What's in a mashup? And why? Studying the perceptions of web-active end users

Nan Zang and Mary Beth Rosson
The Pennsylvania State University
nzz101@psu.edu, mrosson@psu.edu

Abstract

Mashups – web applications that integrate multiple data sources or APIs into one interface – have attracted considerable attention in recent years. The availability of web-based APIs and a growing array of XML data feeds has enabled this novel approach to web applications. However, due to the relatively advanced programming languages needed to integrate the web APIs and data feeds, mashup development still requires considerable programming expertise. In this paper we share the results of an exploratory study of active web users, their perceptions of what mashups could do for them and how they might be created. These users engage in many Internet-based activities but not web programming. Our results show that the technology initiative present in these users is a predictor of the value they see in mashups and the types of mashups they are interested in creating. While they may lack the programming skills, the users do see benefit in the use and creation of mashups as a tool for sharing and integrating information, as well as a means of effectively searching for information.

1. Introduction

In recent years there has been an increasing trend of online services opening their systems to outside use through the implementation of public APIs (application programming interfaces). According to ProgrammableWeb, a web site that tracks a variety of web services, the number of available APIs is growing at over 30 a month [6]. This movement has promoted the development of web applications that integrate across services, popularly known as mashups.

A *mashup* is an application that combines data, either through APIs or other sources, into a single integrated user experience. For example, one could combine weather data with a map by integrating a geospatially-indexed temperature feed with the Google Maps interface. This concept of combining data is not new, but the rapidly expanding number of APIs and data feeds means that, increasingly, users with the right programming skills have the opportunity to quickly develop novel web applications. Unfortunately, the complexities involved in mashup programming are a barrier for many users who might otherwise want to take advantage of these technologies [13].

For many years EUP researchers have studied mechanisms that would allow end-user programmers – people who may write code but are not professional programmers – to use programming techniques as a part of accomplishing tasks [5]. Recently this stream of work has begun to investigate mashup development as a topic for EUP [3, 12]. No piece of software is suitable for every need of every end user, so customizations are often needed for end users to complete their tasks. One view of mashups is as customizations of web-accessible data, thus a form of web-based EUP.

Past EUP research into web development has analyzed the goals and skills of end users who create web sites, and has even gone further to support database interaction through a direct manipulation interface [7]. However, while these experimental tools may enable nonprogrammers to create some web applications, the expertise needed to create a mashup is significant: not only does the developer need to create a user interface, but also identify, analyze, aggregate and manipulate the underlying data. In most cases, these activities still require advanced web technology skills.

While several research studies have worked towards developing tools to support mashup creation, few have examined the needs of the less programming savvy end user. Two tools that have shown considerable promise are Marmite [12] and MashMaker [3]. However, each has its own issues once put into the hands of an end-user.

The present research is aimed at better understanding the requirements for end user mashup tools. The APIs and emerging tools present an opportunity, but is this an opportunity end users will want to exploit? Studies have shown that sophisticated end users can envision and design simple data-oriented interactive web applications [10]; can they also envision and design useful interactions with data and services from a mix of

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mix of sources? We used an exploratory survey to study these issues, hoping to characterize potential end user mashup developers as well as their interests and ideas related to mashup applications. The work was guided by several exploratory research questions:

- *How can we characterize end users who use the web in an active way but are not programmers?*
- *How do such users think about mashups, in terms of costs, benefits, and future behavior?*
- *What user characteristics predict possible future creation of mashups?*
- *Given current interests and web behaviors, what mashup topics do end users envision?*

More generally we aim to provide an initial view of the concepts and expectations that nonprogrammers bring to their understanding of mashups. We hope that our results will be useful to designer of web mashup tools attractive and suitable for end users, as well as the data feeds and web services that they integrate.

2. Survey methods

The survey used for this study was adapted from a previous study of experienced programmers and expert mashup creators; a complete version is available at http://berniezang.com/vlhcc/survey.pdf. A large portion of the survey pertained to general usage of the Internet. We asked participants about the types of content they interact with online, types of content they create online, and more specifically why they create content online. We also asked them to rate their experience with different web technologies and programming languages (e.g. databases, PHP, XML).

