed that the average factor loading for all factors was above 0.70 and the average variance extracted was above 0.50, which according to (Fornell & Larcker,1981), indicated good convergent validity of the scale items. All of the cross-loadings were below 0.5 indicating good discriminant validity. The factor loading of the measurement items for all focal variables is presented in Table 4. Finally, we also checked for any common method bias since survey data are prone to such bias (Podsakoff et al., 2003). We conducted Harmon's one-factor test by running an exploratory factor analysis. Since any single factor did not account for the majority of the variance, according to Iyengar et al. (2015), we concluded that there was no common method bias.

TABLE 4
FACTOR ANALYSIS

	1	2	3	4	5	6	7
Task Significance 1	**0.84**	0.15	0.07	0.21	0.02	0.05	0.07
Task Significance 2	**0.77**	0.06	0.21	0.17	0.25	0.06	-0.09
Task Significance 3	**0.66**	0.2	0.28	0.13	0.31	-0.01	0.15
Task Identity 1	0.25	**0.87**	0.08	0.1	0	0.14	0.12
Task Identity 3	0.09	**0.7**	0.03	0.27	0.44	0.12	0.08
Skill Variety 2	0.3	0.06	**0.76**	0.17	0.26	0.02	0.22
Skill Variety 3	0.17	0.04	**0.86**	0.24	0.05	0.07	-0.17
Autonomy 1	0.26	0.19	0.18	**0.78**	0.01	-0.05	0.14
Autonomy 2	0.18	0.05	0.11	**0.83**	0.26	0.11	0.1
Autonomy 3	0.1	0.15	0.23	**0.7**	0.36	0.1	0.08
Feedback 2	0.26	0.07	0.07	0.35	**0.75**	0.16	0.07
Feedback 3	0.28	0.23	0.31	0.21	**0.67**	-0.01	0.17
Job Engagement 1	0.01	0.14	0.08	0	0.07	**0.69**	0.42
Job Engagement 2	0.03	0.06	0.04	0.1	-0.09	**0.89**	0.09
Job Engagement 3	0.07	0.08	-0.01	0.02	0.27	**0.75**	0.31
Job Satisfaction 1	0.02	0.17	0.02	0.16	0.07	0.32	**0.81**
Job Satisfaction 3	0.08	0.02	-0.01	0.12	0.1	0.29	**0.86**

As Table 4 shows, we excluded two items (Feedback 1, Job Satisfaction 2) from the original set of measurement items. We excluded the first item for feedback and the second item for job satisfaction because

the items had low factor loading and high cross-loadings. The feedback question that was excluded asked "To what extent does doing the job itself provide you with information about your work performance? That is, does the actual work itself provide clues about how well you are doing—aside from any "feedback" coworkers or supervisors may provide?". We believe these terms did not resonate well with the respondents because IS professionals participating in OS projects do not have co-workers or supervisors in the traditional sense. The question on job satisfaction that was excluded stated that "I would prefer another, more ideal job". As Morris and Venkatesh (2010) mentioned, it was a reverse-coded item that tends to give rise to reliability and validity issues.

Table 5 includes the descriptive statistics, reliabilities, and correlations among the variables. The table also includes the means and the standard deviations for the focal and control variables. The correlations were similar to previous studies examining relationships between job satisfaction and job characteristics (Morris & Venkatesh, 2010). The mean scores for all five job characteristics were above 5.3 on a scale of 1 to 7. The mean score for job engagement was 5.44 and 5.63 for job satisfaction, which was measured on the same scale. The standard deviations for these variables hovered around one. Several control variables were found to be slightly correlated with the focal variables. Similarly, the five job characteristics were found to be correlated to each other. It should be noted that all of the five job characteristics were found to be significantly correlated with job engagement and job satisfaction. Job engagement was significantly correlated with job satisfaction. These correlations among the focal variables simply indicate the potential relationship between the job characteristics of an OS project, the IS professional's job engagement, and job satisfaction on that OSSD project.

