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Abstract Location-enabled online tools and/or services (i.e. Google Earth/Maps, Flickr, Facebook check-ins, etc.) have been widely used for distributing and processing geospatial-related data. They attract diverse users to consume and contribute geographic information (GI) in many different forms. This study examines college students' consumption and contribution of GI through these tools and/or services as well as their perception of risk and privacy. It evaluates the impact of Geographic information systems (GIS) and geography knowledge on the related behavior and perception. Through conducting a survey, it was found that college students' consumption frequency of GI through the investigated tools and services is positively related to their knowledge in GIS and geography, but their GI contribution is not related. GIS knowledge was found to help raise students' awareness level of risk. However, this relationship does not translate into students' concern about potential privacy disclosure or their willingness to share personal location information through using location-enabled online tools and/or services. Discussions on the gap between students' consumption and contribution of GI through the tools and/or services are shared in the paper as well as possible explanations on the disconnection between their risk awareness, privacy concern, and willingness to share personal information. Future research directions are discussed.

Keywords Geographic information · Consumption/contribution of geographic information · Geographic information systems · Location-enabled online tools/services · Risk awareness · Social media

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Introduction

Together with the fast growth of Information and Communication Technologies (ICT) emerged a group of location-enabled online tools and services, in particular, online mapping (e.g. Google Map/Earth, OpenStreetMap, and Mapquest) and social networking applications (e.g. blogging, Facebook, and Wikis). Using such tools and services requires little or no training. Due to this, consuming and contributing location information through these tools/services is becoming common practice. Additionally, location aware devices such as smartphones and handheld GPS units have become a widely available means for data collection and sharing (Goodchild 2007b; Hudson-Smith et al. 2009). Mapping that used to be the sole preserve of GIS professionals, cartographers, and survey engineers is now being done by people with no background in such fields (Goodchild 2007a, 2009). These have greatly influenced people's way of sharing,

communicating, and distributing geographic data (Haklay et al. 2008; Hudson-Smith et al. 2009). The impacts are profound for society as well as for the discipline of geography. These development and impacts are collectively described by such terms as neogeography (Turner 2006), Web 2.0 (Goodchild 2007a; Hudson-Smith et al. 2009), or Volunteered Geographic Information (VGI) (Goodchild 2007b, 2009).

However, this development is not without problems. Firstly, the data and maps generated and shared through this process lack the integrity necessary for scientific research. According to Hudson-Smith et al. (2009), Web 2.0 involves "a diverse set of practices that operate outside, or alongside, or in the manner of, the practices of professional geographers" (p. 119) that tend not to claim any scientific standards. Similar concerns were reflected on the credibility (Flanagin and Metzge 2008) and other social and political implications (Elwood 2008) of the data and related practices. Secondly, it is not clear if people with a certain level of geographical education and/or GIS background are responding to these tools/services differently from those without. This is important to know because education and training form the foundation for people's decision making, including when it comes to using or producing geographic information (GI). This study seeks to discover an initial sense of how the knowledge of GIS and geography may impact college students' adoption of location-enabled technologies represented by the various online mapping and social network tools and services. Particularly, we examine the relationship between students' usage of these tools/services and their awareness of the associated risk for privacy disclosure, their willingness to share their location information, and their voluntary contribution of GI through the tools/services. Specifically, this study addresses three questions:

1. How does university students' geography and GIS knowledge relate to their consumption of and contribution to location-enabled online tools/services?
2. What are the university students' perception of and attitude towards the risks associated with making GI contributions through these tools/services? Particularly, what are the levels of their risk awareness, their privacy concern, and their willingness to share personal location information?
3. Are the students' perceptions and attitudes towards these online tools/services reflected through their GI contribution activities to these tools/services?