Regarding mashups, we assumed that few participants would have had exposure to them, and concentrated on introducing the concept and probing their initial understanding. We did this by describing mashups abstractly, then illustrating the idea with examples. Following this introduction of the concept, we probed participants' expectations about the difficulty of mashup creation, as well as the benefits mashups could offer. Also, to gauge more technical understandings of mashups, we asked participants to describe the procedural steps needed to create a mashup. Next, we asked them to brainstorm the types of mashups that they would create if they could. Finally, participants were surveyed for some general demographics.

2.1. Recruitment

The participants for this survey were recruited by invitations sent out through course email lists; thus most participants were students at Penn State University. Faculty members were initially approached and asked to distribute a recruitment email to their students. In a few cases, the invitation was distributed more widely, such that a small number of faculty and staff also completed the survey. We focused our recruitment on disciplines with limited or no programming requirements in their curriculum. Interested students were invited to complete our survey through the SurveyMonkey online data collection system.

The survey was not designed to control for any qualifying variables and we did not offer any incentive. Thus, as for most survey studies our results reflect some degree of self-selection. In this instance, however, we argue that it works in our favor, as we were interested in surveying individuals who have an intrinsic interest in advanced web technology, and these are just the ones most likely to respond to our invitation.

3. A profile of web-active end users

When the survey concluded, we had gathered 259 responses. As is typical in survey data, the sample size (N) for any given question varies, as some individuals skipped questions or failed to complete the survey. For example some respondents simply ignored the open-ended probes that often followed rating scales and other simple responses. Moreover, a subsection of the survey was only completed by participants who had previous experience with APIs. To simplify the results reported here, we use percentages with the corresponding N ranging from 14 to 259.

Table 1: General demographics

Characteristic	Distribution
Gender (N=225)	Male : 60.9% Female : 39.1%
Age (N=225)	18-21 : 74.2% 21-25 : 20% > 25 : 5.7%
Education (N=202)	Some College : 84.2% Associates Deg : 3.0% College : 10.4% Masters : 2.5%
Discipline (N=176)	IST : 50.6% Communication : 29.5% Business : 7.4% Humanities : 7.4% Science & Eng : 5.1%

3.1. General demographics

As summarized in Table 1, our participants included 60.9% male and 39.1% female, with 94.2% between the ages of 18 and 21. All had completed some college, with 2.5% holding advanced degrees. As the Discipline summary indicates, we attracted a broad

sample of disciplinary background, although the largest proportion came from requests to students in our own college (IST is an interdisciplinary program that includes information technology experience but without a focus on programming or software development).

3.2. Technology use and expertise

With respect to general experiences using computers, the majority of the respondents (72%) have used computers for more than 10 years; 76% report that they spend over 15 hours a week doing computer-related tasks and 32.3% spend more than 30 hours. Most of them (84%) work in a Microsoft Windows operating system. With respect to other digital technology, all but one respondent reported owning a cell phone, 93% a digital music player, and 80% a digital camera. More specialized devices were less common, with 41% owning a webcam and 19% a PDA.

When asked to rate their computer expertise on a 5-point Likert scale, a majority (62.2%) rated themselves a 4 or higher; the average rating was 3.83. While many participants reported having taken formal classes on programming (63.4%), the majority (79.6%) consider themselves non-programmers. This is consistent with the disciplinary profile reported earlier; IST students take 1-2 courses that involve programming, but do not become expert programmers.

Table 2: Technology experience

Technology	Mean (Std. Dev.)
HTML (N=135)	3.66 (1.23)
Java (N=135)	2.76 (1.35)
Database (N=134)	2.63 (1.22)
C++ (N=135)	2.59 (1.33)
Streaming Media (N=134)	2.54 (1.32)
CSS (N=131)	2.33 (1.50)
Adobe Flash (N=134)	2.25 (1.19)
Javascript (N=134)	2.21 (1.11)
XML (N=135)	2.10 (1.15)
PHP (N=132)	1.99 (1.18)
ASP (N=133)	1.49 (0.92)
C# (N=132)	1.42 (0.95)
RSS (N=133)	1.42 (0.87)
Perl (N=134)	1.29 (0.80)
Adobe Flex (N=134)	1.28 (0.80)
ColdFusion (N=134)	1.27 (0.81)
Python (N=134)	1.16 (0.65)
Ruby on Rails (N=134)	1.11 (0.57)
Django (N=132)	1.08 (0.45)

Note: 1= No experience, 5=Great deal of experience

To specifically assess skills with advanced web technologies, we asked each participant to rate his/her experience with a broad range of web programming languages and online media, using a 5-point scale from 1=No experience to 5=Great deal of experience. These findings are summarized in Table 2. As we expected, with the exception of HTML, experience with these technologies was on the low end.

