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A Framework for Researcher Participation in Research Information Management Systems

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Abstract. Ensuring the quality of information is a critical ethical issue for any information system. Research Information Management Systems (RIMSs) need to engage researchers in sharing research information and knowledge, and ensuring its quality. This paper introduces a theoretical framework for researcher participation in RIMSs. The framework is grounded in empirical research and can guide the design of RIMSs by defining typologies of researcher activities in RIMSs, related motivations, levels of participation, and metadata profiles. In addition, the framework defines discipline- and seniority-specific priorities for the researcher's activities and motivations. RIMS managers and scholarly communications librarians can use the framework to assemble RIMS service and metadata profiles that are tailored to the researcher's context. Likewise, the framework can guide the construction of communication messages personalized to the researcher's priorities and her or his motivations for engaging in a specific activity, which will enhance the researcher's engagement with the RIMS.

Keywords: RIMS, Researcher Identity Management, Online Communities

1 Introduction

A position paper by the Online Computer Library Center defines research information management systems (RIMSs) as information systems used to "collect and store metadata on research activities and outputs such as researchers and their affiliations; publications, data sets, and patents; grants and projects; academic service and honors; media reports; and statements of impact" (Bryant et al., 2017, p. 6). Curating research metadata alone, however, may not be as useful to researchers as curating both metadata and the content the metadata represent in an integrated way (Dempsey, 2014; Hey et al., 2009; Palmer, 2013; Take, 2012). Hence, we define RIMSs as types of information systems that manage and provide access to researchers' authored content and identity information and related services (Stvilia, Wu, & Lee, 2018a). Publishers, libraries, universities, search engines, and content aggregators have created many different RIMSs, the scope of which may vary. They can be global (e.g., ResearchGate, Google Scholar, Mendeley), national (e.g., NARCIS, researchmap), statewide (e.g., Florida ExpertNet, REACH NC), disciplinary (e.g., DIRECT2Experts), and institutional (e.g., Scholars@TAMU, Experts@Syracuse, Faculty Expertise and Advancement System at Florida State University). RIMSs are essential for sharing, grouping, linking, aggregating, and retrieving scholarship; evaluating the research productivity and impact of individuals, groups, and institutions; identifying potential collaborators, expertise, and new technologies; and assessing the innovation potential of those technologies. Hence, in addition to supporting scholars' research information management (RIM) needs, RIMSs have many different users and beneficiaries, which may include, but are not limited to, librarians, promotion and tenure committees, journal editors and conference program chairs, administrators, external evaluators, funding agencies, innovation and technology transfer offices, industry technology scouts, and members of the public.

Ensuring the quality of information is a critical ethical issue for any information system (Mason, 1986). RIMSs use different approaches to collecting and curating research information: manual curation by information professionals or users, including the subjects of identity data; automated data mining and curation scripts (aka bots); or some combination of the above. Although data curation by professionals usually produces the highest quality results, it is costly and may not be scalable (Salo, 2009). Algorithmic curation which may include automated harvesting, aggregation, ingestion, mining of research identity information is scalable but may still require human intervention to ensure its quality (e.g., research identity disambiguation and determination). It can be effective for some type of research information (e.g., bibliographic data) but not for the other (e.g., expertise identification). Furthermore, both curation approaches can only curate the research information and knowledge that researchers are willing to share or contribute to, or are made public. RIMSs greatly need to engage researchers in sharing research information and knowledge, and ensuring its quality.

The literature on online communities shows that successful peer-curation communities, those able to attract and retain a sufficient number of participants, can provide scalable knowledge-curation solutions of a quality comparable to that of professionally curated content (Giles, 2005). Hence, the success of online RIMSs may depend on the number of contributors and users they are able to recruit, motivate, and engage in research identity data curation. A significant body of research exists on what makes peer knowledge creation and curation groups and communities successful. Some of the issues and factors that affect the success of peer knowledge curation are peer motivation to contribute, the effectiveness of work articulation and coordination, task routing, and quality control (e.g., Cosley et al, 2006; Nov, 2007; Resnick et al., 2012; Stvilia et al., 2008). Most previous research, however, has focused on encyclopedia, question-answering, and citizen science communities. Little investigation has been done on the peer curation of research identity information.

A need exists for shared how-to or best practice guides, software tools, communication strategies, and message templates that are grounded in that research and that can be used by RIMS curators or scholarly communications librarians to communicate with researchers more effectively and enhance their participation in RIMSs. We developed a framework (Framework) that contributes to addressing these gaps. It is based on an analysis of the literature, activity theory, and interview and survey data collected from more than 400 researchers representing 80 Doctoral Universities with Highest Research Activity in the Carnegie Classification of Institutions of Higher Education (Carnegie Foundation for the Advancement of Teaching, 2014) in the United States (see Table 1). The Framework is an extendable knowledge base that includes models of the relationships among RIMS activities; the extent of RIMS use; motivation scales for RIMS activities; activity-, discipline-, and seniority-specific priorities for the motivations; and RIM metadata and services.. This article presents a unified view of the models conceptualized as a Framework grounded in activity theory (Leontiev, 1978).We also discuss implications of the Framework for practice and directions for future research. Individual models and typologies of the Framework, including the research designs used to develop those models are described in greater detail in a set of companion papers that complement this article (Lee et al., in press; Stvilia et al., 2018a; Stvilia et al., 2018b). The complete data file of the survey is published with open access in the Texas Data Repository (Stvilia et al., 2018c).

