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Women Contributions to Open Source Software Innovation: A Social Constructivist Perspective

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Abstract— The popularity of Open Source Software (OSS) is increasing as a platform for modern software innovation with the prominent concept of “freedom”. Freedom in OSS innovation is similar to freedom of speech not in term of price. However, less than 2% of the contributors are women in OSS innovation. Minorities including women are often ignored in OSS innovation process. The gender issues in OSS innovation might be more complex than what it seems, as female contributors are often experience hybrid discriminations, both from the male dominated OSS community and socio-cultural patriarchy. This paper concerns the questions of how innovation is achieved in open source software communities through social constructionist perspectives focusing on feminist views.

Keywords: *Open Source Software, Open source Software Community, SCOT, Female developers*

I. INTRODUCTION

OSS is a software program whose source code is made available to the clients or users. OSS has opened up new possibilities of software innovation for various types of software and products that differ from the characteristics of modern software engineering practices [1] hence promotes innovation through community empowerment and collaborative practice. The availability of OSS's source code to the user helps them to comprehend how the program works and thus improves the interaction between developers and users that is important in OSS innovation and maintenance. The escalating numbers of OSS projects reflected that OSS is shaping the society in several important ways that includes computer science society in reviewing the software engineering and practices, and also stimulate social researchers to look at the phenomenon of volunteerism, motivation in working as a team from globally distributed individuals in software development [2]. OSS phenomenon has also significantly motivated governments, industries and community globally to adopt and implement OSS as an alternative to proprietary software due to varied reasons [3].

Most of the contributors can be anyone regardless of genders, race and cultural diversity that volunteers their effort, skills, tools and time to be part of the software development without any imbursements [1]. This shows that in term of practices and knowledge, the boundary of formal and informal, private and public is becoming blur which illustrates the sharing of knowledge between lays and experts, and vice versa [4]. The contributions from users in the communities can vary from source code, testing the software, finding and fixing bugs, preparing documentations and posting discussions on the bulletin board or forums [5]. Thus the freedom and sharing philosophy of OSS development has indeed a unique form of innovation as it does not corresponds to the monopolization of the richest firms or countries [6].

On the other hand, according to the OSS survey and report [7, 8] there is a great gap between genders where less than 2% are female contributors. This phenomenon of social dynamics demonstrates that OSS is a thoroughly male dominated world where women do not play a role in OSS innovation [8, 9]. When it comes to produce the software that meets the requirement of society needs, inclusion of both males and females developers is needed because software is gendered in both design and use [10, 11]. The shaping and construction of software innovation might be biased in its design and usage without inclusion of both genders in OSS community. The absence of female developers is in fact, disadvantages OSS as the requirements from both genders are important for OSS innovation. OSS innovation in male dominated playground will still be unconsciously biased as every aspect of our lives is touched by socio-technical systems, unless women are involved in its design and development [11].

II. OPEN SOURCE SOFTWARE INNOVATION

Innovation concerns about something fresh, be it an idea, practice or thing perceived as new by an individual. Duggan [12] defined innovation as “the successful exploitation of new ideas”. This definition is very broad but still corresponded to the innovation theory by Schumpeter as stated in [13] that relies on the commercialization of every single one of new

combinations that based on these four characteristics a) the application of new materials and components, b) the introduction of new processes, c) the opening of new markets or d) the introduction of new organizational forms. However, innovation in OSS community differs significantly from the founder of innovation theory definition in terms of the relation of innovation with commercialization since not often OSS being commercialized as compared to proprietary software [13].

OSS community innovation field reflects a broad and relatively boundless innovation system that allows various types of actors (core developers, casual contributors, bug reporters, patch submitters and end-users) participating and engaging in its development[10]. In OSS development, the phases in the innovation process cannot be clearly distinguished as in proprietary software development. Software innovation in OSS community is no longer limited to the experts or certain firms but shift to public openness where promised incentives are not the motivation factors for innovation. As a consequence, the behavior of innovation has transformed progressively from independent innovation to spontaneous and unconscious innovation [14].