TABLE 5
DESCRIPTIVE STATISTICS, RELIABILITIES, AND CORRELATIONS

Variables	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 Gender (1=Female)	0.22	0.41	N/A															
2 Age Group	2.73	0.77	-0.05	N/A														
3 Education	15.99	1.84	-0.09	0.05	N/A													
4 IS Experience	8.28	6.11	0.00	.67**	0.13	N/A												
5 OSSD Experience	5.12	3.98	-0.01	.50**	0.09	.65**	N/A											
6 Tenure in Project	2.42	2.62	0.06	.32**	-.27**	.35**	.43**	N/A										
7 Contribution (1=Free)	0.64	0.48	-0.10	0.10	-0.01	.20*	.18*	0.04	N/A									
8 Team Size	10.21	12.19	0.06	-.18*	0.02	-0.13	-0.03	0.00	0.06	N/A								
9 Project License	2.21	0.72	.17*	.17*	-0.05	0.11	0.04	0.15	0.04	-0.09	N/A							
10 Task Significance	5.30	1.05	.16*	-0.09	-0.02	-0.04	0.02	.18*	-.19*	0.04	0.00	0.77						
11 Task Identity	5.31	1.11	0.12	-.19*	-0.06	-0.12	-0.02	0.06	-.18*	0.01	-0.02	.53**	0.71					
12 Skill Variety	5.35	1.19	0.03	0.12	-0.07	0.14	.23**	.23**	-0.06	-0.13	-0.10	.44**	.26**	0.69				
13 Autonomy	5.49	1.05	0.04	-0.06	-0.10	0.05	.20*	.26**	-0.05	0.14	-0.06	.42**	.49**	.42**	0.82			
14 Feedback	5.57	1.02	0.10	-0.11	-0.03	-0.06	-0.03	.17*	-0.03	0.08	-0.06	.56**	.56**	.39**	.540**	0.72		
15 Job Engagement	5.44	0.96	0.11	-0.03	-.18*	0.03	0.13	.16*	-0.13	0.07	0.03	.49**	.52**	.38**	.47**	.52**	0.74	
16 Job Satisfaction	5.63	1.06	0.02	0.11	-0.11	0.13	0.12	.21**	-0.07	0.11	0.11	.44**	.48**	.30**	.49**	.51**	.58**	0.82

Note: 1. diagonal elements are Cronbach alphas; N/A - Not Applicable
2. $*p < 0.05$; $**p < 0.01$

Theoretical Model Testing

Our research model has two central arguments: job characteristics are important predictors of the job engagement of an IS professional working in the OSSD and job engagement mediates the impact of job characteristics on the job satisfaction of that IS professional. Based on the nature of our hypotheses, we used ordinary least squares (OLS) to test our research model. We also tested for any multicollinearity issues using variance inflation factors (VIF). The VIF values in all the models we tested were well below ten, the acceptable threshold (Gruber et al. 2010; Petter et al. 2007), indicating no serious multicollinearity issue. We conducted the OLS tests in two phases.

TABLE 6
PREDICTING JOB ENGAGEMENT IN OSSD

	Control Variables	Main Effects
R²	0.1	0.44
ΔR²		0.33**
Gender (1=Female)	0.24	0.07
Age Group	-0.19	-0.03
Education	-0.02	-0.02
IS Experience	0	0.01
OSSD Experience	0.06*	0.04
Tenure in Project	0	-0.05
Contribution (1=Free)	-0.35*	-0.19
Team Size	0	0
Project License	-0.04	0.05
Task Significance		0.11
Task Identity		0.17*
Skill Variety		0.1
Autonomy		0.11
Feedback		0.23**

Note: $p < 0.05$; **$p < 0.01$.

In the first phase, we tested the effects of job characteristics on job engagement. We started with the control variables. The results show that an IS professional's experience in the OSSD projects significantly impacts the level of job engagement. The results also show that whether the IS professional is paid or not in the particular project makes a significant difference in the level of job engagement in the OSSD project. The model explained 10.2% of the variance in job engagement. Once the impacts of the control variables were tested, we added the five job characteristics to the model. The results show that the job characteristics strongly influence an IS professional's job engagement in the OS environment given that the influence of OSSD experience and payment in the project became insignificant once the job characteristics were added to the mix of predictors. The model explained 44% of the variance in job engagement. The variance explained by the main effects model was significantly (33.4%, p-value < 0.001) higher than the model that included only the control variables (Table 6. We found that two out of the five job characteristics, task identity (B = 0.167, p < 0.05) and feedback (B = 0.232, p < 0.01), have a significant positive influence on an IS professional's job engagement in the OS environment.