TABLE 1. Descriptive statistics of the sample.

No.	Discipline category	Freq	%	No.	Race	Freq	%	No.	Seniority level	Freq	%	No.	Gender	Freq	%
1	Engineering	75	18.2	1	African American	11	2.7	1	Graduate student	73	17.7	1	Female	180	43.7
2	Humanities	42	10.2	2	Asian	94	22.8	2	Postdoc	101	24.5	2	Male	223	54.1
3	Life Sciences	79	19.2	3	Hispanic or Latino	24	5.8	3	Assistant professor	92	22.3	3	Prefer not to answer	9	2.2
4	Physical Sciences	81	19.7	4	Caucasian	244	59.2	4	Associate professor	72	17.5				
5	Social Sciences	135	32.8	5	Other	13	3.2	5	Full professor	74	18				
				6	Prefer not to answer	26	6.3								

Note. Freq = frequency.

2 RIMS Activities

Activities can be defined as basic, nonadditive units of our lives (Leontiev, 1978). Hence, any analysis of researchers' behavior in RIMSs and any identification of the design requirements for RIMS services should begin with an examination of researchers' current RIM practices and uses of RIMSs and the identification of a set of activities enabled or supported by RIMSs. Furthermore, it is important to have a greater understanding of the value structure researchers have for different RIM activities, including knowing what affects their decision to share or not to share their research identity information publicly in a RIMS and to maintain its quality.

According to Engeström (Engestrom, 2009), an *object* in activity theory is a concern or problem that serves as both a generator and motivator of the activity, as well as its center and target. The object of an activity can be shaped by the interplay or interaction among multiple needs and related motivations. Needs are directly related to motivations (Engestrom, 2009; Kaptelinin & Nardi, 2012). Humans may have different needs, and when they act on their needs, those needs become their motivations for engaging in activities. Furthermore, motivations of multiple types can prompt engagement in activities (Kaptelinin, 2005; Nardi, 2005). In addition, a need can be met through the process of performing the activity (i.e., intrinsic motivation; e.g., feeling generous when publicly sharing a data set), through the outcome of the activity (i.e., external motivation; e.g., expecting credit for a data set when sharing it with other researchers), or both (Kraut & Resnick, 2011; e.g., enjoying research while getting paid for it). Moreover, activity motivations can be hierarchical. That is, a motivation can be composed of multiple primary motivations (Nardi, 2005).

Activities are always embedded in, and consequently affected by, their social context, regardless of whether they are individual or collective (Kaptelinin, 2005; Leontiev, 1978). The context of RIM may change in space and time. Different disciplines may have different norms and tools for evaluating the impact of researchers and research content, and consequently may assign different priorities to the motivations for an activity and the RIMS services used in that activity (e.g., providing a RIMS profile and impact metrics; see Stvilia et al. (Stvilia et al., 2018a). Likewise, a researcher's motivational structure for engaging in a RIMS activity may change in time around a specific event. Examples of events that may be relevant to RIM and may trigger or affect researchers' actions in RIMSs are applying for a grant or an award, receiving a patent, publishing a new article, or starting a new research project. Time-related factors affecting researchers'

RIMS behavior also include changes in researchers' career status, such as securing employment or receiving a promotion or tenure. A researcher may stop actively maintaining her or his RIMS profile after securing a job (Wu et al., 2017; see Figure 1).

Indeed, events such as having a new publication can be an impetus for the researcher to share a preprint and related datasets with the community. Whether the researcher completes the activity using a RIMS, however, may depend on the researcher's motivation for engaging in the activity and other components of the activity and its context, such as norms, as well as the usability, persuasiveness, and credibility of the RIMS or the size of its user community (Choi & Stvilia, 2015; Fogg, 2002; Resnick et al., 2012). For example, if the use of RIMSs is not a norm in the researcher's discipline or sharing the preprint provides too little marginal increase in the researcher's preestablished scholarly reputation, the researcher may not complete the activity. To be effective, a RIMS should be able to sense changes in the researcher's context and update its communication and RIM service offerings for the researcher dynamically.

Currently, the Framework includes a taxonomy of 17 tasks grouped into seven activities or task groups. In the survey, we asked participants to select tasks for which they used RIMSs. Specifically, participants were given a close-ended question that included a list of 26 tasks from which to choose. The tasks were identified based on an analysis of responses to the same but open-ended question included in qualitative semi-structured interviews preceding the survey (Stvilia et al., 2018a; Wu et al., 2017). A factor analysis of RIMS tasks identified seven groups (see Figure 2). The Discover Papers group, which included finding papers and obtaining papers and citations, had the highest mean summated selection frequency, whereas the Ask and Answer Questions group had the least mean summated selection frequency. This means that, on average, researchers selected the tasks in the latter group the fewest times.

