UNDERSTANDING USER DIFFERENCES IN OPEN-SOURCE WORKFLOW MANAGEMENT SYSTEM USAGE INTENTIONS

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ABSTRACT

Open-source software systems have become a viable alternative to proprietary systems. We collected data on the usage of an open-source workflow management system developed by a university research group, and examined this data with a focus on how three different user cohorts – students, academics and industry professionals – develop behavioral intentions to use the system. Building upon a framework of motivational components, we examined the group differences in extrinsic versus intrinsic motivations on continued usage intentions. Our study provides a detailed understanding of the use of open-source workflow management systems in different user communities. Moreover, it discusses implications for the provision of workflow management systems, the user-specific management of open-source systems and the development of services in the wider user community.

Keywords: information systems usage intentions, group differences, motivation, open-source system, workflow, survey research

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INTRODUCTION

Over the last decade, the open source software (OSS) phenomenon has revolutionized the way in which organizations and individuals create, distribute, acquire and use information systems and services, making it an increasingly important topic for information systems researchers. Many aspects have been investigated in this vein of research, including participation in open-source development [29], business models [10], community ideology [34], motivation [6] and governance [33]. In this paper, we aim to contribute to this current and relevant body of knowledge by studying the behavioral factors that lead to individuals' acceptance of an open-source workflow management system. To the best of our knowledge, this is the first time that the acceptance of an open-source workflow management system is analyzed. Also, our study is the first that explicitly examines differences in acceptance behaviors across three different user cohorts.

Specifically, we consider the YAWL system [39] as an example of open-source workflow management system. Two reasons underpin this choice. First, the YAWL system represents a state-of-the-art open-source workflow management system that is developed based on a solid grounding in research. Also, not only has it enjoyed uptake in industry practice, but it has also generated a significant impact in academia [36]. Second, the system is supported by a wide and diversified user community that includes three distinct user cohorts: student users, academic users and professional users. This is because the YAWL system is an OSS system that aims to address three different purposes:

i) to serve as a platform upon which researchers can prototype cutting-edge workflow technology;

ii) to educate students on business process modeling and automation; and

iii) to generate industry uptake.

In this respect, the YAWL system shares some commonalities with the open-source operating system GNU/Linux (whose distributions are used both in educational institutions to teach software and operating systems as well as in commercial environments), but differs from the majority of other OSS products (e.g. Mozilla Firefox) that target general users and do not necessarily have an educational purpose.

In this paper we seek to examine differences in the behavioral motivations to accept the YAWL system across its three different user cohorts. Knowing how different user cohorts perceive OSS software and how these perceptions affect their individual usage decisions is important because it helps managers in charge of software acquisitions to design more effective implementation strategies and offers guidance for personalized management interventions. This knowledge is also important for providers of OSS software solutions and related services for developing effective personalized marketing strategies. Further, the open-source workflow management system YAWL that we are examining is different from traditional information systems in that it explicitly caters to different user cohorts instead of being purpose-built for a particular cohort like many other systems (e.g., DSS for decision makers, EIS for executives, TPS for operational staff). Systems that are built for a variety of users face important challenges in acceptance and usage behaviors because different stakeholders typically have multiple and often conflicting objectives and priorities and rarely agree on a set of common aims [31, 51]. Correspondingly, in our paper we set out to answer the following two research questions:

1) Which factors contribute to explaining individuals' acceptance of an open-source workflow management system?

2) How do these factors differ across three user cohorts of an open-source workflow management system, viz., student, academic and professional users?

We proceed as follows. First, we review the literature on determinants of the behavioral intentions to use open-source systems and introduce the specific research context of our study by providing relevant background to the YAWL initiative. Then, we describe our research model and develop a set of hypotheses about the expected differences across the three user cohorts considered. Next, we describe design and conduct of our empirical study to test the model and the hypotheses. We discuss the results and identify important implications for theory and practice before concluding the paper with a review of contributions and limitations.

PRIOR RESEARCH

Determinants of the Behavioral Intentions to Use Open-Source Systems

Much research has examined different motivating factors that lead to an individual's intentions to use an information system. Venkatesh et al. [43, 45] summarize these studies. Importantly, research has shown that both intrinsic motivators such as hedonistic motives [e.g., 17] or enjoyment [41] as well as extrinsic motivators such as outcome value expectancies [e.g., 50], perceptions of usefulness [12] or social motives [46] are important motivations for the behavioral intentions to use an information system. The strength of these intentions, furthermore, is also known to be dependent on people's perceived control over using the system [42], which is influenced by the technological and resource support facilities available to assist with the use of an information system.

Much of the knowledge on technology acceptance and use holds for both proprietary software and open-source software systems. Still, with the emergence of OSS as an alternative paradigm to propriety software, there are several key attributes that differentiate open-source software from proprietary systems:

- Many OSS software development efforts are provided non-for profit [4].
- Many OSS software products are provided at the expense of limited end user support, uncertain bug fixing and upgrades, and negative network externality effects that typically favor the diffusion of proprietary solutions [7].
- The quality of service provided by an OSS software product can vary greatly [14].
- OSS usage can be strongly influenced by one's socio-cognitive perception of the related open-source user community [3].

- OSS software products are often associated with greater affordances of flexibility than proprietary solutions [16], mostly due to the unconstrained access to source code, free modifications, and the potential to reuse the code in other software [9].

Still, the usage of OSS is dependent on behavioral factors not dissimilar to those of other systems, such as proprietary utilitarian or hedonic technologies. For instance, we also know that in the open-source context evaluations of usefulness and ease of use are key to understanding usage behavior [43]. The prominent theories of reasoned action and behavioral control specifically show that motivational as well as control beliefs add to our understanding of how and why users accept and continuously use technology systems. Still, there are certain peculiarities about OSS usage. For instance, some researchers have found that OSS users are motivated by specific extrinsic factors relating to future rewards such as career opportunities, knowledge gains, reputation and status [20, 22], and that these factors can sometimes dominate utilitarian beliefs such as usefulness, expected performance gains or ease of use. Other studies have also shown that intrinsic motivations such as self-determination, hedonic interest or even fun add to our understanding of OSS use [18, 20, 52]. Other studies have shown how social factors pertaining to the OSS community [3] or ideology [34] affect people's usage behaviors.