Usage of location-enabled online tools/services

Consumption and contribution of GI through the online tools/services

Geographic information (GI) and related applications have permeated nearly every sector of society and altered the way people interact with one another. People's increasing quest and desire for more freedom in daily routines and ability to know other places contribute to the increasing need for accessing, sharing and processing GI (Sheppard 2001a, b), which is being met by the continuous growth of location-enabled tools/services. Traditional geographical information systems (GIS) rely on trained geospatial technicians to collect and analyze geographic data and to communicate data via expert-developed maps; this excludes a sizeable user community from the GI creation and contribution process. By incorporating locationing technologies, many online data-sharing platforms (such as Wikimapia, Facebook mapping applications, and OpenStreetMap) are now location-enabled. Through these tools/services, the ordinary users are furnished with GIS capabilities. Thus, the GI patrons nowadays are not only GI consumers but frequently GI producers (Grira et al. 2009). The boundary between the two is in fact becoming blurred. A user can consume GI published by others; she/he can also contribute by editing online maps, uploading and geo-tagging photos, and publishing personal observations with location information. Citizens are now active sensors of their environment; the data they collect and share are referred to as Volunteered Geographic Information (Goodchild 2007b). VGI data contributors can perform critical role. In the case of Haiti Earthquake in 2010, GI contributed by GIS amateurs proved timely and very valuable (Clark et al. 2010).

VGI contributors are diverse regarding their levels of skill and intent (Coleman et al. 2009). Some are formally trained GIS experts; others are interested in the field with only limited background in the subject area; still others have no training or background at all. The background normally correlates with a particular

person's abilities with such tools/services and the frequency at which she/he uses them. As more people utilize the location-enabled online tools/services, many scholars have become interested in understanding their motivations. Coleman et al. (2009) identified several reasons for making VGI contribution, including altruism, professional or personal interest, intellectual stimulation, social reward, and self-expression. Additionally, pride of place is a major incentive for many contributors of popular tools/service such as Google Maps/Earth and OpenStreetMap. Quick acknowledgement by the host service of patrons' data input further encourages and ensures contribution. The same study revealed that the level of GIS knowledge does not actually determine or motivate people to use the related tools/services or contribute to them (Coleman et al. 2009).

With the continuous development of VGI and location-aware geospatial technologies, the distinction between GI consumers and contributors is getting blurred (Goodchild 2007b). But much like the difference between popular geography and academic geography (Goodchild 2009), we assume that differences exist between those with GIS knowledge and those without when it comes to consuming and contributing GI through location-enabled online tools/services.

Risk awareness and willingness to disclose location information

In spite of the many motivations for involvement in volunteering GI, contributions are in many cases restricted. As more people join the crowd to voluntarily collect, contribute, and share GI at an unprecedented speed, volume, and scale, several unpleasant issues emerge including individual privacy invasion, identity theft, and cyber-crime. Amongst all the concerns, privacy issues are considered the most worrisome, as it is the first step in leading to the other problems (Hudson-Smith et al. 2009). For example, disclosed location information could be used for child kidnapping and other crimes, which have prompted concerns over social networking websites.

Different aspects of private information have various sensitivity and risk levels. People are more cautious about sensitive personal information than general information such as nicknames. A large portion of the sensitive personal information is geographic in nature. A survey of the Facebook communities revealed that the highest level of concern was for the imagined scenario that "a stranger knew where you live and the location and schedule of the classes you take" (Acquisti and Cross 2006: 44). These pieces of information tie a sequence of locations into temporal dimension, which potentially can be used against the subject's will to facilitate or avoid a spatio-temporal convergence with the subject. A privacy issue and related risk concern rise because a stark contrast exists between the subject's high level of uncertainty and discomfort about his or her control over personal information and the inquirer's certainty about the subject's core activity space. Unlike other personal information such as name, or age, the precise location and time information identifies the unique geo-attached individuals. Generally, the more accurate the spatio-temporal information revealed, the more the concern for privacy and risk.

Privacy preferences are complex and are dependent on many factors. Users' willingness to share location information through online social network services is impacted by the characteristics of the location and the type of tracking devices (Toch et al. 2010). Studies also found that an inquirer's identity (i.e. spouse/significant other, employer, stranger, merchant) and the situation (i.e. working lunch, social evening) are two important determinants for the preference of details to be disclosed (Lederer et al. 2003; Consolvo et al. 2005). The inquirer was seen as the strongest determinant. People determine the level of information sharing based on how much they trust an inquirer (Lederer et al. 2003). Junglas et al. (2008) conducted an online survey on care for privacy among college students in the context of location-based services and found that privacy concern is related to personality.