From the literature, current researches on software innovation in OSS community are mostly focusing on two aspects. 1) Organization and process and 2) knowledge and intellectual management. Some previous work in software innovation is [14] that see innovation of OSS community is nurtured through the relation of production that builds up the OSS community economic foundation and dissipative mechanism, supporting the study by [15] that underlined the circulation of ideas and knowledge freely within the bazaar-based production consequently builds up a suitable environment for innovation. Metiu and Kogut [6] see the movement of OSS as an incredible driver of innovation in terms of intellectuality while Tanev [16] stressed in the perspective of process that OSS is an open innovation with a horizontal user innovation networks.

The software innovation in OSS community is an active socio-technical process which is not only influence social and technical issues but by various aspects including the economic, and political issues too [10]. According to Wang and Chen [13], software innovation in OSS community demonstrated a unique combination of private and collective aspect of innovation and knowledge and represent bizarre collaborative effort that depends on the skill and adhered to certain philosophies. Thus, the software innovation ability of OSS community has had phenomenal impact on the industry's evolution.

Although, a large pile of literatures in science and technology studies (STS) suggested that the interaction of actors and artifacts mutually shape each other in development and innovation process, still the influence of linear view analytic inheritance remains [11]. Therefore it is important to

investigate the development and innovation process from all its consequences, not just one-sided approach; technological aspect and the social engineering aspect of the technology. In order not to separate technology and society in two different dominant, the interaction between both actors and artifacts in the development process should not be separated since it will result in failures of the products to meet the real need of its users. To ensure a thorough picture of software innovation in OSS community is explored, multiple contexts of studies such as social engineering that include the diversity of contributors must be employed since a single technical perspective is not sufficient in understanding the nature of collaborative practices and interests of software innovation in OSS community [11]. This is to suggest that both the social context namely the gender perspectives of the software innovation practices and technological issues in OSS communities should also be investigated since technology is gendered in design.

III. GENDER ISSUES IN OSS INNOVATION

The diversity of members in OSS innovation reflects a range of social contexts. Yet, in most of OSS studies, many researchers have ignored the variety of the members, and presumed a stereotyped male dominated 'hacker's community' where the issues of gender inequality are often neglected [9]. Most of the researches in OSS focus on the process and structure of OSS related organizations and management while only a few of the researchers found that gender biasness in OSS is problematic [11]. Although the way software is developed and innovated has changed significantly in OSS community, the issues of gender inequality seems to be duplicated in OSS world from the existing gender problems in software industry [17]. The biasness and inequality issues in OSS innovation occur not only to gender but to other minorities who are not involve in coding such as business and marketing people, and also users [18]. It reflected that the strong programming culture in OSS development and implementation seems to be enjoyed only by hackers that are capable of manipulating technologies thus created imbalanced population of OSS based knowledge demography and unbalanced proportion of gender distribution[17, 19]. The strong programming culture in OSS innovation somehow hinders women participation in its innovation where women are more likely to contribute in writing documentation and reporting bugs. These non-programming activities are equally important to writing code as OSS cannot get widespread since software is not ready to use just as it is written. Yet, programming skills and knowledge is not the only contributions a person needs to be involved in OSS innovation. Bugs reporting, writing documentation, translating and localising, improving graphic or even promoting people to use OSS are also crucial for OSS innovation process since software alone is not straight away ready to use as it is written. The heterogeneity of reasons in contributing to OSS development related to human aspect reflect that diversity of people consequently cause essential differences within OSS community as a whole [7] thus influence the construction of OSS innovation.

Neglecting the inclusion of both sexes actually hinders the full potential of OSS since software is gendered in its design and usage [12, 13]. The lack of female OSS developers results in a large numbers of female unfriendly software where women's perspectives on software design and usage are not accounted in. Consequently, the absence of women's viewpoints in constructing OSS hinders women from contributing in its innovation which in turn portray the stereotype image that women are almost muted in OSS innovation because of lack on skill to write code [17]. Thus, not only the reasons behind the scarce numbers of female developers in OSS development should be investigated but to also find out 'what', 'why' and 'how' women plays their role in contributing to OSS innovation. This will help to prepare OSS community to be a more welcome environment that can attract women to participate in its development.