Mediation Analyses

In the second phase, we tested the mediating role of job engagement between job characteristics and job satisfaction of IS professionals in OS software projects. To test the mediation effect of job engagement, we applied the Baron and Kenny (1986) approach, one of the most well-recognized methods for testing mediation effects. The results of the mediation test are provided in 7. To establish mediation, the Baron and Kenny approach involves three steps of regression. The first step involves finding that the independent variable(s) have a significant effect on the mediator. As seen in Table 6, two of the five job characteristics (task identity and feedback) significantly impacted job engagement. The second step in the Baron and Kenny mediation analysis is to show that the independent variable(s) has a significant effect(s) on the dependent variable. The results for the second step are shown in Table 7.

TABLE 7
PREDICTING JOB SATISFACTION IN OSSD

	Control Variables	Main Effects	Mediation Model
R²	0.09	0.49	0.54
ΔR²		0.40***	0.05***
Gender (1=Female)	-0.04	-0.22	-0.24
Age Group	0.02	0.23*	0.24*
Education	-0.01	-0.01	0
IS Experience	0.02	0.02	0.02
OSSD Experience	0.01	-0.02	-0.03
Tenure in Project	0.05	0	0.01
Contribution (1=Free)	-0.38*	-0.2	-0.14
Team Size	0.01	0.01*	0.01
Project License	0.09	0.16	0.14
Task Significance		0.12	0.09
Task Identity		0.20**	0.15
Skill Variety		0.05	0.02
Autonomy		0.24**	0.20**
Feedback		0.24**	0.17
Job Engagement			0.32***

Note: *p < 0.05; **p < 0.01; ***p < 0.005.

As we can see in Table 7, both task identity (0.20; p< 0.01) and feedback (0.24, p<0.005) have a significant positive impact on the job satisfaction of an IS professional working on the OS project. The final step in the Barron and Kenny mediation test is that the mediator must significantly affect the dependent variable. As it is shown in Table 7, the mediator job engagement has a significant impact on the dependent variable job satisfaction. In addition, when job engagement is included in the regression along with all of the job characteristics the effect of task identity and feedback on job satisfaction becomes insignificant. Thus, the results support H2 and H5 in which the effects of task identity and feedback were fully mediated by job engagement. In addition, we also found that another job characteristic (autonomy) had a significant impact (0.24, p<0.001) on job satisfaction and remained significant (0.20, p<0.001) even when job engagement was added to the regression, though the coefficient became slightly smaller. However, we cannot conclude that the impact of autonomy was partially mediated since autonomy did not significantly

impact job engagement in the second step of the Barron and Kenney mediation test. Thus, the results also support H4 that neither autonomy will significantly impact job engagement nor engagement will mediate the impact of autonomy on satisfaction.

Task significance and skill variety did not significantly impact either job satisfaction or job engagement. Like the prediction of job engagement, the mediation tests were also conducted in three steps. The first step included only control variables, the second step included the five job characteristics along with the control variables, and job engagement was added in the last step. The variance explained by the main effects model ($R^2 = 0.49$) was significantly higher than the variance ($R^2 = 0.089$) explained by the model that included only the control variables. The mediation model explained 53.9% of the variance in job satisfaction, which was significantly higher than the main effects model's.

Robustness Tests
Robustness Test Using Log Transformation

The descriptive statistics in Table 5 show that the focal variables (job characteristics, engagement, and job satisfaction) have a higher mean than the center of the scales. Given that there is self-reported data, upward skewness is expected for such variables (Belanger et al. 2001). The upward skewness has been also found in previous literature that studied engagement (e.g., Rich et al. 2010). The upward skewness indicates that the values are potentially not normally distributed. Hence, to mitigate the issue of normality, we transformed the variables by using the log function. The log transformation appeared to change the distribution to a more normal distribution. In addition to normalizing the focal variables, we also transformed IS experience, OSSD experience, and tenure in a project using a log.