A small group of participants (N=17) reported that they have developed web-based applications using APIs. Not surprisingly this group reports a higher average level of computer expertise level (4.56 versus the overall mean of 3.83); over 90% have had formal programming training. Interestingly, only 7 of these 17 "expert" web developers call themselves programmers, suggesting that web development – even when APIs are used – may not be acknowledged as "real" programming by end users.

3.3. Technology initiative

As a complement to self-reports of technology expertise and familiarity, we wanted to explore the more psychological trait of curiosity, or what we term Technology Initiative. Prior studies suggest that in novel EUP contexts, people's intrinsic motivation to explore and learn new ideas may be a very important predictor of success [9,11]. Thus we expected that some measure of initiative would help us to understand who may be most likely to experiment with mashups.

Table 3. Items assessing technology initiative

Survey item	Mean (Std. Dev.)
Out of my friends I am one of the first to adopt a new technology or gadget.	3.16 (1.29)
I actively search for new and interesting websites to visit.	3.11 (1.25)
My friends and co-workers come to me for help with computer- and technology-related questions.	3.36 (1.36)

Note: 1=Not accurate, 5=Very Accurate

To assess this, we developed three 5-point scales (Table 3). Although responses centered on the average rating, the sample had good variability, suggesting that the scales were tapping into self-perceived individual tendencies. Inter-item analysis revealed good internal reliability (Cronbach's alpha was 0.77), so we averaged the three items to create a single Technology Initiative index that ranged from 1.0 to 5.0, with an average of 3.21 and standard deviation of 1.07.

3.4. Online activities

To get a sense of participants' everyday computing activity context, we asked them to estimate how often they used different types of web services on a scale of 1 to 4, where 1=Never and 4=Daily. As summarized in Table 4, respondents reported relatively frequent use of social networking services (e.g., Facebook, MySpace), but more limited use of other socially-oriented web activities like tagging (e.g., Del.icio.us).

Table 4: Frequency of Online Activities

Online Activity	Mean (Std. Dev.)
Social Networking (N=258)	3.63 (0.74)
Video (N=257)	3.05 (0.71)
Online Maps (N=257)	2.53 (0.63)
Shopping (N=258)	2.39 (0.66)
Photography (N=258)	2.15 (0.87)
Travel (N=254)	1.78 (0.55)
Social Bookmarking (N=256)	1.32 (0.67)

Note: 1=Never, 4=Daily

To probe users' online creating and sharing, we asked them to estimate how often they performed certain activities. Many of the respondents share their self-creations on at least a weekly basis (30.6%). A majority of them have created their own website (69%) and 45.6% have their own online journal or weblog.

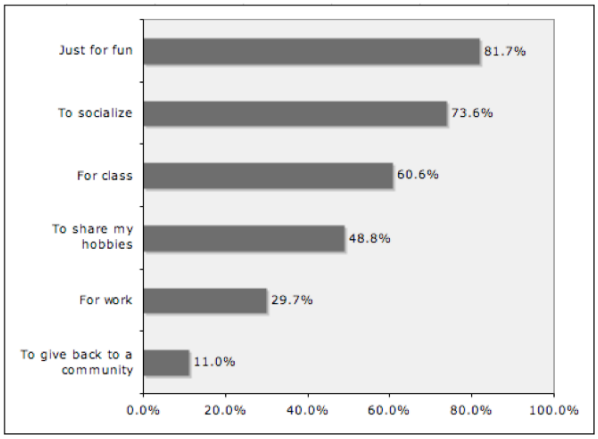

Figure 1. Reasons to create web (N=246)

When asked why they create content online, many respondents chose "Just for fun" or "To socialize" (Figure 1); many also create web content for class. Interestingly, almost half create online content to share hobbies. A survey by the Pew Research group shows that in 2007, 83% of Internet users have used the Internet to find information about their hobbies [4]; an increase from 77% in 2004. Our data echo this trend.