Applying logistic regression to the factor groups revealed that researchers who used RIMS for tasks from the Promote Research, Discover Papers, Monitor the Literature, or Identify Potential Collaborators groups were more frequent users of RIMSs than were other researchers. Interestingly the same analysis showed a different set of the factor group to be significantly related to a researcher having a public RIMS profile. For example, an increase in the Identify Potential Collaborators or Experts factor score did not increase the odds of a researcher having a RIMS profile (see Figure 2; Stvilia et al., 20018a). This result suggests that some researchers benefit from other researchers sharing their research identity information in RIMS, while not sharing their own research identity information.

The Framework includes relationships specific to the researcher's context, which are currently represented by only two dimensions: researcher discipline and seniority (see Figure 2). Compared with full professors and students, assistant professors and postdocs had higher probabilities of using RIMSs to share and promote their scholarship, including contributing to the maintenance of RIMS profiles. In addition, our analysis showed that humanities researchers tended to use RIMSs for evaluating research less than did researchers from other disciplines. We also found that, in general, humanities researchers used RIMSs significantly less often than did researchers from other disciplines. Furthermore, researchers from engineering had significantly higher odds of having a RIMS profile than did humanities scholars (see Figure 2).

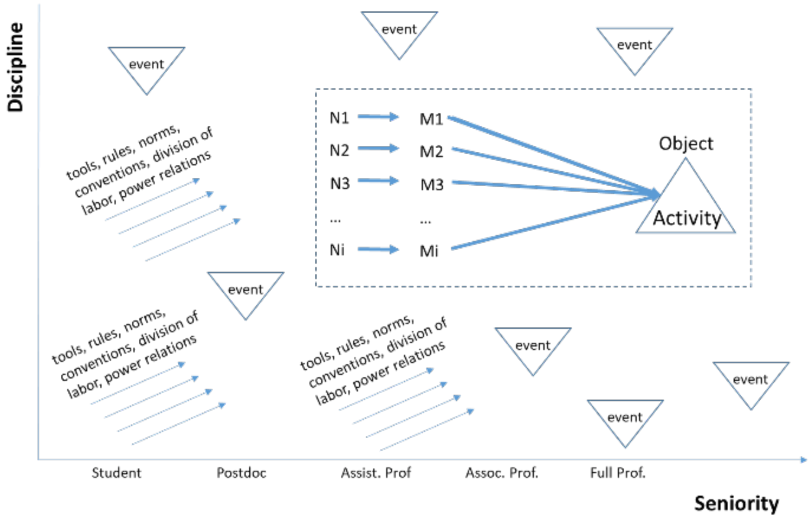

Fig. 1. Conceptualization of motivations underlying a RIMS activity and the dynamics of the context (adapted from Kaptelinin (2005)). N denotes Need; M denotes Motivation.

Our results also showed that early career researchers (i.e., graduate students, postdocs, and assistant professors) were more frequent users of RIMSs than were full and associate professors. In addition, we found that researchers who indicated they used RIMSs for tasks from the Promote Research, Discover Papers, Monitor the Literature, or Identify Potential Collaborators groups were more frequent users of RIMSs than were other researchers. Our findings also showed that an increase in Promote Research, Evaluate Research, or Monitor the Literature scores increased the odds of a researcher having a public RIMS profile (see Figure 2).