Before the background of these findings, our interest in this study is to advance an integrative model explaining the intentions to use an open-source workflow management system that is based on an amalgamation of existing theories, and to examine this model across different user cohorts relevant to the particular system in focus. To that end, we will now detail the background of the open-source workflow management system under consideration, YAWL.

The YAWL System

The YAWL system is one of the most mature open-source workflow management systems available at present. The system has counted more than 100,000 downloads from its main host site (SourceForge), with an average of almost 20,000 unique visitors in the last two years [1]. YAWL has been used as a teching tool in more than 30 universities across 16 countries, while several companies from various business sectors such as utilities, healthcare, public defence and automotive industry, use the YAWL system or variants thereof for commercial purposes.[1] As such, the YAWL community is not limited only to an academic cohort, but also stretches into higher education sectors as well as commercial industry sectors.

The development of the YAWL system started in the form of a proof-of-concept prototype in 2002, to demonstrate that it was possible to realize a workflow system that could offer comprehensive support for the so-called Workflow Patterns [40]. These patterns describe recurrent control-flow structures within a business process, e.g., a sequence or a parallel split, as observed through an extensive analysis of existing workflow management systems. Since then the tool has grown into a fully-fledged workflow management system and support enviroment. As any workflow management system, its main capabilities revolve around the automation of process models. This is acheved via three core components: the YAWL Editor, to design executable YAWL models and link these to organizational resources, business data and external applications; the YAWL Engine, to automate such models; and the

[1] http://yawlfoundation.org

Resource service, to control the allocation of tasks to resources. However, besides the typical amenities of a workflow management system, the YAWL environment offers unique workflow features which stem from its research foundations. These include the underlying YAWL workflow language and its support for advanced workflow patterns (such as cancelation regions and the OR-join), as well as state-of-the-art workflow verification, configuration and exception handling.

YAWL is licenced under the GNU Lesser General Public Licence (LGPL) which fosters developers to contribute modifications and enhancements, while not restricting its use in proprietary works. Further, an entity named The YAWL Foundation has been established to protect all intellectual property (IP) related to the YAWL environment. This serves to indemnify the Foundation from any copyright or IP infringement issues, while providing the right to distribute the software on behalf of any contributor.

HYPOTHESIS DEVELOPMENT

An Integrative Model of the Behavioral Intentions to use OSS software

The literature to date has established knowledge about a wide range of factors that contribute to individuals' intentions to use technology, both in proprietary [e.g., 43] as well as in open-source contexts [e.g., 14]. The literature spans extrinsic and intrinsic motivating factors as well as social aspects. Reconfirming the importance of well-known factors such as the influence of perceived usefulness and perceived ease of use will, therefore, not contribute much to the literature.

Our primary focus is thus not in establishing a new model of continued usage behavior of open-source systems but rather in examining how important selected determinants are among different user cohorts. To that end, we developed a research model based on a synthesis of relevant findings from prior research on usage intentions associated with open-source systems. Figure 1 displays our research model graphically.

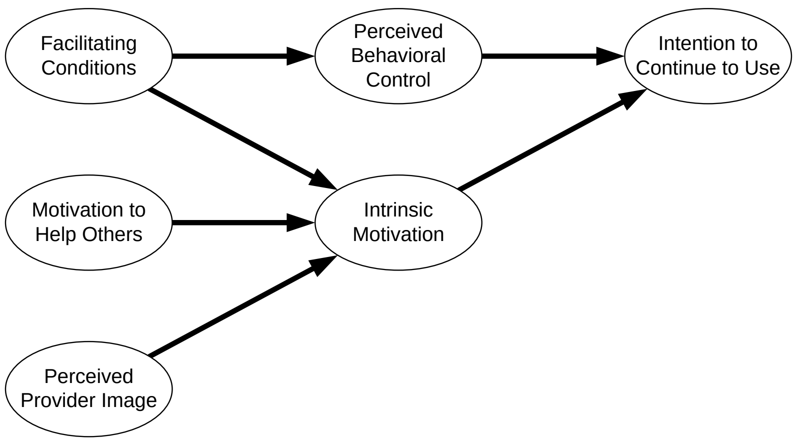

Figure 1. Research model

The model posits that the intention to (continue to) use an open-source workflow management system is a function of two primary beliefs: perceived behavioural control (PBC) and intrinsic motivation (MOT).

PBC is a construct that captures beliefs regarding access to the resources and opportunities needed to perform a behavior, or the internal and external factors that may impede behavioral performance [2]. In the context of software system use, PBC relates to the beliefs of users to have the skills as well as the resources available that are required to successfully use the system. Aside from self-efficacy beliefs [11], a key component in PBC is therefore "facilitating conditions" [38], which reflects the resources made available by a provider that are required to engage in a behavior.

Facilitating conditions are defined as the degree to which an individual believes that an infrastructure exists to support use of a software system [47]. Taylor and Todd [35] decomposed this infrastructure into technology facilitating conditions (such as technology compatibility) and resource facilitating conditions (such as time, money, access to knowledge and support resources), and found that resource facilitating conditions have an importance greater than technology facilitating conditions.

In the context of open-source system use, the provision of *resource* facilitating conditions (FC) is a key type of facilitating condition that can influence system usage intentions. By providing instruction and guidance resources to users and assisting them when they encounter difficulties, some of the potential barriers to successful use are reduced or eliminated [37]. Open-source systems often come with limited documentation, installation or other assistance material, making the external availability of resources to provide such knowledge an immensely important positive contributor to successful usage. All other things equal, therefore, perceived behavioral control will increase as more assistance and support access is available because users will feel that if they have limited a priori knowledge about using a system, support and knowledge will be readily available, thereby amplifying beliefs about the control of use.

In contrast to control beliefs, intrinsic motivation describes those psychological forces that arise from within an individual and cause him or her to volitionally perform a task or activity for gains of satisfaction or interest. Intrinsic motivation has been well-studied in the literature and has been firmly established as a key driver of OSS participation [21, 33] and technology usage [12, 42], which suggests its relevance to understanding behavioral intentions to use OSS software. Intrinsic motivations capture those factors that determine the decision to engage in system usage behavior volitionally [42].