Moreover, in the pile of most current researches of OSS are focusing on the cases that centered in advanced or developed countries even though OSS seems to be a global phenomenon [10]. There are still a lot of undocumented activities that occurred in the developing countries which include the lack of sufficient trainings and support, the digital divide and regional specificities that should not be taken for granted which influenced the shaping and construction of software [12].

IV. RELEVANT THEORIES

A. Social Construction of Technology

This research is mainly guided by Social Construction of Technology (SCOT) theory where the developmental process of a technological artifact is described as multidirectional views of technological development as contrast to the linear models that follows pre-specified steps used explicitly in many innovation studies, and implicitly in many of the history of technology studies [20]. SCOT is bounded with some insights: 1) technologies are socially formed but they are also shaped by other technologies and are not just purely social; 2) technologies have social consequences that must be analyzed; and 3) technology's form is path dependent – that is, decisions made in the past constrain its evolution in the future. In other words, existing technologies will shape future technologies and decisions made in the past will shape future technological evolution. SCOT consists of four main concepts in its approach: 1) relevant social groups (RSGs); 2) interpretive flexibility; 3) technological frame, and 4) closure and/or stabilization [21].

RSGs concept emphasized that the members need to be using and sharing the same set of meanings on a certain technological artifact in order to be considered 'relevant.' The RSGs can be institutions and/or organization of groups of individuals (be it organized or unorganized) that assign similar meanings to a particular technological artifacts. SCOT approach views that a technological artifact has no value other

than what RSGs see in it where it portray that the meanings assigns to a technological artifact in fact constitute it and not just a simple matter of perception. Through the lens of SCOT, a problem is defined as such only when there is a RSG for which it makes up a problem.

The second concept of SCOT analysis is interpretive flexibility. SCOT researchers believe that technological artifacts are interpretively flexible. Interpretive flexibility means that not just how people interpret or assign meanings to an artifact flexibly, but flexibility exists in how the artifacts are designed. SCOT's second concept shows that there are also other possible ways in designing an artifact rather than just one possible way or one best way [20]. SCOT emphasis that meanings assigned by social groups are in fact constitute an artifact through the process of social negotiation that shows the 'competition' of many interpretations of an artifact may possibly co-exist before a consensus is achieved between the RSGs based on a dominant interpretation

The concept of closure and stabilization emerges when interpretive flexibility decreases that shows that the meanings given to an artifact is becoming more stable and less vaguely. Closure is believed to have happened when one interpretation of the artifact emerges as dominant over others as a result of consensus from the process of social negotiation between RSGs (inter-group). Therefore, the consensus emerged from the inter-group social negotiation has limited interpretive flexibility. The meanings attributed to the artifact and the design associated with it become resistant and relatively inflexible to change. When closure occurred, an artifact only requires a few words to identify it since RSGs see the problems as solved and the artifact is accepted [20]. Finally, the artifact become ground and stabilizes around the dominant interpretation.

A Technological frame is the concept on sharing similar interpretations of an artifact within RSGs. This concept suggests that each member of the RSGs has similar interpretations and assigned same meaning towards an artifact. Technological frame or frame with respect to technology, facilitates or constrains the interaction in a RSG by providing its members with appropriate resources, tools and structures that lead to meanings attribution and constitution of an artifact. As a consequence, the technology frame that develops within members of an RSG can be both the outcome and the enabler of social interaction.