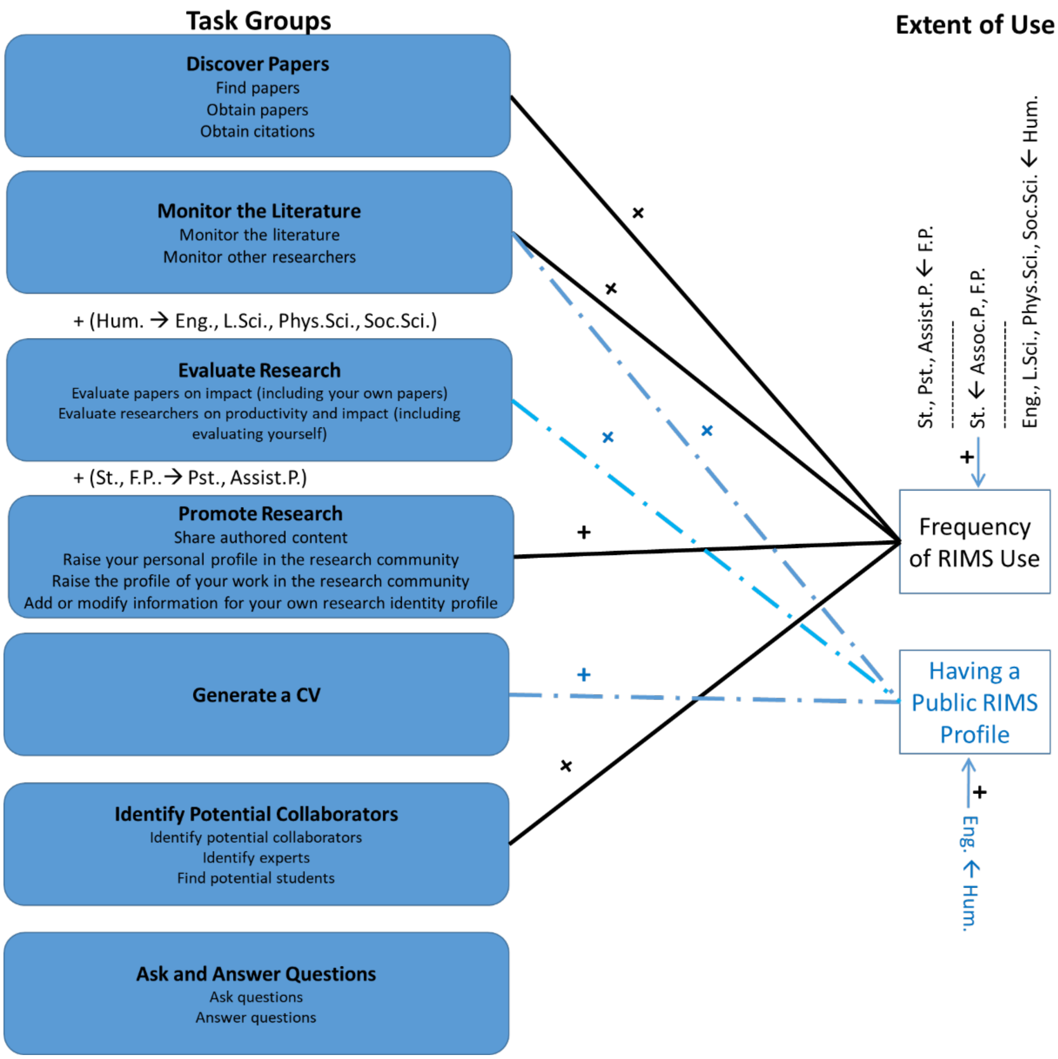

Fig. 2. Relationships among task categories, seniority, discipline, frequency of use, and having a RIMS profile. St. denotes student, Pst. denotes postdoc, Assist.P. denotes assistant professor, Assoc.P. denotes associate professor, and F.P. denotes full professor. Hum. denotes humanities, Soc.Sci. denotes social sciences, Eng. denotes engineering, L.Sci. denotes life sciences, and Phys.Sci. denotes physical sciences. Lines denote statistically significant relationships (adapted from Stvilia et al. (2018a)).

2.1 Implications for RIMS design and management

The taxonomy of tasks for which researchers use RIMSs can help generate a set of requirements for and groupings of the services RIMSs need to provide. Likewise, identifying the groups of tasks linked to frequent use of or interaction with RIMSs can help prioritize services with regard to implementation, support, and marketing to users.

The Framework can shed light on how (i.e., for which tasks) specific RIMS services (e.g., providing RIMS profiles) are used. Future research could enumerate RIMS services and provide mapping schemes among additional services (other than providing a RIMS profile) and the activities they support. These mapping schemes could help identify what services new RIMSs need to implement to enable the same activities. Furthermore, learning about discipline- and seniority-specific differences in completing activities or using specific RIMS components, such as having a public RIMS profile, can help RIMS managers create RIMS service templates that are parameterized for those variables. RIMS managers can use the

Framework to predict the initial parameters of those templates based on the researcher's career status, discipline, or both (see Scenario 1, Figure 2).

> *Scenario 1. John is a newly hired RIMS librarian. He was asked to lead a team of graduate assistants to design a RIMS for the University. He needs to determine what tasks the RIMS should support. Because they cannot implement services for all the tasks immediately, he needs to identify which user tasks should be given priority.*

The relationships among tasks and RIMS services could also be enumerated and used to tailor communication with users to promote higher RIMS use and adoption. Specifically, the identified relationships could be used to assemble communication messages that educate users on how a specific RIMS component or service could be used, including uses that were not intended when the system was designed. For example, the Framework suggests that graduate students are more hesitant to establish and maintain a public RIMS profiles than other early career groups (i.e., postdocs and assistant professors). They might be worried that they are too early in their research careers and may not have enough publications to warrant a public RIMS profile. They might incorrectly assume that the only purpose of a RIMS profile is to share and/or receive credit for their authored content. A scholarly communications librarian can intervene and craft a communication message that addresses these doubts and explains to the members of this group how having public RIMS profiles can benefit them and the community (e.g., not to miss collaboration offers or invitations to serve as a peer reviewer, build reputation as a subject expert by participating in the RIMS's Q&A forums). The librarian can also provide them with a RIMS profile template and a repertoire of RIMS services that are aligned with their current career needs and opportunities.