In summary, the activity profiles are just what we expected from this university setting, and reflect a population of "web-active end users". They use the web in a variety of ways and for a variety of purposes, but in general do not consider themselves to be experts in web development or programming more generally.

4. To mashup or not to mashup?

As documented in the previous section, few if any of the survey respondents were mashup developers (we did not ask this question specifically, but only 14 respondents agreed that they were familiar with the term and of those, only 7 provided a meaningful definition). But recall that for our research questions, this can be viewed as a success, as our primary interest is in *prospective* users of *future* mashup tools, i.e., if and when such tools are usable by end users.

Our research goal required us to probe end users' initial expectations about mashups, but this meant that they needed a basic introduction to the concept. We provided this as an explanation: "*Mashups are web applications that combine information or data from two or more sources into one interface. For example, plotting the top 25 best companies to work for onto a map is considered a mashup (Figure 1). Another example could be cross referencing CNN news feeds with Wikipedia (Figure 2).*" Accompanying this brief explanation were two examples that made the concept more concrete (see Figure 2). Our hope was that for these generally web-savvy users, this brief introduction would be enough to activate an initial understanding of mashups that we could then investigate with a set of mashup-specific questions.

4.1. Perceptions of difficulty and usefulness

We used two 5-point Likert scales to gather users' beliefs concerning the Difficulty of creating mashups on the one hand, and mashup Usefulness on the other. Thus on one scale, participants rated "How difficult do you think it would be to create the mashup (in Figure 2)?" A second scale asked, "How useful do you believe mashups are?" Because these users had been given only a modest introduction to mashups, we expected that their responses would be representative of other "novice" web-active end users.

In general, Difficulty ratings were slightly lower than their ratings of Usefulness (3.34 versus 3.14, $t(214)=2.12$, $p<.05$). However, it is difficult to interpret this side-by-side comparison because we do not know how end users "scale" their judgments of usefulness and difficulty, especially for a very novel technology like this. Nonetheless, it was interesting to note that

Figure 2. Examples of mashups provided as part of introducing concept in the survey

end users' concerns about the difficulty of using this novel web technology were modest: 41% chose a response at the midpoint or lower on the scale.

When we examined users' ratings as a function of the demographic and online activity measures summarized earlier, we found a relationship between Difficulty and Gender, with women judging mashup creation to be more difficult than men (3.38 for women; 3.04 for men, $t(219)=2.60$, $p<.01$). This relationship held even when self-reports of computer expertise were used as a covariate. In contrast, ratings of Usefulness were not related to demographic or online activities variables.

The gender effect on predicted difficulty of mashup creation is consistent with other reports of gender differences in EUP. Several studies have shown that women report lower self-efficacy for spreadsheet debugging and that this seems to inhibit their use of novel features [1]. Another study found that women had less confidence in their success on a web development project [10]. These researchers have theorized that males may be more likely to overestimate their ability to solve new problems, and that this may be one source of the differences in confidence and self-efficacy.

In addition to the rating scales, the survey included open-ended probes about Difficulty and Usefulness. After asking for a Difficulty rating, we asked users to make their best guess as to the steps required to create the second example (integrating CNN with Wikipedia). We received 171 responses, and coded each on a scale from 0-3 for accuracy. The coding was derived from a baseline model of the steps needed to create a mashup: data collection, data manipulation, interface building. Answers received 1 point for each aspect; for example, "Design an interface […] and program feeds into the interface" was coded as 2. Responses not mentioning any of these steps were assigned a score of 0.

Initially we thought that knowledge of how to create a mashup might make the process seem less intimidating and lead to lower Difficulty ratings. However we found no relation at all between ability to specify mashup creation steps and Difficulty. We speculate that there may be competing tendencies contributing to this lack of a trend: it may be that users who either know very little or who know quite a bit about mashups choose higher Difficulty ratings, because they are clueless or because they know how complex it is.