TABLE 8
PREDICTING JOB ENGAGEMENT

	Control Variables	Main Effects
R²	0.10	0.47
ΔR²		0.37**
Gender (1=Female)	0.00	0.00
Age Group	-0.00	-0.00
Education	-0.00	-0.00
IS Experience	0.00	0.00
OSSD Experience	0.00	0.00
Tenure in Project	0.00	-0.00
Contribution (1=Free)	-0.00*	-0.00
Project License	0.00	0.00
Task Significance		0.00
Task Identity		0.05*
Skill Variety		0.01
Autonomy		0.05
Feedback		0.18*

Note: $p < 0.05$.

As before, we first tested the effects of job characteristics on job engagement using the transformed variables. The results (provided in Table 8) are fairly in line with the original findings except that the coefficients were smaller; both task identity and feedback significantly influenced job engagement. The model explained 47.11% of the variance in job engagement. The variance explained by the main effects model was significantly (36.74%, p-value < 0.001) higher than the model that included only the control variables. Next, we tested the mediating role of job engagement following Barron and Kenny's approach.

The results of the mediation test using the transformed variables are provided in Table 9. The results differed slightly from the original findings because we did not find task identity to significantly impact job satisfaction. Overall, the original findings supported H2, H4, and H5 but the results using transformed variables supported H4 and H5, and only partially supported H2. The variance explained by the main effects model ($R^2 = 0.56$) was significantly higher than the variance ($R^2 = 0.11$) explained by the model that included only the control variables. The mediation model explained 70% of the variance in job satisfaction, which was significantly higher than the main effects model's.

TABLE 9
PREDICTING JOB SATISFACTION AND TESTING MEDIATING EFFECT OF
JOB ENGAGEMENT

	Control Variables	Main Effects	Mediation Model
R^2	0.11	0.67	0.70
ΔR^2		0.56***	0.03*
Gender (1=Female)	-.00	-0.00	-0.00
Age Group	0.00	0.00	0.00
Education	-0.00	-0.00	-0.00
IS Experience	0.00	0.00	-0.00
OSSD Experience	0.00	-0.00	-0.00
Tenure in Project	0.00*	0.00	0.00
Contribution (1=Free)	-0.00	-0.00	0.00
Project License	0.00	0.00	0.00
Task Significance		0.01	0.02
Task Identity		0.04	0.02
Skill Variety		0.01	0.00
Autonomy		0.22**	0.20**
Feedback		0.28**	0.24*
Job Engagement			0.31*

Note: *$p < 0.05$; **$p < 0.01$; ***$p < 0.005$.

DISCUSSION

Von Krogh and Spaeth (2007) note that overall there are five key reasons that researchers are heavily interested in the OSSD phenomenon: its contribution to society and economy, its challenge to established theory, its tendency to provide widely accessible data, and its ability to create its community of developers and researchers, and its innovativeness. The primary goal of our paper was to explore role-specific project attributes that can positively influence engagement and satisfaction among IS professionals working in the OSSD environment. By studying the psychological concept of engagement, we hope to provide a comprehensive understanding of the relationship between IS professionals and their work roles in OSSD. We used the job characteristics model (Hackman & Oldham, 1980) as a theoretical lens to achieve our goal. Using the job characteristics model, we propose a middle-range theory (Van de Ven, 2007) in which we examine how job characteristics (task significance, task identity, skill variety, autonomy, and feedback) impact the job engagement of an IS professional and whether job engagement plays a mediating role between job characteristics and job satisfaction in the OS environment. We used a survey design to ask participants, who are currently contributing or have recently contributed to OS software development, about their job engagement, the characteristics of their job in the OS project they were working and their job satisfaction.

The proposed engagement framework contributes by unraveling IS professionals' relationship to their OSSD projects more meaningfully. The study unravels how engagement is influenced by various OS software job characteristics, with an eventual influence on developers' satisfaction. In addition to applying the JCM in the OSSD context, our study extends the literature studying job characteristics by positioning engagement as a mediator in the nomological network between job characteristics and job satisfaction. As the overarching theoretical framework to study the antecedents and consequences of engagement of IS professionals in the OSSD environment. Because JCM does not presume financial rewards, we bring to the fore a new theoretical lens with wide applicability to the OS environment, where IS professionals are primarily volunteers.