3 Researcher Participation Levels

The identification of activity roles and user participation levels are essential for designing effective activity centric RIM services and information objects, and managing the complexity of a RIMS' user ecology (Kaptelinin & Nardi, 2012). The Framework defines three levels or types of researcher participation in RIMSs: Readers, Record Managers, and Community Members. The participation typology was developed by using the method of conceptual categorization (Bailey, 1994) and was guided by Preece and Shneiderman's (2009) Reader to Leader framework. Preece and Shneiderman's (2009) framework is based on a literature analysis and distinguishes users' four consecutive levels of participation in online communities progressing from reader, to contributor, to collaborator, and finally to leader. They also summarized factors that motivate those different levels of participation based on the literature. Arazy et al. (2015) studied functional roles in Wikipedia, including the dynamics of role evolution between the community's periphery and the core. They found that Wikipedia's participants often moved directly from the community's periphery to the community's core without going through the intermediate functional roles.

Those classified as Readers might or might not have a profile in a RIMS, but they did not maintain it if they had one and did not contribute to the RIMS. They did not answer other members' questions, and they did not endorse other members for their expertise. Researchers classified as Record Managers maintained profiles in a RIMS but did not contribute to the RIMS beyond that. Finally, those classified as Community Members not only maintained profiles, but also contributed to the RIMS community by answering other members' questions or endorsing other members for their expertise. The findings of the interviews informed the decision of what activities to include in the definitions of the participation levels. Endorsing others for their expertise and answering questions were most frequently performed community-level tasks by researchers (Wu et al., 2017).

We found that graduate students had the greatest share of Readers, whereas assistant professors had the greatest share of Record Managers and postdocs had the greatest share of Community Members. Furthermore, assistant professors had significantly higher odds than did other seniority groups of being Record Managers rather than Readers. Postdocs and assistant professors had significantly higher odds than did the rest of the seniority groups of being Community Members rather than Readers. Likewise, postdocs had a higher probability than did the other seniority categories, except for students, of being Community Members rather than Record Managers (see Figure. 3). Thus, overall, assistant professors and postdocs were more engaged in RIMSs as Record Managers and Community Members than were other seniority groups, and postdocs exhibited higher odds than did assistant professors of being Community Members rather than Record Managers. That is, although assistant professors were more focused on maintaining their RIMS profiles, postdocs were more willing than assistant professors to answer questions or endorse others in addition to maintaining their RIMS profiles (see Figure 3).

Regarding discipline, we found that life scientists exhibited a significantly higher propensity than did engineers of being Community Members rather than Readers. Furthermore, life scientists had significantly higher odds than did physical scientists of being Community Members rather than Record Managers.

Finally, the Framework defines participation level-specific metadata profiles that are grounded in an analysis of metadata use from ResearchGate profiles (Lee et al., in press). The profiles present sets of metadata elements that have significantly higher odds of being used by a specific RIMS participation group than by other groups. The profile of the Readers group has the least number of metadata elements: first name, last name, and department. In contrast, the profile of the Community Members group has the greatest number of metadata elements: photo, first name, last name, affiliation, position, research experience, project, and skills and expertise.