In the specific context of OSS software system usage, we believe three key antecedents are particularly relevant to understanding the intrinsic motivations to use OSS software, viz., the facilitating resource conditions (FC), the motivation to help others (HELP) and the perceptions of the provider image (IMG).

First, *facilitating (resource) conditions* are important to understanding motivations to use a system because the availability of support and guidance structures can not only increase control beliefs but also add to the motivation to use a system because beliefs about the ease of use of the system can be amplified [24].

Second, OSS software use provides an opportunity to feedback knowledge to the OSS community. Studies of OSS participation have found that the *opportunity to help* *others* in the community is a key motivator to contribute to the development of OSS software [50] or the prosperity of the community itself [18]. We believe that such altruistic motives also pertain to the decision to use OSS software because the use of OSS software provides the ground on which experiences, modifications or extensions can be fed back to the developer/user communities.

As a last antecedent to the motivations to use OSS software, we consider social motives – such as ideology or sense of belonging, which have been found to be key to understanding the OSS movement [3, 34]. In light of the relevance of such social motives, we believe that especially the status image of the OSS provider could be a key factor to examine OSS usage contexts. Consider the unlucky history of Netscape in the open-source community. In 1998, Netscape, in a move to counter the growth of Microsoft Internet Explorer, created the Mozilla project. Still, their strategy was not fully in line with the general notion of the OSS ideology. The source code of the program was released only partially, several interesting modules were kept closed, and a specific license allowed Netscape to alter any external modifications made to the program. In effect, the initial system, Netscape Navigator, failed to attract any significant level of end user acceptance and it was only when the company re-established its status as a true open-source company by incepting a GPL-like licensing scheme for the Mozilla project that OSS users started extending the system. These and other similar stories point to the relevance of the perceived social status (we call this the *perceived provider image*) of an OSS provider in the community of OSS users. For instance, firms try to conform to the social norms that rule the OSS community to raise their perceived status as the basis for cooperative behavior of users [7]. Placing trust in the capabilities of a provider to provide high-quality software products and to act in the 'true spirit' of the open-source community is thus expected to raise the motivations to use OSS software. Thus, the construct "provider image" defines the perceptual status image of the software provider and assesses the degree to which people believe that the provider of an open source software solution has a high status as a provider in the relevant social network (i.e., the open source community or the particular business domain in which an organization operates).

Expected Differences in the Behavioral Patterns leading to YAWL Usage Intentions

On the basis of the research model described above, we now detail our expectations about how the three user cohorts of the YAWL system will differ in terms of the behavioral factors explaining the system's usage intentions.

First, we examine the role of antecedents to intrinsic motivation. Turning to the role of the perceived provider image, we believe that IMG is most important for students, then academics, and finally practitioners. Our argument rests on the observation that students are typically required to actively and intensively research the development and functionality of the system. Moreover, they may engage in close interactions with the research team involved in the development and maintenance of the system, as they read the relevant research papers. Such engagement often leads to elevated perceptions about the status of the system provider (in this case the university team behind it), in turn elevating motivations to use this system created by those researchers that occupy roles such as lecturers, mentors and research advisors. Second, academics tend to use the YAWL system with the view to developing software extensions, because they believe on the solid research foundations of this system, which are evidenced by the proven track-record of the research group that developed the system. Such beliefs would again manifest elevated perceptions of provider image. Still, we believe the influence of these beliefs to be decreased in comparison to the strong status beliefs of students. By contrast, we believe that practitioners will be motivated to use the system because they trust the university environment in which it has been developed. They recognize the social function of universities and the unbiased judgment of academics as important requirements to produce software with state-of-the-art functionality. However, practitioners know that software developed by a university typically lacks production quality and adequate customer support (as indeed in the case of the YAWL system). While these aspects are less important for academics, they become critical in a commercial setting, in turn justifying a somewhat lesser influence of IMG than in the academic and student user cohorts. Formally, we state:

H1a. *The impact of IMG on MOT will be stronger for academics than practitioners.*

H1b. *The impact of IMG on MOT will be stronger for students than academics, and by extension it will also be stronger than practitioners.*

Second, we turn to the relevance of the motivation to help others. We believe that HELP is more important to academics and students than practitioners. Academics mainly use YAWL for research purposes. Thus, they may have an interest in helping the YAWL community grow because this will give their YAWL extensions more visibility and uptake, which eventually will generate more research impact. To a lesser extent, we expect students of IT courses to be similarly motivated to use YAWL because of their desire to contribute to the community from which the system originates. Often, students develop close ties to the research institute they are connected with, and they may also become engaged in activities to promote this software community (e.g. by participating in the OSS forum of the YAWL system, where they can report bugs and improvement requests, or better, by donating code). Such effects could manifest in increased motivations to use the YAWL system because students realize the opportunity to contribute to the community.

Practitioners, by contrast, use the system mainly for commercial purposes. Thus, helping the OSS community around YAWL may not necessarily influence their motivation to use the system. For example, in our experience, those organizations that use YAWL for commercial purposes, have close-sourced their custom extensions to the YAWL code base (this is possible due to YAWL's LGPL license). Therefore, we do not expect strong influence of HELP on MOT for practitioners. Formally, we state:

H2a. *The impact of HELP on MOT will be stronger for academics than practitioners.*

H2b. *The impact of HELP on MOT will be stronger for students than practitioners.*

Third, we turn to the role of facilitating conditions. We believe that the availability of FC such as documentation, customer support and periodic system updates, will play a most important role for academics. Facilitating conditions can help academics develop their YAWL extensions quicker, especially through the availability of technical documentation such as developer's manuals. In an effort to extend the system itself or the knowledge around the system, we believe that the availability of assistance will strongly leverage feelings of behavioral control over the system. Second, we believe the availability of facilitating conditions will be important also to practitioners. This is because such conditions increase the practitioner's confidence that a system is reliable since it is maintained over time (periodic updates) and easy to use (documentation and customer support). Thus these conditions can help justify an investment in a commercial setting. And while licensing costs are cut down in OSS software, a company still needs to significantly invest in training to be able to use the software product effectively and efficiently, which further justifies the importance of facilitating conditions for practitioners. Finally, we believe that facilitating conditions are less relevant to students since they do not typically need to extend or customize the YAWL system within the scope of their studies. In most instances, they will rather use the system to create examples and learn about process modeling and automation. Formally, we state:

H3a: *The impact of FC on PBC will be stronger for practitioners than students.*

H3b: *The impact of FC on PBC will be stronger for academics than practitioners, and by extension it will be stronger than students.*

Finally, we examine the relative importance of the two main drivers of usage intentions, viz., perceived behavioral control and intrinsic motivation.