According to the Deconstruction of Information Boundary Theory (DIBT) (Xu et al. 2008), each individual constructs his/her own personal information space with defined boundaries, which are related to the nature of information, an individual's personality, and the environmental characteristics. When assessing the risk of information disclosure against information control, an individual first decides whether information disclosure is acceptable, followed by a choice of opening up the boundary or not. Overall, objective external conditions (the identity of the inquirer, time of request, context) and subjective sensitivity perception shape the concern for privacy

and in turn the willingness to disclose location information.

However, the concern for privacy can be complex when a decision point for information disclosure is not clear or absent. One nature of the online location-enabled tools/services is that a data contributor only has one-time control over data. As long as the information is posted online, the contributor does not have control over who can access what data at what level and when. Therefore, a contributor cannot apply his/her judgment on privacy risk for each data inquiry as expected by DIBT. Moreover, concern over privacy is more an issue when sensitive personal information is disclosed through the tools/services without a data contributor's knowledge. For instance, location information can be released unknowingly through actions like sharing photos that were taken with cameras or smartphones that automatically store GPS coordinates. In this study, the authors assume that the individuals who are knowledgeable about GIS are more aware when they disclose personal location information because they tend to better understand the potential risks associated with their interaction with location-enabled online tools/services. Therefore, we seek to understand data contributors' level of privacy concern and willingness to share location information given the one-time control for personal location information with location-enabled online tools/services. Is there any difference for privacy concern and willingness to disclose location information between those who are aware when they disclose personal information and those who are not?

Data and methods

Survey design and data collection

A survey was conducted to collect primary data for this study. The survey was created using the Qualtrics (www.qualtrics.com) online platform. This platform allows for the creation of rules so that a question can be presented or skipped based on a survey participant's response to a previous question (logic—show/skip question). For instance, those who identify themselves as being non-geographers are additionally asked if they have taken a geography course (due to the fact that this may affect their knowledge of geographic information). These rules also allow for error capture so a participant cannot submit multiple answers where it is not applicable.

The survey instrument consisted of 14 questions that were binary, multiple choice, or open-ended with write-in option. The data collected fall into four categories: demographic and educational background, data consumption and contribution activities, risk awareness and concern levels about privacy, and willingness to disclose personal location information. The first category gains information on gender, year in college, and background in geography and GIS. The next category of questions assesses a subject's usage of these services and tools in terms of what type and how often. Data were collected to gauge a subject's data contribution activities, i.e. if she/he supplies data to these tools/services, to which one(s), and how much. The third category of question ask if a subject is aware of the privacy risks associated with the tools/services, and how concerned she/he is about identity disclosure through using them. The last category inquires on subject's willingness to disclose personal location information through the online tools/services. The target population for this survey was the entire student body at Texas State University - San Marcos, totaling over 32,500 students at the time of the study. To adequately and objectively draw a sample from this population, recruitment was conducted by sending a campus-wide email message containing a hyperlink to the online survey. Therefore, every member of the target population had an equal opportunity of participating in the survey. The data for this study were collected over a two week period in late November 2011.

Data analysis

A total of 1,092 students completed the survey (3.4 % of the total student population). Table 1 shows the breakdown of the sample in comparison to the entire campus student. Geographers and graduate students were overwhelmingly receptive to completing the survey. This is believed to be related to the shared interest the geography students have with this project (the research topic was mentioned in the recruitment email). As for graduate students, their high participation rate was likely due to their interest in research and sympathy towards data collection for research projects. This was expressed in a number of email messages received from graduate students. The response rates appear to be higher among female

Table 1 Sample distribution

Category	Sample	Population
Males	35.7 %	44 %
Females	63.8 %	56 %
Geographers (graduate and undergraduate)	10.8 %	2.8 %
Undergraduates	60.5 %	86.5 %
Graduates	39.5 %	13.5 %
Total	100 % (1,092)	100 % (32,572)

students compared to male, which confirms the findings from studies on students' response rates to surveys (e.g. Sax et al. 2003). However, given that a total of 390 valid responses were received from male students and that the gender ratio in the sample is reasonably close to that in the student population on campus, we believe that the sample is robust and the gender bias is minimal.