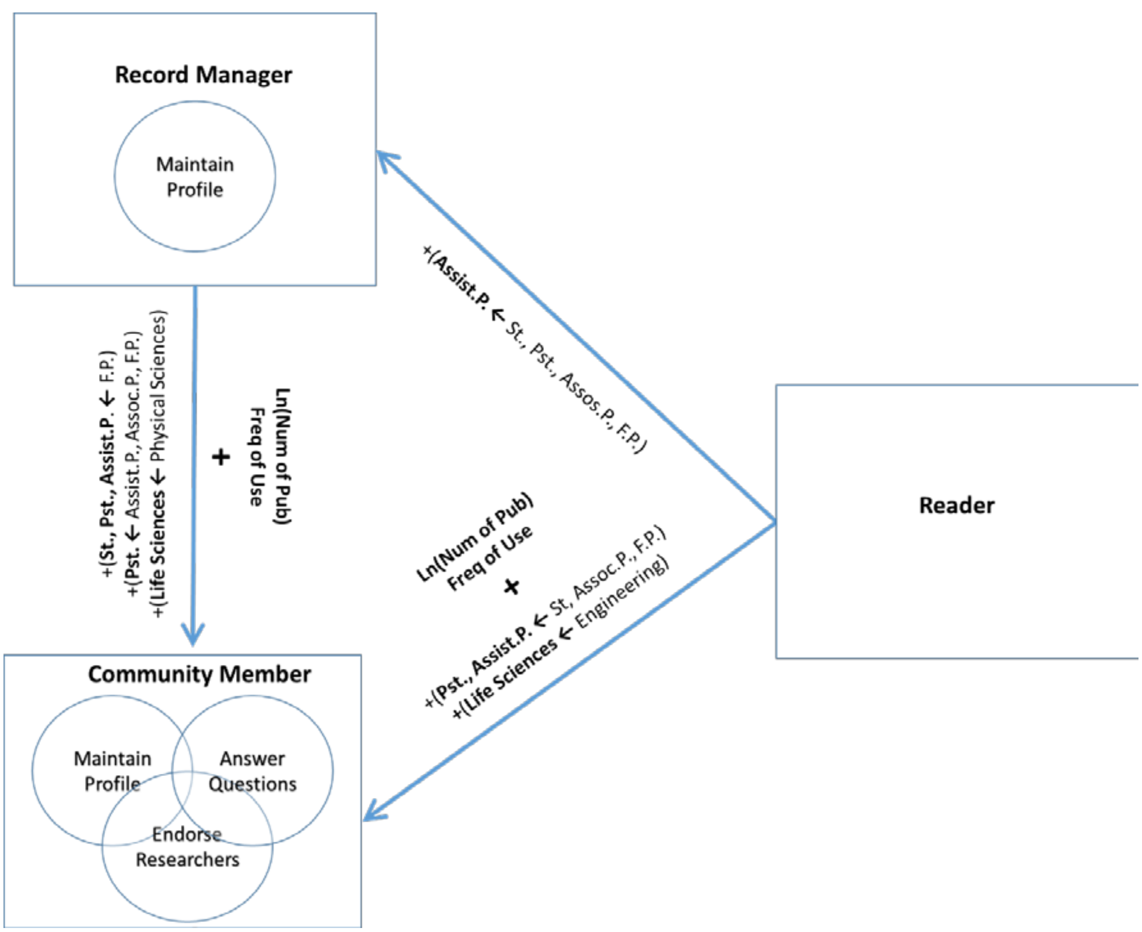

Fig. 3. Relationships among the participation levels. Numbers represent the ranking of a scale relative to the other scales. St. denotes Student; Pst. denotes Postdoc; Assist.P. denotes Assistant Professor; Assoc.P. denotes Associate Professor, and F.P. denotes Full Professor (adapted from Stvilia et al. (2018b)).

3.1 Implications for RIMS design and management

Once the set of metadata elements used by researchers is identified, it can serve as a basis for constructing metadata schemas or vocabularies of researcher identity for new or existing RIMSs. In addition, categorizing researchers into participation levels or categories can help in constructing level-specific RIMS services and metadata templates that are more closely aligned with researchers' metadata needs and priorities (Foster et al., 2004; Stvilia & Gasser, 2008). Alternatively, these participation level-specific metadata templates can be used in machine-learning algorithms to classify researchers automatically into their RIMS participation levels. Likewise, defining the participation categories and their relationships with other researcher characteristics (i.e., frequency of use, discipline, seniority, number of publications) allows RIMS managers to categorize researchers by their participation levels and thus automatically predict their propensity for related activities. Predicting a researcher's participation level can help RIMS librarians or curators craft messages that suggest performing certain tasks associated with her or his participation level, which allows the researcher to connect to those tasks and enhance her or his motivation to perform them.

The Framework defines three general participation types based on theory. These types can be used as an initial set in a "cold start" when little or no information is available on researchers' actual participation in a RIMS. As more information is collected on researchers' activities in the RIMS, a more community-specific participation typology can be generated through automated clustering and by classifying logs of researchers' activities (Dou et al., 2007).

4 Motivation Scales

The Framework defines a set of motivations for three RIMS activities and researchers' priorities for those motivations (Stvilia et al., 2018b). Figure 4 summarizes the motivation scales developed for the three activities. The numbers indicate the ranking of each motivation scale relative to the other motivation scales for that activity. The Framework defines six motivation scales for RIMS profile maintenance. The Share Scholarship motivation scale which combined the items stating a researcher's desire to share her/his authored content was ranked significantly higher than the rest of the scales. The question-answering and endorsement activities both had similar sets of motivation scales and were ranked similarly, although the question-answering activity had one extra scale - External Pressure – which included the motivations induced externally from peer pressure or system prompts. Expertise which included the motivation items linked to the need of feeling competent was the top-rated scale for the question-answering and expertise endorsement activities. In addition, Enjoyment was common for all three activities; and for the question-answering and endorsement activities, it shared the second highest ranking with Build Community Ties. Thus, Expertise, Enjoyment, and Build Community Ties were rated higher than other motivations for the question-answering and endorsement activities. These motivations can be categorized as intrinsic. Self-determination theory postulates that to be intrinsically motivated, a person must feel competent, inherently autonomous, and related to others; and must find the overall activity she or he is performing interesting or pleasant (Ryan & Deci, 2000).

For each activity, in addition to the general rankings for motivations, the Framework defines seniority- and discipline-specific differences in researchers' priorities for their motivations. For instance, for the profile maintenance activity, graduate students, postdocs, and assistant professors rated the Enjoyment motivation scale significantly higher than did full professors. In addition, comparisons of the discipline categories showed that engineering researchers had higher ratings for the Support Evaluation motivation scale than did humanities researchers (Stvilia et al., 2018b; see Figure 4). This scale included the motivations related to researchers' need to maintain the accuracy of their profiles, be discoverable by potential employers and enable the evaluation of their research productivity and impact.