We also probed users' expectations about mashup Usefulness in more depth, asking them to describe the benefits they could see from creating mashups. The 182 responses were quite diverse, ranging from denials of any benefit ("I don't think I would have any big benefit"), to benefits that mentioned impacts on search, web browsing efficiency, data integration, creativity and discovery, visualization, and simply having a new skill. Some explanations proposed multiple benefits, and we found a positive correlation between the number of benefits listed and Usefulness ratings ($r=.28$, $p<.001$). Thus in contrast to the exploration of Difficulty, it seems Usefulness ratings may be tied to users' ability to articulate why these applications might help.

4.2. Exploring cost-benefit tradeoffs

One reason we were interested in perceptions of Difficulty and Usefulness was that we would expect these beliefs to predict future interest in developing end user mashups. For instance, imagine a hypothetical situation where an end user has the chance to use a mashup creation tool. Drawing from Blackwell's discussions of attention investment [2], his/her decision about whether to try the tool might be a function of current beliefs about the benefits that would accrue versus the costs required to learn about the new tool.

To explore this cost-benefit relationship, we need an estimate of how likely each end user is to use mashup tools once they are available and accessible. Thus as part of the same subset of questions probing Difficulty and Usefulness we asked: "If you had the skills and experience necessary to build something similar to the

examples above, how often would you do it?" We used a 4-point rating scale corresponding to Never, Rarely, Weekly, and Daily. We hoped to use this Mashup Frequency scale to gain insight into users' future intentions: after seeing the examples and thinking about difficulty and usefulness, to what extent could they see themselves creating mashups in the future?

Table 5. Difficulty and Usefulness by Estimates of Mashup Frequency

	Never N=38	Rarely N=148	Weekly N=30
Difficulty	3.29	3.10	3.17
Usefulness	2.74	3.37	3.97

As seen in the header of Table 5, the most common response was "Rarely", with some distribution on either side of this choice (just one respondent chose "Daily", so we eliminated this end of the scale). Also in the table are corresponding mean values for Difficulty and Usefulness. The pattern suggests that users' interest in mashups is a function of Usefulness but not Difficulty. Correlation analysis confirmed a positive relationship of Usefulness and Mashup Frequency ($r=.36$; $p<.001$); there was no relation with Difficulty.

These results suggest that at least for these users, expectations about future mashup activity is determined by beliefs about usefulness (benefits) of the technology but not on the expected difficulty of creating them (cost). To some extent this may be due to our framing of the question (we told them to assume they had the skills to create a mashup). However it may also be that for novel end-user programming opportunities (e.g., cases in which relevant mental models are virtually nonexistent), it may be so difficult to estimate costs that beliefs about benefits become the main driver. We return to this possibility later when reviewing some of the more qualitative results and again when considering implications of our findings.

4.3. Predicting mashup activity

Although few end users currently create mashups, the emergence and refinement of tools like Yahoo! Pipes or Microsoft PopFly may soon make it possible for nonprogrammers to participate in such activities. Thus another goal of our survey was to identify subgroups within a broad population of active web users that might be most likely to be future users of such tools. We assume that EUP tool designers want to create mashup tools that appeal to the right people at the right time, so as to maximize uptake and impact.

To investigate this question, we developed a more expanded analysis of the factors that predict Mashup Frequency. Table 6 summarizes the variables we examined in this process. For example, we were interested in Gender because it has been known to predict aspects of end user programming; the same is true for Computer Experience [1, 8].

Table 6. Variables Examined as Predictors of Mashup Frequency

Variable	Definition	Summary
Gender	Male or Female	Males, N=137 Females, N=88
Computer Experience	Sum of four normalized scales (α=.76)	Mean: -0.018 SD: 3.05
Technology Initiative	Average of three 5-point scales (α=.77)	Mean: 3.21 SD: 1.07
Advanced Media	Uses video camera, web cam, Blackberry	Mean: 1.41 SD: 1.18
Web 2.0	Uses online maps, photo, and video services	Mean: 2.26 SD: 0.51
Hobbies Online	Post online content for hobbies (Y/N)	Yes, N=120 No, N=126

Another potential predictor is end users' curiosity about technology, summarized earlier as the Technology Initiative index. Finally, we wondered if online activity context might predict interest in mashups. We included a number of questions assessing different aspects of online behavior, including an inventory of specific technology use (Advanced Media) and a sum of three online activities that we classified as Web 2.0. Given the recent Pew study suggesting that hobbies are a major motivation for Internet use, we also included a variable representing this behavior (Hobbies Online).