One key difference between student, academic and practitioner user cohorts is the degree to which the use of YAWL is driven by mandate. Consider the situation of students, for example. The use of YAWL in university courses on process modeling and automation is often mandated or at least encouraged. It is thus most often not up to the students to use YAWL out of pure intrinsic interest. Given this scenario, it is likely to expect that intrinsic motivation plays a relatively minor role in contributing to the intention to use YAWL. By contrast, the relative importance of perceptions of behavioral control will be more important because perceptions of control are important especially in situations where system usage is mandated [8]. For academic users, however, we believe a different mechanism will be at work. Academics dominantly use YAWL out of individual research interest, to study the workflow technology and/or to develop extensions or other artifact contributions. These interests are driven by an intrinsic motivation to study topics around workflow and by an intrinsic interest to use the particular system. In turn, we believe the relative importance of intrinsic motivation will be strong for this cohort. Last, turning to the practitioner cohort, we believe that for organizational end-users, the decision about which software or system to use is often an organizational decision made by managers or boards of IT directors [8]. We believe that in this situation, similar to the student cohort, the role of PBC will be relatively stronger than that of MOT. Formally, we state:

H4a: *For students, the impact of PBC on ITU will be stronger than the impact of MOT on ITU.*

H4b: *For academics, the impact of MOT on ITU will be stronger than the impact of PBC on ITU.*

H4c: *For practitioners, the impact of PBC on ITU will be stronger than the impact of MOT on ITU.*

RESEARCH METHOD

Data Collection

We collected empirical data via a field survey of users of the YAWL system during six months in 2009/10. The survey method is appropriate when clearly identified independent and dependent variables exist, and a specific model is present that theorizes the relationships between the variables [27], which is the case in our study.

As discussed above, the YAWL system has three primary user cohorts: it is in use in small-to-medium sized organizations, it is in use by academics working on business process management solutions, and it is in use in higher-education teaching institutions in courses on process modeling and automation. Across these three cohorts, the application purposes range from classical workflow engineering, process modeling and process automation to discrete process simulation [30].

Data was collected globally from YAWL users via a web-based instrument. Web-based surveys are advantageous over paper-based surveys in several ways (e.g., lower costs, no geographical restrictions, faster responses). Users were invited to participate in the online survey through advertisements made in online forums and blogs, email announcements, through the YAWL community (www.yawl-foundation.org) and through a link present in the YAWL system itself. Participants were informed about the type and nature of the study and they were offered incentives for participation, specifically, a summary of the results and the opportunity to win a textbook.

We received 220 responses in total, of which 14 were incomplete and twelve invalid. After eliminating these entries, we obtained a sample of 194 usable responses. The respondent group varied in organizational and personal demographics. Over 87% of respondents were male. 28.4 % of participants were **academic users**, 27.3 % were **student users**, 44.3 % were **practitioners** (in positions such as analyst, developer, IT manager, system administrator, software engineer, process manager), with the rest indicating “other” occupations. Practitioner respondents were spread amongst small (41.1 %), medium (23.3 %) and large (35.6 %) companies. These statistics are largely similar to those reported in other open-source community studies [18, 20, 50], thereby indicating appropriateness of the survey population. Over 50 % of respondents had more than one year experience with workflow systems in general, while 21 % had less than one month experience with such systems. On average, the respondents had created nearly 30 workflow models using the YAWL system.

Design and Measures

According to the research model illustrated in Figure 1, we measured six latent constructs in this study: intentions to continue to use the open-source system (ITU), intrinsic motivation (MOT), perceived behavioral control (PBC), facilitating conditions (FC), motivation to help others (HELP), and perceived provider image (IMG). All constructs were measured using pre-validated multiple-item scales, using a seven-point Likert scale for each item, anchored between “strongly disagree” (coded as 1) and “strongly agree” (coded as 7), with the midpoint “neither disagree nor agree” (coded as 4).

Specifically, ITU was measured using a four-item scale adapted from Bhattacherjee [5]. This scale had been used extensively in prior work [e.g., 28] and captures the extent to which users are willing to continue using a system after initial usage experiences, in contrast to other potential alternatives as well as globally. We set the focus of the scale on the behavioral intentions to continue to use the OSS because, first, our data examination concerned how motivations stood in relation to behavioral intentions (i.e., a reflective purpose) and second, because our data set only comprised users that already had usage experience with the OSS we considered – YAWL.

MOT was measured using the three item scale used by Venkatesh et al. [49]. The scale was originally developed by Davis et al. [12] and extensively validated [48].

PBC was measured using the scale used by Venkatesh [42], which was adapted from [23, 35]. The scale items measured perceptions of control over using the system in terms of required knowledge, technology compatibility, as well as an overall scale measuring control over resources, knowledge and opportunities.

FC was measured using the resource facilitating conditions scale developed by Thompson et al. [37]. The scale items measured the perceived provision of support resources available when users encounter difficulties pertaining to the usage of a system in terms of guidance, specialized instructions and assistance.

HELP was measured using the four-item scale on altruistic motivation from Hars and Ou's [18]. The scale items specifically measured individuals' recognition of the importance of helping each other in the OSS community, the self-perceived relevance of helping others, altruistic motives, and the recognition of a helping opportunity.

Finally, IMG was measured by adapting three items from the social image scale used by Venkatesh and Davis [44], which was adopted from the scale developed by Moore and Benbasat [26]. Specifically, we did not anchor our IMG measurement items on perceptions on one's social status gains through the use of a system. Instead, we anchored them on perceptions on the social status of the provider of the open-source system within the organizational setting in terms of prestige, community profile and organizational image. The Appendix displays all scale items used.