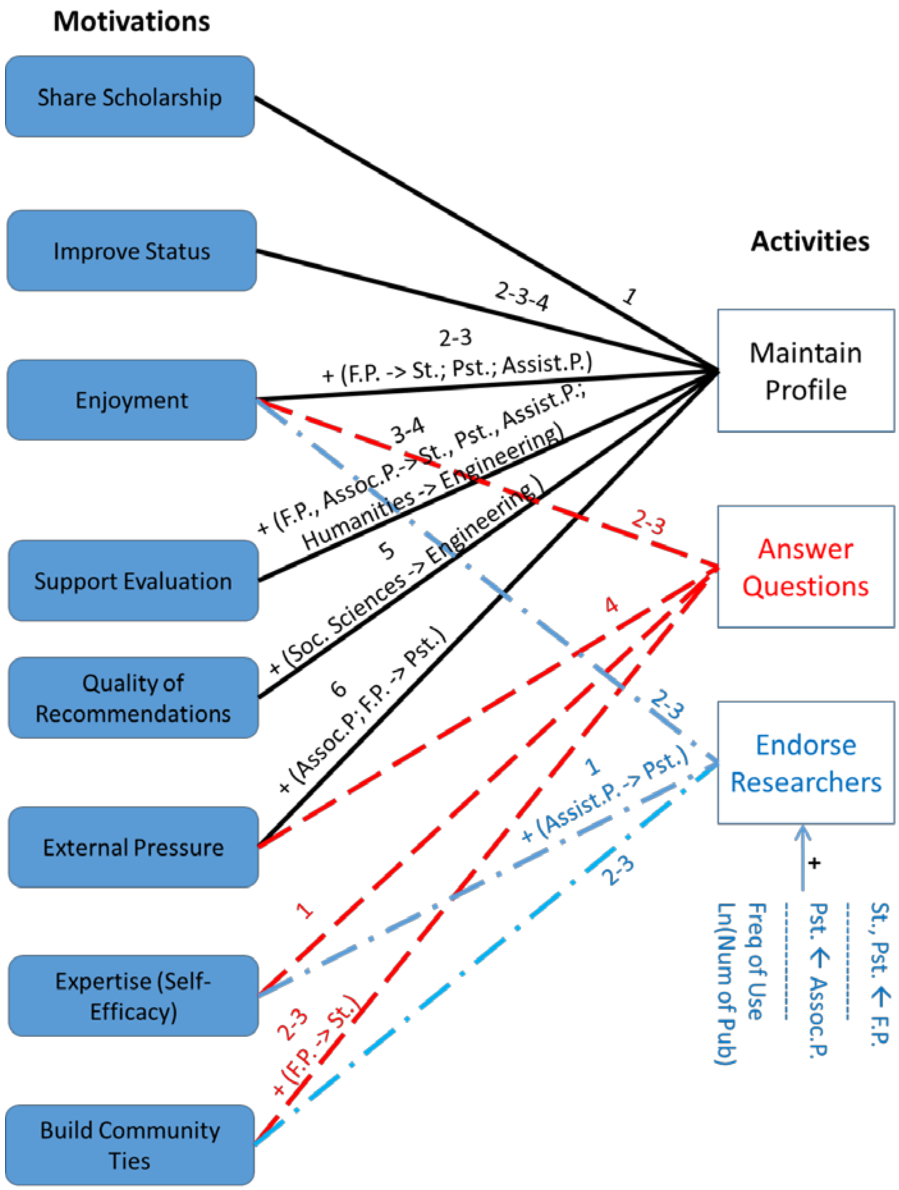

Fig. 4. Relationships among activities, motivation scales, and researcher seniority. Numbers represent the ranking of a scale relative to the other scales. More than one number assigned to a motivation scale (e.g., 2-3-4) means that the scale shares the rankings indicated by these numbers with other scales for the activity. St. denotes Student; Pst. denotes Postdoc; Assist.P. denotes Assistant Professor; Assoc.P. denotes Associate Professor, and F.P. denotes Full Professor (adapted from Stvilia et al. (2018b)).

4.1 Implications for RIMS design and management

Once activity-specific sets of motivations are known, they can be used to guide the design of personalized communication strategies and message templates to increase researchers' participation in RIMSs and the quality of their contributions. Communication strategies can be implemented as sets of association (i.e., If–Then) rules. The If part may specify the condition of the rule, such as the recommended activity or task for the researcher, and the researcher's context, such as the discipline, seniority, extent of RIMS use, trigger event, or number of publications. The Then part of the rule may specify a communication action(s) and the related message templates the RIMS curator can use to engage the researcher in the recommended activity. Furthermore, the activity-specific priorities for motivations from the Framework can be used to define what motivations the content of a message template should connect to and in what order. Specifically, the message template connects to the most important motivations first and the least important motivations last (see Scenario 2, Figure 5). The literature shows that templates are effective in managing complex content-authoring activities (e.g., (Kittur et al., 2011; Stvilia et al., 2008). Likewise, it has been shown that recipients perceive system design and communication messages tailored to their motivations and context as more relevant, and they successfully engage in the activities recommended by such messages (e.g., Kreuter et al., 1999).