As discussed previously, this study was laid out to investigate college students' adoption of location-enabled online tools/services and if this is reflected or influenced by their knowledge in geography and GIS. Based on their responses to the related survey questions, the participants are grouped into four categories: GIS-Aware Geographers (AG—a total of 114), GIS-Unaware Geographers (UG—4 in total), GIS-Aware Non-geographers (AN—304 in total), and GIS-Unaware Non-geographers (UN—670 in total). Note that 38.3 % of the survey participants are aware of GIS, meaning that they can correctly spell out what the acronym GIS stands for. This assessment of GIS awareness does not suggest that students have a full understanding of GIS. However, it does allow for an assessment of those students who know GIS versus those who do not have any a priori knowledge or understanding of GIS. Because only four students fell into UG, the group was dropped from further analyses.

Similar approaches were taken to address the first two research questions, each using the Statistical Package for the Social Sciences (SPSS: An IBM Company). Cross-tabulation and Kruskal–Wallis tests were used to explore the differences amongst the three students groups as defined above. The test variables for the first research question are the data describing how often the students use the related online tools/services and how often they contribute to them. As the frequency of students' consumption or contribution activities are reported on an ordinal scale, a Kruskal–Wallis test is applied to find if there are statistical differences across the multiple groups. The same test was performed for the second research question. The test variables were level of concern for privacy risk and students' willingness to disclose personal location information through the online tools/services; both test variables were recorded as ordinal data. Moreover, the binary yes/no responses to whether or not a participant has thought about the risks associated with using the tools/services are examined by Chi-squared test. The last research question was examined by Spearman's Rho coefficient of correlation to investigate if there is a relation between students' level of concern and their contribution frequency, and between the level of willingness to share personal location information and their contribution frequency. Spearman's Rho is employed because it provides the best way to examine the correlation of ordinal variables.

Survey analysis and results

Consumption and contribution

Figure 1 shows the types of tools/services that are used by the students. Survey participants were offered the opportunity to check all the answers that apply. Many students use multiple tools/services. Online map querying with Google Maps, Bing Maps, or another similar service was found to be the most used, followed by In-Vehicle/Cell Phone GPS, Handheld GPS, and lastly the catch-all 'Other' category. An Independent-Samples Kruskal–Wallis test was conducted to test the null hypothesis that there is no

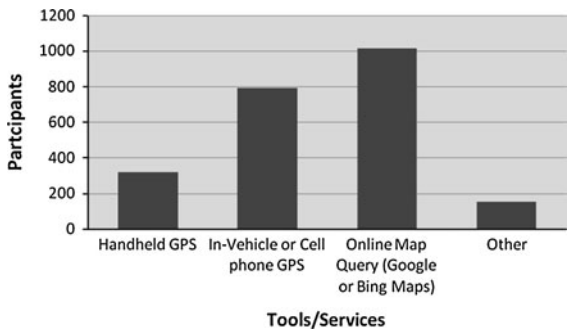

Fig. 1 Location-enabled tools/services consumption venues

significant difference among the different student groups regarding their usage (or consumption) of the location-enabled online tools/services. The null hypothesis was rejected at a 99.9 % confidence level, indicating the existence of a significant difference across the student groups.

To further confirm this, Table 2 shows that, among those who use the tools/services on daily basis, the AG (GIS-Aware Geographer) group has the largest proportion (29.1 %) among the three groups. Moreover, the AG group has a fairly even distribution of consuming frequencies: daily use, 2–3 times a week, once a week, and 2–3 times or less a month. When considering the AG and AN (GIS-Aware non-geographer) groups together, 18.6 % use these tools/services on daily basis, which is much higher than that of the UN (GIS-Unaware non-geographer) group (10.6 %). On the other end, the UN group has the largest proportion of students who use the tools/services 2–3 times a month or less.

For contribution activities, Fig. 2 summarize the types of tools/services that are used by the students. Once again, the participants were given the option to check multiple answers. Overwhelmingly, Facebook "check-ins" is utilized the most, followed by uploading geo-tagged images, and providing location information on sites like Wikimapia. Table 3 reports on contribution frequencies by the survey participants across the different student groups. Compared to the consumption activities, only 42.9 % of the survey participants (468 students) reported contributing data at various levels. A cursory glance shows that for each group (AG, AN, and UN) over 50 % of the students make contribution 2–3 times a month or less. Overall, there is a clear shift of the high percentage of participants to the less active categories across all three student groups. An Independent-Samples Kruskal–Wallis test was conducted for the null hypothesis that there is no significant difference among the three student groups regarding their contribution levels to these tools/services. The null hypothesis was retained confirming no significant difference among the groups.