The results corroborate three of the five hypotheses that are related to predicting job engagement. As hypothesized, the results show that task identity and feedback positively influence an IS professional's job engagement in OS software development. The results also supported the hypothesis that autonomy in OS software projects will not have any sway on the job engagement of an IS professional. However, the results did not support our hypotheses that task significance and skill variety will positively impact an IS professional's job engagement in the OS environment. The results support the premise that project attributes that are specific to the role(s) played by an IS professional in the OSSD projects influence the engagement of these professionals. The base (control variables only) model showed that an IS professional's experience in the OS environment and whether they are paid in the project are important factors that drive job engagement. However, when the job characteristics were added to the model, OSSD experience and payment became insignificant. Their finding shows that the JCM and the job characteristics that are part of the Hackman and Oldham (1980) model are important antecedents of job engagement, important enough that they can offset the significance of OSSD experience and payment.

The results also corroborate that job engagement plays a mediating role in the relationship between job characteristics and job satisfaction of an IS professional working on an OS software project. The findings showed that job engagement fully mediated the impacts of task identity and feedback on job satisfaction. Task significance and skill variety did not directly impact job satisfaction; therefore, no mediation is discernible for these two variables. Since job engagement was found to mediate two of the five job characteristics' effects on job satisfaction, our findings support the premise that job engagement is an important mediating construct. These findings make significant contributions to the research in the OS domain.

Theoretical Implications

Our study unravels new relationships that influence the affective well-being of OS software developers. Notably, we establish job engagement as a crucial mediator to job satisfaction, driven by the OS context's job characteristics. This contributes to the nascent literature examining satisfaction in OSSD (Casalo et al., 2009; Gerede & Mazan, 2018). Elsewhere, job characteristics are considered to be important for engagement and satisfaction (Rich et al., 2010; Saks, 2006). We leverage these theoretical foundations, to extend the OS research identifying job characteristics that trigger the mediating effect of IS professional's engagement. This extends the previous research that underlines the role of job characteristics in influencing employee engagement (Christian et al., 2011; Rich et al., 2010; Saks, 2006). By examining these relationships for OS software developers, we unravel the uniqueness of the relationships in the context of open innovations.

Context, a situation or a scenario, can change relationships among variables and influence outcomes such as "organizational behavior" in various ways (Johns, 2006). As a context, OSSD is unique in its approach (voluntary) and economics (the availability of the source code) and has been established to be fundamentally different from traditional organization-driven, managed, and resourced software development (Hars & Ou, 2002). Because OSSD is heavily dependent on IS professionals voluntarily joining projects, we argue that the job characteristics of a project will play important roles in driving the engagement of those who will participate in the project.

Our focus on role-specific project attributes that are important for engaging IS professionals in OS projects extends previous OS research examining developer contributions. Previous research on the topic

highlights various factors, such as social identity, commitment to the company and OS community, and altruism (Alam & Campbell, 2017; Bagozzi & Dholakia, 2006; Hars & Ou, 2002; Maruping et al., 2019). We offer a new set of factors – job characteristics – that explain why individuals contribute to OSSD projects. These findings extend previous research that focused on general project attributes such as quality control, type of project, and OS product quality (Ho & Rai, 2017; Setia et al., 2012). Notably, our findings provide a better understanding of the attributes related to *OS project design* that may encourage participants to join and continue their contribution. For instance, the importance of task identity in driving IS professional job engagement may explain how engagement may be greater for OSSD projects designed with roles tied to an optimum portion of the project's workload.

In general, our focus on five job characteristics from the JCM model–proposed by Hackman and Oldham (1980), as used by recent IS studies (Morris & Venkatesh, 2010; Tripp et al., 2016; Venkatesh et al., 2010)– extends previous IS research studying the relationship between job characteristics and job satisfaction (Bala & Venkatesh, 2013; Goldstein & Rockart,1984; Igbaria et al., 1994; Kaplan & Duchon, 1988; Morris & Venkatesh, 2010; Specht, 1986). The use of the job characteristics model unravels the set of OS task characteristics. Because financial rewards are not underlined in the JCM, the theoretical model unravels the set of mutually exclusive and collectively exhaustive characteristics of OS jobs, for which most workers are not directly paid.