Not surprisingly, many of these candidate predictor variables are inter-related. For instance, men rate themselves more highly than women in both Computer Experience ($t(223)=7.09$, $p<.001$) and Technology Initiative ($t(222)=7.12$, $p<.001$). Thus we used stepwise multiple regression to distinguish among the predictive power of different variables, with Mashup Frequency as the single dependent measure (in a stepwise solution, variables are added to the regression equation in an order that corresponds to the strength of their association, and only when they add significant predictive power beyond the variables already in the model). We also included Usefulness, because our earlier analysis had shown it to be a strong predictor.

The stepwise regression produced a model with three predictors: Usefulness ($p<.001$), Hobbies Online ($p<.01$), and Technology Initiative ($p<.05$). The overall model was significant with $F(3,209)=15.69$, $p<.001$, and accounted for 18.4% of the variance. We found it particularly interesting that neither Gender nor Computer Experience played a role in predicted Mashup Frequency, although at the same time we must keep in

mind that Difficulty judgments were strongly related to Gender.

5. What might end users mash up?

Researchers developing end user mashup tools should know not only who is most likely to experiment with these tools, but also what they might want to create, so that the defaults and supporting resources can be tuned to better serve these needs. As part of asking users to reflect on mashup difficulty and usefulness, we also asked them to brainstorm a list of mashup ideas. We had two goals for this: we were seeking user-accessible mashup concepts that we could use as part of a follow-up set of focus groups. However with respect to the current analysis, we wanted to understand the types of projects that "novice mashup developers" might come up with and pursue.

116 respondents completed the open-ended question asking for mashup examples, generating a total of 134 ideas; 25 of the respondents simply indicated that they had no ideas or were not sure how to respond. We coded each response according to the type of idea(s) it mentioned, providing as many codes as the person mentioned ideas. Thus some of the frequency data summarized in Figure 3 reflect multiple codes for the same individual.

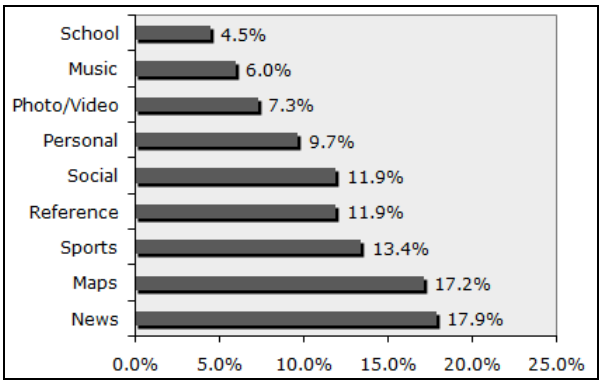

Figure 3. Frequency of Idea Types (N=116)

Most of the codes listed in the figure are self-explanatory, reflecting the nature of the data that the user was imagining. The codes Personal, Social and Reference are a combination of different ideas: Personal was used to identify mashups tailored for individual use; Social was used to categorize mashups involving social activities (especially Facebook); and Reference was used to code mashups involving static data, such as dictionaries and encyclopedias.

The Maps and News categories were the most popular types, perhaps because the two examples offered in the survey illustrated both. The Social and Personal types may be explained by the increasing use of the Internet to manage many aspects of one's personal life; the media-related examples may have been inspired by interaction with websites like YouTube and Flickr. However we were quite interested to see the relatively high number of Sports examples, making us wonder if sports data services could be an attractor for end users who might not otherwise consider using mashup tools.