Risk awareness and willingness to disclose location information

The survey assesses risk awareness by inquiring if a student has thought about the risks associated with using the location-enabled tools/services (Table 4). It also gathers information on a student's level of concern with disclosing personal location information through these tools/services. Only those participants who claim to make contributions to the tools/services

Table 2 Consumption of the location-enabled tools/services by students

How often do you use such services?	Group			Total
	Aware geographer (AG)	Aware non-geographer (AN)	Unaware non-geographer (UN)	
Daily				
Count	32	43	69	144
% within group	29.1	14.7	10.6	13.7
2–3 times a week				
Count	26	89	156	271
% within group	23.6	30.4	24.1	25.8
Once a week				
Count	23	75	153	251
% within group	20.9	25.6	23.6	23.9
2–3 times a month or less				
Count	29	86	270	385
% within group	26.4	29.4	41.7	36.6
Total				
Count	110	293	648	1051
% of total	10.5	27.9	61.7	100.0

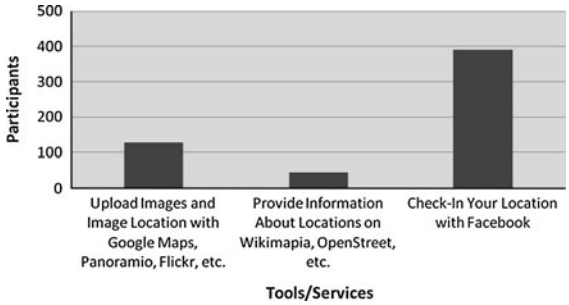

Fig. 2 Location-enabled tools/services contribution venues

were invited to respond to these questions. Among the 469 respondents, the majority (62.7 %) stated that they have thought about the risks involved in using these tools/services. As geography and GIS awareness increases, so does the percent of respondents who reported having thought about the risks associated with these tools and services: 59.7 % from the UN group, 65.7 % from the AN group, and 76.1 % of the AG group. The differences across the groups are statistically significant with a Chi-square of 5.18 and a significance level at 0.075.

Table 5 reports on the levels of concern for potentially disclosing or distributing location information through contributing information to the tools/services. Most of the participants fall into the middle levels of concern: "concerned", "neither concerned nor unconcerned", and "not really concerned". The extremes only account for 14.1 % of the sample (9.1 % "very concerned" and 5.1 % "not concerned at all"). Moreover, the AG group has the highest percentage of students (47.8 %) who are "very concerned" or "concerned", followed by the AN group (45.4 %) and then UN. The AG group also has the lowest percent of students (23.9 %) who are "not really concerned" or "not concerned at all". Nevertheless, an Independent-Samples Kruskal–Wallis test reveals no difference among the three groups on their concern levels.

Directly related to the concern level about disclosing or distributing location information is the degree of willingness to share location information through these tools/services. Again, only those who claimed as making data contributions were invited to respond. Table 6 reveals that most participants fall into the middle categories of "limited" or "somewhat" (a total of 76.7 %). A Kruskal–Wallis test revealed no difference amongst the groups. The null hypothesis that there is no significant difference among the groups in their willingness to share personal location information through these tools/services was retained. However, it is worth to note that half of the AG group claimed to be willing to share their location

Table 3 Contribution to the location-enabled tools/services

How often do you contribute to these tools/services?	Group			Total
	Aware geographer (AG)	Aware non-geographer (AN)	Unaware non-geographer (UN)	
Daily				
Count	1	3	19	23
% within group	2.2	2.8	6.1	4.9
Once a week				
Count	11	30	67	108
% within group	23.9	27.8	21.3	22.2
2–3 times a week				
Count	9	17	62	88
% within group	19.6	15.7	19.7	18.8
2–3 times a month or less				
Count	25	58	166	249
% within group	54.3	53.7	52.9	53.2
Total				
Count	46	108	314	468
% of total	9.8	23.1	67.1	100.0

Table 4 Risk awareness of college students by group

Have you ever thought about any risks associated with any of these tools or services that you use?	Group			Total
	Aware geographer (AG)	Aware non-geographer (AN)	Unaware non-geographer (UN)	
Yes				
Count	35	71	188	294
% within group	76.1	65.7	59.7	62.7
No				
Count	11	37	127	175
% within group	23.9	34.3	40.3	37.3
Total				
Count	46	108	315	469
% of total	9.8	23.0	67.2	100.0