Aside from the latent constructs, we collected demographic data such as age (ordinal scale with the categories Less than 20 years, 20 - 35 years, 36 - 50 years, Older than 50 years), gender (male/female), experience with workflow management systems (I am evaluating to do so/I have just started, Less than 1 month, 1 - 6 months, 7 - 12 months, 1 - 5 years, More than 5 years), experience with process specifications (number of process models read or created), experience with workflow specifications (number of YAWL workflow specifications designed), and breadth of YAWL usage (number of features used and their ranking of importance; the features include execution environment, syntax checker/verification, cancellation region, OR-join, multiple instantiation, deferred choice and other workflow features). This data was collected (a) to provide demographics for the sample frame for our study population, and (b) to be able to profile the different user groups, viz., practitioners, academics and students.

Scale Validation

To avoid potential interpretational confounding, we assessed the validity of our empirical indicators via confirmatory factor analysis before proceeding with the data analysis, following the suggestions by Segars and Grover [32]. Each scale item was modeled as a reflective indicator of its theorized latent construct.

Table 1 shows the factor loadings, and Table 2 presents construct reliabilities and descriptive statistics. Construct correlations are shown in Table 3. Reliabilities of the scales were assessed using Cronbach's alpha and found to be greater than 0.78 in all cases. The means of all scales were above the midpoint of 4, with standard deviations being above 1. All constructs were correlated with each other, with the highest correlations being between perceived behavioral control (PBC) and intention to use YAWL (ITU). Principal components analysis, with varimax rotation yielded a six-factor solution, as expected. Those results supported internal consistency, with all loadings being significant (0.79 or above), and discriminant validity with all cross-loadings being less than 0.5. Convergent validity was further supported by all composite reliabilities exceeding 0.8 and average variance extracted (AVE) of each construct exceeding 0.7 or above. Discriminant validity was supported by showing that the AVE of each construct was higher than the squared correlation between any two factors (the highest squared correlation being 0.52, between PBC and ITU).

Table 1: Factor loadings

Item <- Construct	**Loading**	**St. Dev**	**t-Statistic**	**Sig.**
FC1 <- FC	0.04	0.04	10.07	< 0.001
FC2 <- FC	0.05	0.05	7.65	< 0.001
FC3 <- FC	0.04	0.04	9.09	< 0.001
HELP1 <- HELP	0.04	0.04	5.90	< 0.001
HELP2 <- HELP	0.04	0.04	7.25	< 0.001
HELP3 <- HELP	0.03	0.03	8.46	< 0.001
HELP4 <- HELP	0.05	0.05	5.16	< 0.001
IMG1 <- IMG	0.03	0.03	11.76	< 0.001
IMG2 <- IMG	0.03	0.03	11.13	< 0.001
IMG3 <- IMG	0.05	0.05	8.96	< 0.001
ITU1 <- ITU	0.02	0.02	12.46	< 0.001
ITU2 <- ITU	0.02	0.02	11.86	< 0.001
ITU3 <- ITU	0.03	0.03	10.86	< 0.001
ITU4 <- ITU	0.02	0.02	14.22	< 0.001
MOT1 <- MOT	0.02	0.02	17.35	< 0.001
MOT2 <- MOT	0.02	0.02	20.34	< 0.001
MOT3 <- MOT	0.02	0.02	19.48	< 0.001
PBC1 <- PBC	0.03	0.03	14.55	< 0.001
PBC2 <- PBC	0.02	0.02	16.89	< 0.001
PBC3 <- PBC	0.02	0.02	16.99	< 0.001

Table 2: Scale properties

Construct	**Number of items**	**Average factor score**	**St. Dev.**	**Cronbach's α**	**ρ_c**	**AVE**
FC	3	4.01	1.22	0.79	0.88	0.70
HELP	4	4.82	1.29	0.92	0.95	0.82
IMG	3	4.09	1.33	0.83	0.90	0.74
ITU	4	4.97	1.25	0.92	0.95	0.81
MOT	3	4.44	1.10	0.90	0.93	0.83
PBC	3	4.68	1.23	0.89	0.93	0.81

Table 3: Construct Correlations

Construct	FC	HELP	IMG	ITU	MOT	PBC
FC	1.00					
HELP	0.27	1.00				
IMG	0.66	0.23	1.00			
ITU	0.49	0.46	0.50	1.00		
MOT	0.59	0.38	0.60	0.71	1.00	
PBC	0.52	0.35	0.48	0.72	0.71	1.00

ANALYSIS AND RESULTS

Data analysis proceeded in several steps. First, our data analysis concerned the examination of the introduced research model in terms of the significances and effect sizes (β) for each hypothesized path, and explained variance (R^2) for each dependent variable. Data analysis was carried out using component-based structural equation modeling implemented in SmartPLS v2.0 (www.smartpls.de). Figure 2 gives the results.

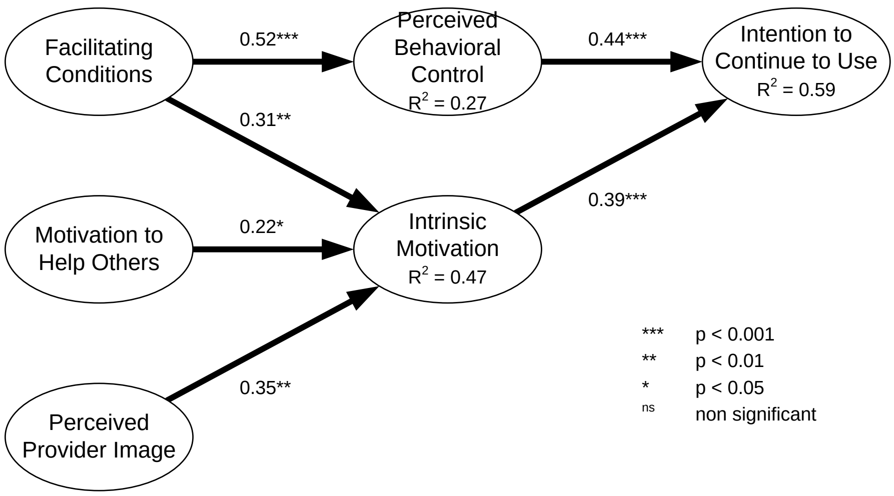

Figure 2. Structural model results (all groups)

The results displayed in Figure 2 show that our model explained 59% of the variance in intention to continue to use, 27% of the variance in perceived behavioral control, and 47% of the variance in intrinsic motivation. As expected, PBC was a significant predictor of ITU (β = 0.44, $p < 0.001$) and so was MOT (β = 0.39, $p < 0.001$). Facilitating conditions positively influenced perceptions of behavioral control (β = 0.52, $p < 0.001$) and, to a lesser extent, intrinsic motivation (β = 0.31, $p < 0.01$). Intrinsic motivation was further a function of HELP (β = 0.22, $p < 0.05$) and IMG (β = 0.35, $p < 0.01$), as expected. These results are in line with our expectations and consistent with prior literature [e.g., 18, 37, 42, 44, 49].