Scenario 2. Laura is a Scholarly Communications librarian at University X. She received an alert from Google Scholar that a faculty member, Tina, had published a new article. Laura plans to send an e-mail to Tina congratulating her on her publication, asking her to submit a preprint of the article, and suggesting that she update her profile in the University's IR. Laura wants to craft a message that would be relevant to Tina and enhance her motivation to complete the recommended activity.

As with the other models in the Framework, the motivation typology and models can be further expanded and refined unobtrusively through association rule learning by collecting and mining RIMS logs of researchers' actions and changes in their contexts (e.g., events such as seniority status changes or having new publications). In addition, the rules can be refined by directly requesting feedback from researchers.

5 Conclusion

This article describes a Framework for researcher participation in RIMS. The Framework can guide the design of RIMSs by defining typologies of researcher activities in RIMSs, researchers' motivations related to these activities, their levels of RIMS participation, and their metadata profiles. In addition, the Framework defines researchers' discipline- and seniority-specific priorities for their activities and motivations. RIMS managers and scholarly communications librarians can use the Framework to assemble RIMS service and metadata profiles that are tailored to the researcher's context. Likewise, the Framework can guide the construction of communication messages personalized to the researcher's priorities and motivations for engaging in a specific activity and can enhance the researcher's engagement with the RIMS. In future research stemming from this study, we will extend the Framework by identifying the types of communication interventions or actions that RIMS librarians can take to encourage researchers' participation in RIMSs. In addition, future research will identify activity-specific events that can trigger those actions. These sets of actions and action triggers will be integrated into the existing models and the relationships in the Framework and will be used to design activity-specific communication strategies and message templates.

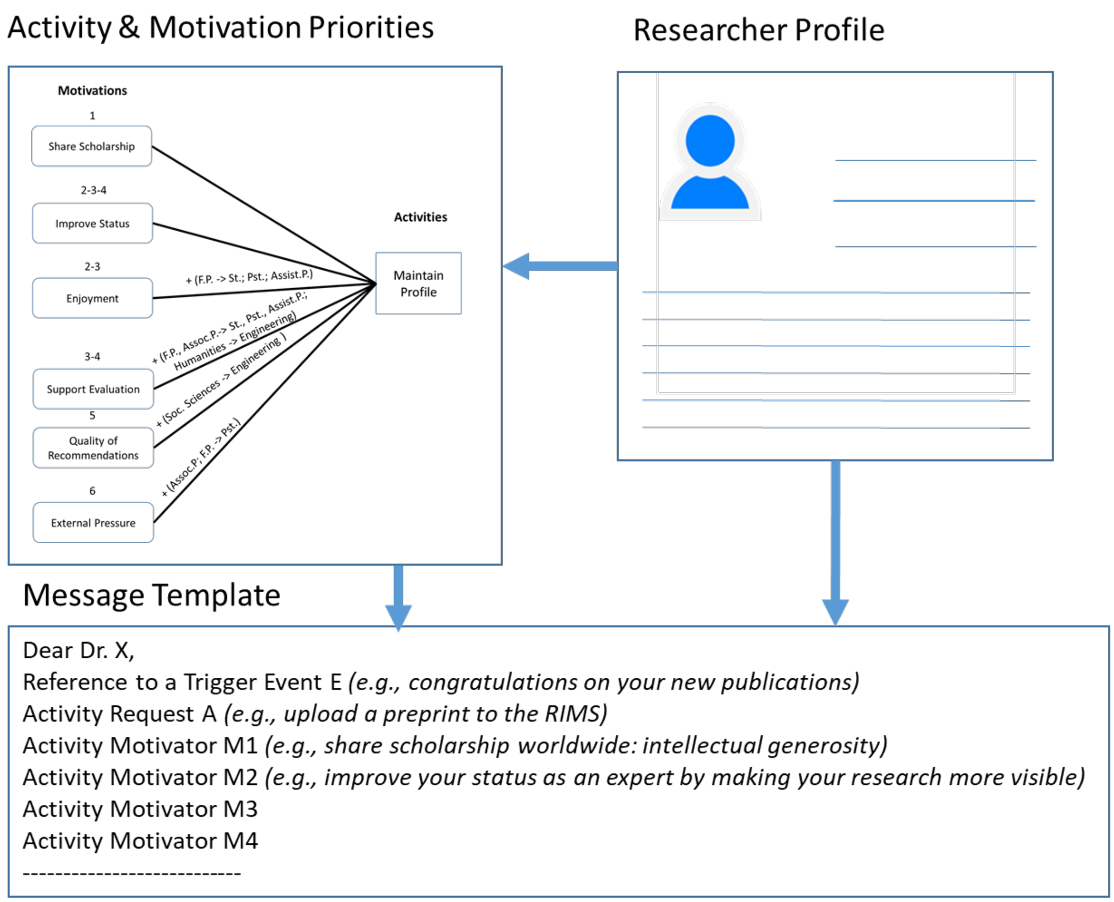

Fig. 5. Message template relationships.

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