Table 5 Concern about potentially disclosing or distributing personal location information by group

How concerned are you that these tools/services could potentially disclose or distribute your location information to third parties?	Group			Total
	Aware geographer (AG)	Aware non-geographer (AN)	Unaware non-geographer (UN)	
Very concerned				
Count	6	8	28	42
% within group	13.0	7.4	8.9	9.0
Concerned				
Count	16	41	107	164
% within group	34.8	38.0	34.2	35.1
Neither concerned or unconcerned				
Count	13	24	87	124
% within group	28.3	22.2	27.8	26.6
Not really concerned				
Count	9	30	74	113
% within group	19.6	27.8	23.6	24.2
Not concerned at all				
Count	2	5	17	24
% within group	4.3	4.6	5.4	5.1
Total				
Count	46	108	313	467
% of total	9.9	23.1	67.0	100.0

information to a "limited" degree. Perhaps one can speculate that the AG group is willing to share their location information if, by applying their specialty knowledge, they can reach a safe conclusion on releasing location data. Overall, this finding may provide indirect evidence that people's willingness to share location information may be related to other factors such as location characteristics and tracking tools (Toch et al. 2010), inquirer's identity (Lederer et al. 2003), or data provider's personality (Junglas et al. 2008).

The relationship between risk awareness and data contribution

The third research question investigates how risk awareness affects the level at which the college students contribute data through these tools/services.

Table 6 Degree of willingness to share location information by group

To what degree are you willing to share your location information through these tools or services?	Group			Total
	Aware geographer (AG)	Aware non-geographer (AN)	Unaware non-geographer (UN)	
Very much				
Count	4	6	20	30
% within group	8.7	5.6	6.4	6.4
Somewhat				
Count	14	47	109	170
% within group	30.4	43.5	34.7	36.3
Not sure				
Count	3	12	40	55
% within group	6.5	11.1	12.7	11.8
Limited				
Count	23	35	131	189
% within group	50.0	32.4	41.7	40.4
Not at all				
Count	2	8	14	24
% within group	4.3	7.4	4.5	5.1
Total				
Count	46	108	314	468
% of total	9.8	23.1	67.1	100.0

Table 7 is a cross-tabulation of the level of concern and the frequency at which the students make contributions. A high level of privacy concern was expected to correlate with less frequent student contributions. However, the correlation analysis revealed a Spearman correlation coefficient of 0.017 at an insignificance level (0.721), indicating the unrelated nature between these two variables. A similar relation was identified when dropping the group who contribute 2–3 times a month or Less. It can be seen from Table 7 that regardless of the levels of concern, most students contribute only occasionally: 53.4 % of sample contributes 2–3 times a month or less.

When examining the correlation between willingness to share location information and data contribution frequency, significant relationship was revealed. The coefficient is 0.22 at a significance level of 0.01 (Table 8). Therefore, those who claimed to be more willing to share personal location information through the investigated tools/services tend to contribute data more frequently to these tools/services. However, the small value of the coefficient suggests that the increased level of contribution does not fully reflect the increase in willingness to contribute.

Findings and discussion

This paper aims to gain an initial understanding of how college students have responded to location-enabled online tools/services. The analyses revealed a positive relationship between GIS/geography knowledge and students' consumption of location-enabled online tools/services; but no connection was found between students' online GI contribution and their GIS/geography knowledge. The analysis of students' risk awareness on using the online tools/services confirmed that knowledge of GIS/geography increases college students' risk awareness level. Students' privacy concern level, however, was not found to be associated with their GIS/geography knowledge. No difference was found across the three student groups regarding their willingness to share personal location information through the online tools/services. Furthermore, students' frequency to make online GI contribution is not related to their privacy concern level about using the online tools/services, but it is significantly related to their willingness to share personal location information through the tools/services.