Second, we examined the research model individually for all three user groups, and compared the significance of the path coefficient differences among the three user groups employing the multi-group analysis approach suggested by Henseler [19]. This approach does not require any distributional assumptions. The significance of differences is based on pair-wise comparisons of the bootstrap estimates that are generated by prevailing PLS implementations such as SmartPLS. The descriptive profile of the different user groups is shown in Table 4, and the results from the multi-group analysis are summarized in Table 5.

Table 4: User Group Descriptive Statistics

Measure	Academics n = 55	Students n = 53	Practitioners n = 86
Age			
Less than 20 years	1	1	0
20 - 35 years	40	45	39
36 - 50 years	12	6	26
Older than 50 years	2	1	21
Gender			
male	44	44	86
female	11	9	0
Experience with the YAWL system			
I'm evaluating to do so/I have just started	17	24	60
Less than 1 month	8	6	6
1- 6 months	16	15	12
7 - 12 months	2	3	2
More than 1 year	12	5	6
Use of YAWL per week (in hours)			
Mean	21.3	13.03	2.53
St. Dev.	71.15	29.03	2.26
Number of process models created or read			
Mean	167.54	33.67	92.03
St. Dev.	705.88	50.99	259.01
Number of YAWL workflow specifications defined			
Mean	15.76	63.47	9.59
St. Dev.	25.68	411.20	30.42
Number of YAWL features used			
Mean	4.89	3.83	2.95
St. Dev.	3.48	2.80	2.97

As expected, we find that academics tend to use the YAWL system more broadly (average number of features used is 4.89 versus 3.83 for students and 2.95 for practitioners) and also more intensively (in number of hours per week) than the other two cohorts. Likely, this is because academics are exposed to a broader range of system features due to the nature of their in-depth work than, for instance, practitioners, who are more likely to rely on a limited set of features steadily over a longer period of time.

This also reflects on the average time spent on the system. Both academics and students use YAWL significantly more intensively than practitioners (21.3h and 13.03h per week versus 2.53h per week). This would be explained by their more exploratory usage of the system and active participation to the OSS community around YAWL, in comparison with practitioners who would typically use the system to maintain control over some dedicated business processes.

Another aspect that is in line with our expectations is the experience with the YAWL system. While academics have used YAWL for longer, students are typically involved with the system during a semester or two. This is in the context of the units they are enrolled in where they may model a great number of YAWL processes. However, they rarely continue using the system beyond their university commitments (e.g. through alumni networks). Similarly, since the YAWL system has only been adopted in industry quite recently, only a few practitioners out of those who participated in the experiment have actually used YAWL for more than one year (less than 10%). Most of them are still evaluating to do so or have just started using YAWL.

Table 5: Multi-group analysis results

Criterion variable	Predictor	Group 1 (academics) n = 55	group 2 (students) n = 53	group 3 (practitioners) n = 86	academics vs students	academics vs practitioners	students vs practitioners
ITU		*R^2=0.72*	*R^2=0.68*	*R^2=0.51*			
	PBC	0.53***	0.68***	0.18^{ns}	0.16	**0.01**	**0.00**
	MOT	0.39**	0.21**	0.57***	0.14	0.12	**0.00**
PBC		*R^2=0.42*	*R^2=0.19*	*R^2=0.28*			
	FC	0.65***	0.44***	0.53***	**0.04**	0.15	0.22
MOT		*R^2=0.54*	*R^2=0.50*	*R^2=0.57*			
	FC	0.41**	-0.07^{ns}	0.47***	**0.00**	0.36	**0.00**
	HELP	0.01^{ns}	0.47***	0.48***	**0.00**	**0.00**	0.48
	IMG	0.34**	0.61***	0.27*	**0.04**	0.30	**0.02**

After discussing the descriptive statistics, we turn to the results from our multi-group analysis summarized in Table 5. This data allows us to reason about our hypotheses. Our first set of hypotheses concerned differences in the impact of IMG on MOT. In line with our expectations in H1a and H1b, the data in Table 5 shows that IMG displays the strongest impact on MOT for the student cohort ($\beta = 0.61$, $p < 0.001$), followed by academics ($\beta = 0.34$, $p < 0.01$) and then practitioners ($\beta = 0.27$, $p < 0.05$). The contrast between students to academics as well as practitioners is significant ($\Delta\beta = 0.27$, $p = 0.04$ and $\Delta\beta = 0.34$, $p = 0.02$, respectively), while the difference between academics and practitioners is not significant ($\Delta\beta = 0.07$, $p = 0.30$).

Regarding the role of HELP, we note that the impact on MOT is almost identical between students and practitioners ($\beta = 0.47$ and 0.48, respectively); but for academics the impact is weak and insignificant ($\beta = 0.01$, $p > 0.05$). In turn, these results are not in line with our hypotheses H2a and H2b.

Third, we turn to the role of FC. Regarding its impact on PBC, the data shows that FC displays the strongest impact on PBC for the academic cohort ($\beta = 0.65$, $p < 0.001$), followed by practitioners ($\beta = 0.53$, $p < 0.001$) and then students ($\beta = 0.44$, $p < 0.001$). The results support hypothesis H3a and H3b.

Finally, we examine the role of PBC in relation to MOT. Our data shows that PBC is a stronger predictor of ITU than MOT in the student user cohort ($\beta = 0.68$, $p < 0.001$ and $\beta = 0.21$, $p < 0.01$, respectively), in line with hypothesis H4a. PBC is also a stronger predictor of ITU than MOT in the academic user cohort ($\beta = 0.53$, $p < 0.001$ and $\beta = 0.39$, $p < 0.01$, respectively), although the relative difference is not that stark. This result does not support hypothesis H4b. Finally, for practitioners we see that MOT is the only significant predictor of ITU ($\beta = 0.57$, $p < 0.001$), which is not what we expected in hypothesis H4c.