Technological frame is crucial since if it does not exist, there will be no RSG and future interactions. It exists between the actors logically, neither inside actors nor above them but around them even to those that do not acknowledge it. Each RSG understands the technology based on what they know about related technologies, thus technological frame applies to all RSGs not just technical RSG. If an individual belongs to more than one RSG, the individual may see the artifact in new and innovative ways by integrating two or more technological frames [21]. Bijker [21] further explained about the degree of

inclusion in a technological frame by actors contribute to the dynamics of innovation. Actors with high degree of inclusion in a technological frame, usually are constrained by its term whereas, actors with lower degree of inclusion towards a technological frame may be moderately less constrained by it. Furthermore, actors that have inclusion in more than one technological frame of the same artifact have the tendency to drive change and innovation contrary to a single inclusion by actors that seems to provide constancy. A single inclusion of technological frame represents a specific interpretation that may limit actors' actions and interaction in terms of the interpretation

SCOT shows better articulation and methodologically robust than other neighboring theory such as Social Shaping of Technology (SST) and Actor-Network Theory (ANT) since it breaks down the technology development and change processes. It helps in giving guidelines that are heuristically constructive in analyzing and describing the development of a technology [20].

However, gender is an issue that has been largely ignored in most of constructivist studies of technology and innovation including SCOT. Generally, SCOT has particular problem in its methodology in addressing the gender divisions where its analyses begin with the actors who directly involved with innovation. This analysis in return generates difficulties in explaining the influence of broader social structures and why some actors are excluded or marginalized and why some actors and outcomes may be absent [22, 23]. The issues indicate a general problem in its methodology that relates to conception of power. The theorists in this genre were concerned about identifying and studying the social groups or networks that actively seek to influence the form and direction of technological design [22]. These theories failed to see women's involvement in development and consumptions of many technologies [24] thus led to the representation of technology is sharply gendered [22]. Feminists have stressed out that the absence of female in the technological development is a key feature of gender power relations. The effects of structural exclusion of actors who are excluded and marginalized on technological development should not be neglected even it is hard to analyze, as pointed out by commentators on the problems with "relevant social groups" in the process of technological development [22].

Furthermore, these theories have generally assumed that gender has little bearing on the development of technology because the masculinity of the actors involved was not made explicit. It might be seen as ironic that the focus on agency has rarely sensitized these authors to issues of gendered subjectivity [22].

B. Feminist Theory

Both men and women have gender identities which structure their experience and beliefs that need a full

understanding of theoretical integration of genders in technology studies [22, 25]. Most of feminist scholars in the field of technology studies view technology as socially constructed and genders plays a role in its production [25]. To conform to feminist view on representation of technology is sharply gendered, Wajcman [26] has stressed in her book that every aspect of technology in human lives is a socio-technical system which is gendered and unless women are part of the team of technological development, only then women have their level of power to touch the socio-technical aspect.

Cockburn and Omrod [27] and Wajcman [26] have laid two important foundations on feminist technology concept. The first is there are existence of mutually shaping relationships between technology and gender which technology is a source and the outcome of *gender relations* and *structures* or vice versa. Gender relations shows that the particular power dynamics which is embodied in the conceptualization of differences and sameness, or inequalities or assumed equalities between men and women [28]. Thus, the technological development approach should not focus solely on women per se, but the social construction relations between both genders. Gender relations also recognize that men and women are structurally positioned differently in society, hence considers how this differentiation acts as the basis for the unequal distribution of power although not all men and women share the same experiences[28]. Second foundation on feminist concept is *gender identities* and *symbols* since gender-technology relations are apparently not only exist in gender relations and structures, in other words it is about how we go as regards for being men and women. Faulkner [25] stated, close identification with technology and pride engineers have in technical competency are crucial elements towards individual identities and shared cultural of engineers of a technology development. The pleasures which men have more in technology as compared by women are an important factor in the dominance of technical work. It captures the notion of socio-technical in technology development that social and technological elements are mutually constituting and hence the so-production of gender and technology[25]. Therefore, the feminist approach to technology studies suggests that a technology development and use cannot be understood without reference to gender and vice versa.