Table 7 Level of concern and contribution frequency

Spearman's Rho result Correlation coefficient: 0.017 Significance: 0.721	Contribution frequency				Total
	2–3 times a month or less	Once a week	2–3 times a week	Daily	
Level of concern					
Very concerned					
Count	26	6	7	4	43
% of total	5.5	1.3	1.5	0.9	9.1
Concerned					
Count	88	33	38	6	165
% of total	18.7	7.0	8.1	1.3	35.1
Neither concerned or unconcerned					
Count	63	25	32	5	125
% of total	13.4	5.3	6.8	1.1	26.6
Not really concerned					
Count	59	19	28	7	113
% of Total	12.6	4.0	6.0	1.5	24.0
Not concerned at all					
Count	15	5	3	1	24
% of total	3.2	1.1	0.6	0.2	5.1
Total					
Count	251	88	108	23	470
% of total	53.4	18.7	23.0	4.9	100.0

Table 8 Willingness to share location information and data contribution frequency

Spearman's Rho result Correlation coefficient: 0.220 Significance: 0.000	Contribution frequency				Total
	2–3 times a month or less	2–3 times a week	Once a week	Daily	
Willingness to share					
Not at all					
Count	13	6	4	2	25
% of total	3.1	1.4	1.0	0.5	6.0
Limited					
Count	129	21	36	5	191
% of total	31.0	5.0	8.7	1.2	45.9
Somewhat					
Count	67	44	50	9	170
% of total	16.1	10.6	12.0	2.2	40.9
Very much					
Count	11	9	6	4	30
% of total	2.6	2.2	1.4	1.0	7.2
Total					
Count	220	80	96	20	416
% of total	52.9	19.2	23.1	4.8	100.0

Consumption of and contribution to online tools/services

The survey participants for this study are predominately geographic information (GI) consumers (1051 participants; 96 % of sample) and not contributors (468 participants; 46 % of sample). Students were found to consume and contribute to a number of location-enabled tools/services (see Figs. 1, 2). Statistical test confirms that the three student groups use the online tools/services at different levels, as reflected by their usage frequency. Moreover, the numbers in Table 2 suggest that AG group has the highest percentage of daily consumers, signifying a possible connection between the increased GIS and geography awareness and the tendency to use these tools/services more frequently among the college students. We speculate that knowledge about GIS and geography among AG group students, despite at different levels, may have contributed to their increased exposure and adoption of location-enabled online tool/services.

No difference was found across the different student groups on their GI contribution through location-enabled online tools/services. However, Facebook was overwhelmingly utilized to contribute GI, which may be related to its ease of use. The GI contribution venues demand varying levels of effort. A Facebook "check-in" takes the least amount of time and effort. Geo-tagging a photograph entails more work than "check-in", involving the upload of a picture and the pinpointing of its location on a map or querying a place name. Contributing data to sites like OpenStreetMap and Wikimapia is the most time consuming among the three, which requires writing descriptions and/or editing geographic boundaries/features. A general trend exists that the time and effort required for a user to make data contribution plays a major role in the college students' level of GI contribution through location-enabled online tools/services.

Overall though, our findings do not fully agree with Coleman et al. (2009) who found that people's knowledge of GIS has no relation to their consumption or contribution to the online geographic tools and services. In our study, GIS-Aware college students tend to use the online tools/services more, but they do not necessarily contribute more than the other students. It seems that the time and efforts needed for one to make data contribution through the online tools/services determines how frequent the tools/services are used by college students for GI distribution.

Risk awareness, privacy concern, and willingness to disclose location information

Our analysis reveals that GIS and geography knowledge help increase risk awareness associated with using the investigated tools/services (Table 4). But no difference was found amongst the student groups regarding their privacy concern on contributing GI using the investigated online tools/services (Table 5). It is important to note that while 59.7 % of the student GI contributors have thought about the associated risks, only 44.1 % of them self-identified as being either "very concerned" or "concerned" about privacy disclosure. This discrepancy between risk awareness and privacy concern may suggest a lack of connection for the college students between general knowledge of risk and their specific understanding of the online risk behavior. For example, a person may understand the concept of GeoSlavery (Dobson and Fisher 2003), but she/he may not be able to assess the possibility for a sensitive location being identified accurately from a general newspaper map after location re-engineering is applied (Curtis et al. 2006). A student may know there are certain risks with online tools/services, but she/he may fail to connect the risk perception with online sharing of personal location information.