In addition, by using JCM in the context of OSSD, we extend an understanding of where engagement would fit in the nomological network of job characteristics and job satisfaction. Doing so, we extend the previous IS research that has largely focused on proprietary software development environments (Morris & Venkatesh, 2010; Rich et al., 2010; Tripp et al., 2016). Our study shows that JCM can also provide valuable insights about IS professionals in the OS environment. In other words, as Whetten (2008) suggested, by applying the well-established theoretical lens of JCM to an emerging field, we contribute the theory to the OS literature. Further, by unraveling the mediating effect of engagement, their research enriches the IS literature by extending the IS literature using the JCM model (Morris & Venkatesh, 2010). Specifically, we highlight that more research may be required, as the direct effect of job characteristics on job satisfaction fails to identify the mediating influences. Therefore, we also contribute to the theory by identifying the mediating influence in the relationship (Whetten, 2008).

In general, by focusing on engagement, we offer a new perspective for focusing on IS professionals' contributions. Many have identified engagement in the management literature as an important concept that helps us understand the relationship between a person and their work role. Many management and organizational behavior scholars have found that engagement leads to various positive individual and organization outcomes (Anthony-McMann, 2017; Harter et al. 2002; Kahn, 1990; Rich et al. 2010; Saks, 2006; Soane et al., 2012;). We enhance their stream of literature by studying antecedents and outcomes of job engagement in the OS domain, as few studies offer comprehensive models with both antecedents and consequents to various engagement constructs. Further, IS research will likely be able to build on our conceptualization to study engagement in various software development contexts, such as those related to outsourcing, proprietary software development, or virtual communities.

Managerial Implications

Openness in software development has transformed the software industry, contributing tremendous value. SourceForge, one of the most popular OSSD platforms, claims that it has hosted more than 500,000 software projects in its platform and facilitated more than 2.6 million downloads of OS software on average per day (SourceForge, 2025). A large number of developers working on these projects constitute valuable community Samaritans. Linux Foundation, a pioneer of OSSD, claims that more than a million IS (IS) professionals have participated in its OS drive, resulting in an estimated sixteen billion dollars worth of software projects (Linux Foundation, 2019). The effectiveness of the OS format leads to more private and public organizations' reliance on OS for software development (August et al., 2018). Government organizations such as Data.gov use OS software–e.g. GitHub (Data.gov, 2025). Prominent private software organizations such as Google and Microsoft have joined OSSD as well (Ho & Rai, 2017).

Managing IS projects and IS professionals is always challenging. The IS professionals are usually highly skilled and well-paid. Software development in the OS environment adds another layer of complexity to the project development and management process for the IS project managers. While OSSD has created tremendous opportunities for software development, an opportunity utilized by many organizations, the complexity around managing OS project development is increasing. Research shows that, as organizations, both private and government, become more and more interested in the new and unique way of software development, IS project managers and researchers are looking at various factors that trigger and stabilize the participation of IS professionals in OSSD projects (August et al., 2018; Hahn et al., 2008; Ho & Rai, 2017; Maruping et al., 2019). Their study guides organizations that are either exploring or already involved in utilizing the OSSD to accomplish projects needed for the organization. The study will also help private citizens who use the OSSD to procure software for their necessities by guiding them to design projects that include job characteristics that are appealing to IS professionals.

Limitations and Suggestions for Future Research

Several limitations to our study can lead to opportunities for future research in the OS development environment. For instance, engagement has been found to significantly influence many individual work outcomes in the existing literature. Since we focused on the job characteristics model as our theoretical framework, we have only examined job satisfaction as the outcome of job engagement. Future researchers can examine whether job engagement can lead to better performance or lesser turnover in OS projects. Turnover is especially very important given that the highest percentage of OS project failures are attributed to the turnover of developers (Fang & Neufeld, 2009; Maruping et al., 2019).

Future researchers can also look at the organizational aspects of engagement in the OS domain. For instance, Saks (2006) has conceptualized job engagement to be distinctly different from organization engagement. While IS professionals working on OS projects are not necessarily employed by an organization, they have relationships with potentially two types of organizations – those that provide the platform to develop the OS software and the organization that owned/initiated the OS project (if owner/initiator of the OS project is an organization). Future researchers may examine the antecedents (job characteristics) and consequences (organizational citizenship behavior, organizational commitment) of the IS professional's engagement (organization engagement) in the OSSD platform or the owner/initiator organization.