V. CONCEPTUAL FRAMEWORK

The conceptual framework of Social-OSS innovation in OSS community shown in Figure 1 represents the theoretical guide will be used for the study. The framework shows the proposed relationships among the constructs of interest as derived from the theories. SCOT theory suggests that the constructs are related to *relevant social groups* and contributes *interpretive flexibility, closure and stabilization*, and *technological frames*. Since, SCOT did not acknowledged technological influences in determining the construction of technology [20], there is the need to incorporate technology use influence in the framework since the nature of OSS

development is mostly relies heavily on computer-mediated communication [29, 30]. Crowston et. al [30] discuss *technology use* as a very important input variable to an OSS project since the type of technology use by contributors in OSS community is very crucial in coordinating their OSS development activities that has significant impacts on the software development. The type of technology use for communication are emails, Internet Relay Chat (IRC), Concurrent Versions System (CVS), or subversion is critical for knowledge sharing and creation of OSS development especially in coordinating OSS development and for mediating control of OSS source code when at the same time, multiple developers may be working on any given portion of OSS development [30]. The influence of the features offer by technology use have impacts on the OSS development in terms of sharing of knowledge and creation of software innovation [30]. Thus, the concept of technology use is necessary to facilitate the four concepts of SCOT theory in understanding the construction of OSS innovation.

Another SCOT weakness is, it is blind toward societal power relations, since different actors and RSGs can posses different power [31]. SCOT only recognizes the only relevant groups that have active roles towards the construction of technology thus, groups without great power such as female or other minorities or the so called “irrelevant” social groups may have been unknowingly underrepresented and intentionally ignored during its design [24]. Thus for this study, constructs of feminist theory are incorporated in this conceptual framework where as described in preceding section, feminist theory offers insights about the *gender relations and structures* that shows the power relations between genders and minorities along with *identities and symbols* embedded in respect to gender.

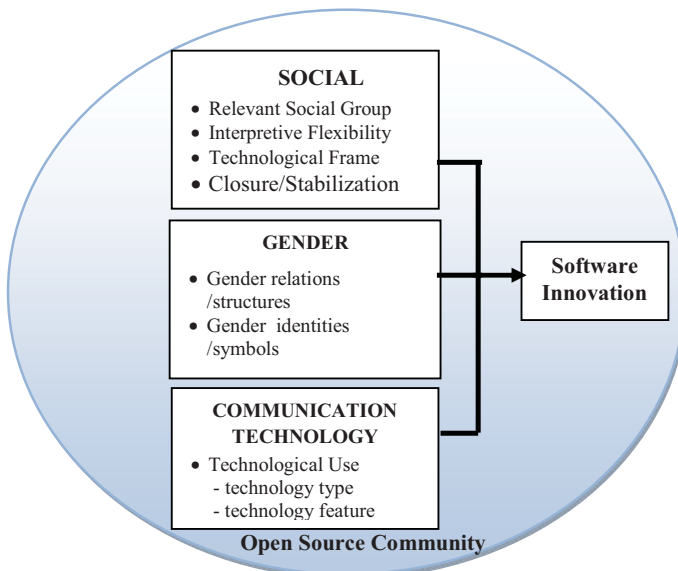


Fig.1 Conceptual Framework of Social-OSS innovation in OSS community

VI. SUMMARY AND FUTURE WORK

This paper has demonstrated the importance of feminist perspectives incorporated in OSS innovation process through social constructivist view since software innovation in OSS communities employs new types of socio-technical practices, development processes, and community networking when compared to proprietary software innovation in industry and differs greatly with traditional modern software engineering practices. Since the freedom of contribution philosophy is still not best exploited by female contributors, which are reflected with the very low percentage of less than 2% of the software developers in OSS community, it is an urgent need to realize the proposed conceptual framework in real phenomena study.

This conceptual framework incorporates SCOT theory, Crowston et. al [30] technology use variable and feminist approach can therefore make an important contribution generally to Information System and STS research and highlight the need to draw on the theoretical foundations of OSS innovation discipline. We believe that this study will offer insights on how women play a role in contributing to the construction of software innovation in OSS through the lens of SCOT Theory with feminist foci.

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