DISCUSSION

In our data analysis, we examined differences in the relative importance of behavioral factors on the intention to (continue to) use the open-source workflow management system YAWL. Our research model, synthesized from prior literature, received overall strong support from the data and confirmed relationships as expected. More importantly, our subsequent analysis showed a number of significant differences between academic, student and practitioner users; with some of the differences being in line with our expectations, and some uncovered differences being surprising indeed. Table 6 summarizes the findings about our hypotheses.

Table 6: Hypothesis testing results

No	Hypothesis	Support
H1a	The impact of IMG on MOT will be stronger for academics than practitioners	Yes, but not significantly (p = 0.30)
H1b	The impact of IMG on MOT will be stronger for students than academics and by extension it will also be stronger than practitioners	Yes, significantly (p = 0.04 and p = 0.02)
H2a	The impact of HELP on MOT will be stronger for academics than practitioners.	No, directionality reversed
H2b	The impact of HELP on MOT will be stronger for students than practitioners	No, impact almost equal
H3a	The impact of FC on PBC will be stronger for	Yes, but not

	practitioners than students	significantly (p = 0.22)
H3b	The impact of FC on PBC will be stronger for academics than practitioners, and by extension it will be stronger than students.	Yes, partially significantly (p = 0.15 and p = 0.04)
H4a	For students, the impact of PBC on ITU will be stronger than the impact of MOT on ITU	Yes, ($\beta = 0.68$ vs $\beta = 0.21$)
H4b	For academics, the impact of MOT on ITU will be stronger than the impact of PBC on ITU	No, PBC stronger that MOT
H4c	For practitioners, the impact of PBC on ITU will be stronger than the impact of MOT on ITU	No, PBC not significant at all.

Overall, our analysis clearly confirms the cohort-specificity of the open-source workflow management system intention to use decision. We identify a number of key findings: First, we note how, for practitioners, intentions to use the YAWL system were fully determined by intrinsic motivation and not at all by perceived behavioral conditions. This is in stark contrast to the other two cohorts, where perceived behavioral control was a stronger determinant than intrinsic motivation. We interpret this result before the background of the experience practitioners have with YAWL. As shown in Table 4, most of the practitioners who use YAWL are at an early stage, or are still evaluating to do so. This may indicate that perceived behavioral control has not fully developed in these people, since behavioral control perceptions tend to develop with increased longitudinal exposure to a system [44]. Another possible explanation may be derived when considering the background of the different application settings. Practitioners mostly employ the YAWL system to maintain or develop control over the coordination of specific business processes; while academics and students tend to use the system in a more exploratory, research-oriented manner. In exploratory or academic applications settings, therefore, our findings suggest that the perceptions of control over the use of the system are strongly important whereas for ‘pure’ application purposes such control is not that important.

In line with this interpretation, we found that facilitating resource conditions are specifically important to academic users, to assist them in their bids to extend the software and/or to extend the knowledge around the use of the system. Having access to technical expertise and guidance around the details and specifics of the system appears to be important to allow academics to focus on their key work.

Further, we found that the role of perceived provider image was a strong determinant especially for student users of the YAWL system. These findings draw attention to the motivational components that inform how students perceive and behave in relation to technological artifacts created at research institutes. The influence of a positive image conveyed by a research group can have a strong impact on behavioral intentions exerted by student users.

Interestingly, we also found that motivations to help others appear not to be a strong motivational component for academic users of the YAWL system. We can speculate that this cohort decides to use the system not for reasons to assist the community but rather for the individual (selfish) motives of progressing their own research and work. In that regard, it would appear that a research job profile demands more selfishness than other profiles. Students as well as practitioners showed strong interests in contributing to the user community.

Overall, our research draws attention to the question whether our models of technology acceptance and usage behaviors can be applied unequivocally to different user cohorts. Our analysis revealed significant cohort-specific differences across all determinants considered. In turn, these findings provide a note of caution to apply theoretical models to technologies that are being used by user groups with different application purposes and tasks (such as user groups associated with decision-support systems, different user types of hedonistic systems or widespread information systems such as mobile devices and laptop systems).

Implications for Research

We identify several opportunities for future research that can extend the scope of our work. First, our analysis uncovered user group-specific differences in a theoretical model of workflow management system acceptance. Our analysis can yield similar insights into user differences for other theoretical models such as those describing proprietary system acceptance [43] or task performance [13]. Our approach can also be applied to study other differences such as those stemming from cultural backgrounds [25].

Second, our research set out to examine a set of specific antecedents to open-source system acceptance and is by no means considered compete or exhaustive. Further research could examine user differences across other antecedents previously found relevant to OSS usage, such as knowledge gains [22], sense of belonging [34] or fun [20].

Finally, our work calls for further research on theorizing around different types of technology users, and the impacts on behavioral processes and outcomes in interacting with technology that user differences implicate.

Implications for Practice

In addition to the academic merits of this work, we identify several implications for practice, stemming from the specific insights our empirical study provided. We group these implications in three main strategies: i) the provision of open-source system solutions, ii) the user-specific management of workflow management systems, and iii) the further development of the YAWL community specifically. In doing so, we can draw specific suggestions for three important roles: i) the providers of open-source systems, ii) the different user types (especially student and academic users), and iii) university developers of open-source systems.

Implications for the Provision of Open-Source Systems

Our data revealed several interesting findings for providers of open-source system solutions. For example, while we expected a high influence of FC on intrinsic motivation for practitioners (β=0.47), we did not expect to have an equally high influence of HELP on the motivation of practitioners to use the open-source workflow management system we examined (β=0.48). This suggests that providers of open-source systems can potentially increase the uptake of their products in commercial settings if they aliment a practitioner's desire to help others, besides enhancing the system's facilitating conditions. For example, this can be achieved by:

1. Making it easier for users to extend the system, e.g. via well documented code, developer's manuals and wikis (which, in turn, would provide facilitating conditions); but also

2. Providing infrastructure services to engage the community, such as forums for users to help solve each other's issues with the product, and submission systems for users to donate their own code and receive feedback from the community. Such services could increase the ability of users to help each others, in turn also contributing to usage motivations.