Our study hypothesized and found that autonomy in OS projects does not significantly impact job engagement. However, we did find that autonomy significantly impacts job satisfaction of IS professionals in OS software development. We also noted that the level of significance did not change when job engagement was added to the regression. Hence, future researchers can examine the role of autonomy in OS projects with more focus on their specific construct. For instance, future researchers can examine whether autonomy may impact organization engagement since the organization would be the entity that manages the level of autonomy an IS professional would enjoy in an OS project. Future research may also try to understand what is the optimum level of autonomy that is beneficial to most OS projects, or what type of projects would benefit from a high level of autonomy and what type of projects would not. Finally, future researchers may conduct a mixed-method study by starting with a qualitative study that will allow them to develop measurement items for the OS context and then apply them in a quantitative study. The qualitative study will allow future researchers to capture the richness of the OS context and the quantitative study will allow them to evaluate the measurement model.

CONCLUSIONS

Their research examines the relationships among job characteristics, job engagement, and job satisfaction in OSSD. Further, we empirically unravel that engagement is an important mediator in the relationship between job characteristics and the satisfaction of OS developers. We hope our study makes another advancement in enhancing our understanding of how to leverage the potential of OS developers and nurture their potential.

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APPENDIX 1: JOB CHARACTERISTICS RESEARCH IN THE IS LITERATURE

Reference	Independent Variables	Dependent Variables
Goldstein and Rockart 1984	Skill variety, autonomy, task identity, task significance, feedback from job	Job Satisfaction
Specht 1986	Job complexity, task analyzability, task identity, job level, routine clerical decision-making, managerial decision-making, strategic decision-making	Data quality requirement, data manipulation requirement, special reports requirement
Kaplan and Duchon 1988	Skill variety, task identity, autonomy, and feedback.	Computer system variables
Igbaria et al. 1994	Job Characteristics in terms of intrinsic and extrinsic rewards	Job Involvement, job satisfaction, organizational commitment
Morris and Venkatesh 2010	Skill variety, autonomy, task identity, task significance, feedback	Job satisfaction
Venkatesh et al. 2010	Skill variety, autonomy, task identity, task significance, feedback	Job satisfaction, performance
Bala and Venkatesh 2013	ES implementation, change in job Characteristics (job demands, job control)	Job Satisfaction
Tripp et al. 2016	Extent of use of Agile PM practices, Extent of use of agile SDA practices, Skill variety, autonomy, task identity, task significance, feedback	Job Satisfaction

APPENDIX 2: MEASURES FOR JOB ENGAGEMENT AND JOB SATISFACTION

Job Engagement (Saks 2006)
- I really "throw" myself into my job in the OS project.
- Sometimes I am so into my job that I lose track of time.
- Their job is all-consuming; I am totally into it.
- My mind often wanders and I think of other things when doing my job (R).
- I am highly engaged in their job.

Job Satisfaction (Morris and Venkatesh 2010)
- Overall, I am satisfied with my job in their specific project in the OS environment.
- I would prefer another, more ideal job. (reverse score)
- I am satisfied with the important aspects of my job in their OS project.

Data availability

Due to the IRB constraints restricting the release of only aggregate data, raw data cannot be shared.

Data not available / The IRB restricted the release of data to the aggregate level.

Glossary

Autonomy (H4) is defined as the degree of freedom enjoyed by the IS professional in deciding how to accomplish their task in the OS project.

Feedback (H5) is defined as the extent of information provided by the OS software project itself that helps the IS professional determine the quality of their input in the project.

IS: information systems

Job: when an IS professional uses their capabilities to perform a task (or group of tasks) that fulfills their role(s) (e.g., developer, tester) in an OS IS development project.

Job characteristics as defined by task significance, task identity, skill variety, autonomy, and feedback.

Job engagement: the relationship (physical, emotional, and cognitive) between an OSSD project and the role(s) played by the IS professional working on the project, going beyond mere participation. It mediates the relationship between job characteristics and job satisfaction in OS projects.

Job satisfaction in OSSD refers to the degree of positive emotional response generated by an IS professional's assessment of the experience gained due to their role(s) in the OS project.

OS: open source

OSSD: open-source software development

Skill variety (H3) is defined as the variation in a skillset that is utilized by the IS professional to accomplish their or her task in the OS project.

Task identity (H2) is defined as the part of the OS project the IS professional has been involved with.

Task significance (H1) is defined as the perception of the IS professional as to how significant the OS project is to society or an organization.