As one final analysis, we explored the relation of mashup ideas to other characteristics of end users. For example, do people who are high in Technology Initiative, or Online Hobbies envision different mashup activities? To explore these questions, we used a median split to group individuals into high or low Technology Initiative (Online Hobbies was already dichotomous). We then collapsed the types from Figure 3 into four groups: Hobbies (Sports or Music), People (Social or Personal), Media (Photos/Videos or News), and Data (Maps or School or Reference). When we examined the cross-tabulation of the two grouping variables with mashup categories, we found no patterns for the Online Hobbies variable. However there did seem to be some evidence of contrast between high and low Technology Initiative participants, as depicted in Figure 4.

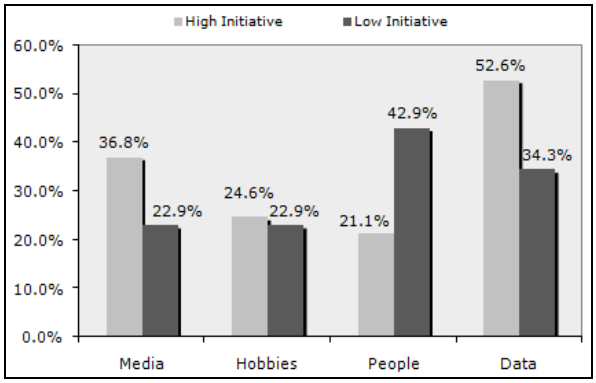

Figure 4. Mashup Ideas by High-Low Technology Initiative (N=116)

We observed a marginal trend for Data-related ideas to be presented more often by the High initiative group (χ^2=2.94, p<.10); there was a complementary pattern for the Low initiative group to suggest People-related ideas (χ^2=4.97, p<.05). As this is an exploratory study, we should not over-interpret these patterns, but it does seem believable that users with lower Technology Initiative may draw ideas from the "familiar" activities of managing social relations or personal information. At the same time, this suggests that helping users to access and integrate personal data feeds may be an effective approach for reaching out to these individuals.

6. Summary and Implications

A "web-active end user" is one who engages in many Internet activities, but lacks programming expertise. When these users consider the prospect of creating their own mashups, beliefs about mashup usefulness are more important than the expected difficulty of creating them. Furthermore the extent to which they know *how* to create a mashup is not related to their ratings of mashup creation difficulty. This suggests that end users may not know enough about mashups to make good predictions of difficulty. We speculate that this may be true in any unfamiliar technology domain, and that personal interest or perceived utility will be the drivers of initial decisions about whether to experiment with the new opportunities. The predictive power of Technology Initiative reinforces this interpretation, though future work is needed to consider whether it generalizes to other novel EUP tools.

We also found that sharing hobbies online may predict end users' future mashup activity. As the trend for Internet users to look online for hobby information continues to grow, the possibility of supporting end-users in hobby-related mashups seems quite promising. It may be that if we can provide sufficient support for interesting data feeds and usable tools, that even individuals who are not "technology curious" will be begin to pursue their hobbies via mashups.

The observation that female users expect mashing up to be more difficult than males is consistent with other studies of gender effects in EUP. Unfortunately, the self-perceptions that promote these differences may also inhibit women from exploring new EUP technologies like mashups. Given the relation of hobby activities to likely mashup use, perhaps one direction for future work is to create data feeds and services that specifically support women's hobbies and interests.

When end users brainstorm possible mashup ideas, many propose ideas are map- or news-oriented. It is possible this was a result of our introductory examples or that these are the most common. However, sports mashups were also mentioned frequently, suggesting another interesting problem domain to pursue. Finally when we consider end users' ideas through the lens of technology initiative, we see that those with less initiative seem to prefer mashups related to people, while those higher in initiative prefer more complex and media-rich mashups. It may be that two different sets of tools should be designed to support these two implicit sub-populations of end users.

In future work, we plan to probe end users' mental models and mashup concepts in more detail, using a combination of think-aloud and interview procedures. Using the current analysis as a starting point, we will attempt to identify possible participants who represent different subgroups within the active web user population, and introduce them to a basic mashup building task. We hope that by encouraging these novice end users to explore a task involving data integration, we will be able to discover how nonprogrammers might actually approach a mashup task. We expect that the rich qualitative data we will further inspire and guide developers of end-user mashup tools.

7. Acknowledgements

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