Considering the example of YAWL as an OSS workflow management system, we note that it is actually not very easy to help others through code contributions. Typically, the code base is not consistently well commented, and the technical documentation about the system is often not in synch with the actual system implementation (which is in part related to a lack of proper facilitating conditions).

Such situations are especially typical for software developed in university settings, where various research students and academics contribute to the development of the system, instead of having a dedicated team of developers who work on the system over a prolonged period of time. One potential ramification of this situation is to provide resource support for university-based OSS providers, to implement and promote facilitation services complementary to the software development. At present, however, such staffing is often obstructed by financial limitations. Our research can provide some substantive arguments in favor of additional resource provision in order to increase the uptake of research solutions in industry networks.

Implications for the User-Specific Management of Workflow Management Systems

One key finding of our work is the significant differences in control and motivation perceptions of different user groups as they relate to the intention to use an open-source workflow management system.

Considering students as a dedicated user cohort of interest to the workflow management community, we believe that an important implication for practice derives from the noted strong importance of IMG over MOT for students (β=0.61). This finding suggests that by investing in the social image of the provider of a workflow management system, providers can increase acceptance of the product by students. In the case of YAWL, for instance, the development team is a research team, since the product has been developed at a university. Thus, a possible way of elevating the social image of the YAWL team is by actively advertising, through various channels, the impact of the research team, as an indicator of the team's reliability and high quality. For example, the YAWL Foundation web-site could feature a dedicated page for each team member highlighting their main achievements in workflow management research and beyond, besides reporting on the specific contribution that member has brought to the YAWL system. At the moment, the web-site only briefly reports on the individual contributions and provides a link to each member's personal page for further information. This can be further extended to the image of the research group the YAWL team belongs to, and to that of its hosting university and to the network of other research institutions the YAWL team collaborates with.

Considering academics as a second dedicated user cohort of workflow management systems, we found that FC is the strongest antecedent to both PBC and MOT (β=0.65 and β=0.41, respectively). This suggests that enhancing facilitating conditions will strongly contribute to increase academics' intentions to (continue to) use a workflow management system. This finding draws attention to the importance of developing complementary services such as documentation, manuals, training provision and assistance offered to the community of workflow users, especially those within an academic application setting.

Implications for the Development of the YAWL Community

As previously discussed, most OSS solutions – including the YAWL system - suffer from poor facilitating conditions. While this situation tends to be true for most OSS products [22], the situation is exacerbated in the case of YAWL. Similar to other OSS products developed in a research institute where limited funds are available, most funding tends be directed towards advancing its development rather than on enhancing its facilitating conditions. And while for such reasons the provision of a help desk or the availability of dedicated consultancy services would be out of reach, the YAWL community could still be leveraged to enhance other facilitating conditions. There are various ways in which this could be achieved. For example, the host team of YAWL could outsource the maintenance and development of specific sections of the user manual to wider parts of the YAWL community. The community itself could also be stimulated to provide tutorials, illustrative videos and examples, and to manage a user-based wiki around the product. Leveraging a community to assist the wider management of university-led product development has already been demonstrated to yield benefits. The BPM Academic Initiative[2], for example, illustrates how a modeling solution developed at a research institute leverages the wider academic community working with the platform. Notably, the community provides additional content in terms of modeling examples, exercises and tutorials. A similar initiative could be envisaged to further enhance the profile and services of the YAWL community.

In summary, given the scarce availability of funds, the YAWL community with its three different user cohorts, is probably the most important assess for the YAWL team to guarantee the future of this product, both in terms of extending the functionality of the system as well as providing complementary services that boost provider image and facilitating conditions – both of which, as per our study, will result in increased acceptance of the system.

CONCLUSIONS

In this paper we examined a model of open-source workflow management system acceptance across three specific user cohorts, viz., academic users, practitioner users and student users. To the best of our knowledge, this is the first time such a comparative study on open-source system acceptance is carried out over different user cohorts. Our findings attest to significant differences in the perceptions of motivations and behavioral control leading to the intentions to use the open-source system. Thereby, our research provides empirical evidence about behavioral differences among technology user cohorts and can be used to stimulate further theoretical work to circumscribe the characteristics, role and implications of user differences in technology use.

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[2] http://www.signavio.com/en/academic.html

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APPENDIX

Operationalization and Instrumentation of Constructs

Theory Construct	**Reference**	**No**	**Item Definition**
Intention to Continue to Use	Adapted from [5]	ITU1	I intend to continue to use YAWL.
		ITU2	I predict I would continue to use YAWL.
		ITU3	I plan to use YAWL in the future.
		ITU4	I prefer to continue to work with YAWL.
Intrinsic Motivation	Adapted from [49]	MOT1	I find using the YAWL system to be enjoyable.
		MOT2	The actual process of using the YAWL system is pleasant.
		MOT3	I have fun using the YAWL system.
Perceived Behavioral Control	Adapted from [42]	PBC1	I have the knowledge necessary to use the YAWL system.
		PBC2	Given the resources, opportunities and knowledge it takes to use the YAWL system, it would be easy for me to use it.
		PBC3	The YAWL system is not compatible with other IT systems I use (inversely coded).

Theory Construct	Reference	No	Item Definition
Facilitating Conditions	Adapted from [37]	RFC1	Guidance was available to me in the selection of the YAWL system.
		RFC2	Specialized instruction concerning the YAWL system was available to me.
		RFC3	A specific person or group was available for assistance with difficulties with the YAWL system.
Motivation to Help Others	Adapted from [18]	HELP1	Being able to help OSS developers is important to me.
		HELP2	Participating in OSS projects gives me an opportunity to help others.
		HELP3	Helping each other in an OSS community is important to me.
		HELP4	Members of the OSS community do help each other.
Perceived Provider Image	Self-developed on basis of [44]	IMG1	I use the YAWL system because the system provider has more prestige than other workflow system providers.
		IMG2	The people who designed and built the YAWL system have a high profile
		IMG3	The YAWL system is important to the image of my organization.