The study found no difference across the student groups in their willingness to contribute GI through the investigated tools/services (Table 6). However, it is worthwhile to note that half of the AG group claimed to be willing to share their location information to a "limited" degree. Perhaps one can speculate that the AG group is willing to share their location information if, by applying their specialty knowledge, they can reach a safe conclusion on releasing location data. Technological approaches such as anonymization and geomasking (Lu and Liu 2012) can be applied to location data before releasing them to control for the risk of disclosing personal information. Following the Deconstruction of Information Boundary Theory (Xu et al. 2008), the students who are technically savvy enough to apply such a technique before sharing location data may utilize a relaxed information boundary and make more online GI contributions. Furthermore, students differing levels of willingness to share location information may be related to other

factors such as location characteristics and tracking tools (Toch et al. 2010), inquirer's identity (Lederer et al. 2003), or data provider's personality (Junglas et al. 2008).

Overall, this study shows that knowledge in GIS and geography may increases students' risk awareness associated with contributing GI through location-enabled online tools/services; but the risk awareness does not translate directly to students' privacy concern nor their willingness to share personal location information. It seems that knowledge in GIS and geography plays a double role. On the one hand, general knowledge in GIS and geography increases students' overall risk awareness but not necessarily raising their privacy concern with online GI contribution. On the other hand, for those who are technologically savvy, their willingness to share personal location information and their actual GI contribution activity are more context-based, depending on if they can apply certain techniques to control for disclosing privacy.

Online data contribution

Less than half of the student participants in our survey identified themselves as making data contribution using various location-enabled online tools/services (Fig. 2; Table 3). The majority of the surveyed students do not contribute very often, with 53 % contribute "2–3 times a month" (Table 7). Among the participants who make online GI contributions at similar frequencies, their levels of concern for privacy vary greatly. It is possible that among those who are "very concerned" about privacy, some may not have reached the breaking point at which they cease to make contributions. In other words, their concern does not outweigh their desire to contribute. Therefore, some people can be "very concerned" but still contribute fairly frequently.

The positive relation between the actual online GI contribution level and the willingness level to share personal location data was revealed to be weak. On the one side, this may indicate a barrier effect of the inherent effort required by using the online tools/services. The inherent effort requirements by the various online tools/services impact not only which tools/services are used but also who can use them and at what frequency. On the other side, it is interesting to note that some claim to be unwilling to share location information but they contribute anyways. For instance, 6 % of the respondents flagged their willingness to share their information as "Not At All", but they still (at any rate of frequency) contribute to the tools/services.

In summary, the patterns of college students' online data sharing through various location-enabled tools/services are complex, more so when trying to explain them by the contributors' privacy concern and willingness to share personal location information. A number of factors need to be considered in order to understand the college students' online GI contribution, including, for example their backgrounds, experiences, and motivations, as discussed by Coleman et al. (2009).

Future research

It is important to notice that the survey samples for this study are mostly young adults, a typical college student population. Future research in this area could look into a different aged population group to see patterns of usage across generations (i.e. younger—high school students, or older—working professionals). Furthermore, specific demographic characteristics should be explored in future studies. This is especially the case with gender. Our survey data indicates that while more male students tend to use these online tools/services on a daily basis (21.1 % male versus 9.5 % female), a higher percentage of females are making daily online GI contributions (4.3 % male versus 5.1 % female). While a higher percentage of males claimed to be "very concerned" about disclosing personal location information through these online tools/services (12.3 % male versus 7.8 % female), more males than females are "very much" willing to share their location information (6.6 % male versus 6.3 % female). Hartgittai and Shafer (2006) found that the difference in online activities (how often and what type) between males and females is related to gender difference in self-assessment rather than in web skills. Does this extend to online activities with location-enabled tools/services? Furthermore, is there a gender difference in online skills to handle location-enabled tools/services?

Future research should also examine how people's awareness of the risks involved in using location-enabled online tools/services influences the accuracy or data integrity of their GI contribution. This is especially important given that the credibility of data

obtained through VGI is an important topic in literature (e.g. Flanagin and Metzge 2008; Lu and Liu 2012). Through these collaborative mapping tools and social media outlets, more people are exposed to GI and are fascinated with the related applications and functions. By inspiring and maintaining a large pool of enthusiastic amateurs (and some professionals as well) who continue to invest time and effort into using or contributing GI, these tools/services have and will continue to increase interest and awareness of geography and GIS in an exceptional way.

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