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Co-Creating Value: Student Contributions to Smart Cities

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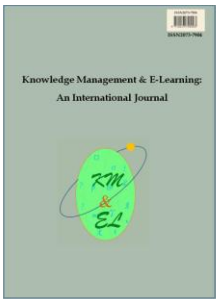

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Co-creating value: Student contributions to smart cities

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Abstract: Given the interdependence of the public and private sectors and simultaneous and massive impact of widespread disasters on the entire community, this paper investigates the use of information technologies, specifically geospatial information systems, within the multi-organizational community to effectively co-create value during disaster response and recovery efforts. We present and examine in depth a participatory action research project in a disaster-experienced coastal community conducted during the 2006-2014 time period. The results of the action research project and analysis of a survey completed by stakeholders leads to a list of findings, in particular those related to developing a model of next generation learning design where students are co-creators of value to the smart cities.

Keywords: Co-create IT value; Disaster response and recovery; Action research; Coastal communities; Student involvement; Next generation learning; Smart cities

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1. Introduction

It is generally accepted that within a community, information is critical to organizational and overall community stability and sustainability. The need for information is especially important during disaster recovery. From an information technology (IT) perspective, when disasters occur, many firms follow business continuity plans (under the guidelines prescribed by the Information Systems Security Certification Consortium) and enter into stages of Interim Operation and Alternative Operation in an effort to return to Normal Operation (Harris, 2008). While vital for information-dependent organization, these efforts are not sufficient to restore operations for organizations that are location-dependent. For example, real estate rental property and tourist-based services, a vital economic element of many coastal communities, are suspended following an ocean-borne storm. Repairs and recovery for these organizations occurs only after the resumption of public sector services, such as water and electricity, in addition to approval from city inspectors and contracted engineers, who are in high demand and short supply after a disaster. Thus, following a disaster, the priority of information collection and exchange focuses first on public safety and then re-establishing those community physical infrastructure elements that the private sector relies upon.

The disaster recovery process is difficult and costly. One of the current situations is that large amount of the data that could be used for restoration of infrastructure assets for both the private and public sectors are in paper form. Infrastructure may refer to "big, durable, well-functioning systems and services" (p. 365) and refers to physical and the digital equivalent of e-infrastructures (Edwards, Jackson, Bowker, & Williams, 2009). In this paper we define the infrastructure data as describing the physical infrastructure (transportation, utility, and communication) that support a community along with the interdependent data and information components that correspond to those physical community assets, either publicly or privately owned and operated. Collectively, infrastructure data describe the critical community infrastructure, including but not limited to the locations of electric utilities such as meters, cables, transformers; telecommunication utilities such as fiber optic cables, telephone poles and pedestals, switch stations; and water and gas utilities (Walsham & Sahay, 1999). The data include location, function, and ownership of the infrastructure assets. Paper format infrastructure data is problematic when wind, water, and debris destroy landmarks that act as reference points for locating infrastructure assets because it is difficult to pinpoint physical infrastructure location in the field based on paper form data. One of the solutions to the above problem is to transfer the data to digital format and use IT to collect and present geospatial data in real time to emergency personnel (National Research Council, 2007). The term *geospatial* refers to those interdependent resources – imagery, maps, data sets, tools, and procedures – that tie every event, feature, or entity to a location on the Earth's surface.

Rao, Eisenberg, and Schmitt (2007) concluded that IT has a great potential to improve the way that communities, the national community, and the global community handle disasters. One of the technologies that could contribute to the disaster recovery process is Geographic Information Systems (GIS). GIS capture, store, display, analyze, and model natural and artificial environments (Robey & Sahay, 1996) and can increase the speed and accuracy of decisions, especially for a geographically contained area (Dennis & Carte, 1998). While this is a seemingly straightforward solution from a technological standpoint, the multi-organizational setting of a community presents a variety of other challenges.

Implementing GIS can be difficult for government agencies because the process involves not only technical expertise, but also the creation of a stable network of stakeholders who need to cooperate to develop and maintain a geospatial system that spans many industries: utility, telecommunications, construction, realty, insurance, local and state governments and organizations (Baker, 2008; Robey & Sahay, 1996; Walsham & Sahay, 1999). Further, "the creation of a stable network [of participants] could be particularly problematic" (Walsham & Sahay, 1999, p.58). This requires a thorough training and education process among the users of the GIS (Walsham & Sahay, 1999). A study of GIS implementation in two county governments in the U.K. found that GIS should be perceived as "competence-enhancing" versus "competence-destroying" to overcome the existing political structures and alignments that tend to inhibit adoption (Robey & Sahay, 1996). Location must be expressed in some standard and readily understood form, such as latitude-longitude, street address, or position in some coordinate system (National Research Council, 2007). These challenges are exacerbated during and following a disaster event to maintain availability and access to infrastructure asset information for disaster recovery activities.

Including *both* the physical and information aspects of a community infrastructure as related to GIS is an instance of digitization of physical assets in a smart city. *Smart cities* are generally understood to mean the use of IT and information systems (IS) to continually monitor, regulate, and manage city infrastructures for greater efficiencies (Hernández-Muñoz et al., 2011), Rai & Sambamurthy (2006) argued that such digitalization of physical assets need to be conceptualized as service management and it is important to find out how such services are offered and orchestrated, and how interactions for innovation and production of services are managed. They further stated that advances in business intelligence, synchronous and asynchronous interaction, and security and privacy provide opportunities to develop and evaluate new models for coproduction and innovation. They stated that an important research question for Management Information systems (MIS) scholars to investigate is: how can these capabilities be leveraged to understand the needs of customers, to identify microsegments, to co-produce services, and to innovate?

Despite this call, the smart city concept is yet to be incorporated into mainstream MIS research and is likewise absent from MIS curricula. The need for research and student engagement to this difficult question and important issue of developing smarter cities is addressed in this paper. It recounts the emergence of a *next generation learning model* in which university students serve as co-creators of community infrastructure asset information via an integrated network of community stakeholders. The development of this model grew from first-hand inquiry into stakeholder needs in a disaster-prone multi-organizational community setting. From initial contact with community representatives, a three-stages participatory action research project grew from the 2006 to 2014 time period. The project investigated the collection, storage, and sharing of geospatial infrastructure asset data in the context of a multi-organizational community. This project required several public and private entities to co-produce digital versions of the infrastructure asset data, ensure that it is both secure and accessible to share during emergencies so that disaster recovery can be prompt and effective. Drawing from the diffusion of innovation (Rogers, 2003) theoretical perspective, an analysis of the project led to development of a *next generation learning model*. The project became a successful proof-of-concept and is now in a fourth phase of ongoing sustenance coordinated in a newly formed university research center. Among other activities, the center serves as a proving ground for the learning model, which serves as a conduit for MIS students to interface with community stakeholders at the operational (collecting GIS data) and strategic levels (presenting to community and government leaders) thereby introducing them to the challenges and opportunities of developing tomorrow's smart cities.

The remainder of this paper is organized as follow: first, a literature review describes the practical and theoretical background that led to the participatory action research approach. Next, a detailed account of the geospatial project conducted within a coastal community is provided including data gathering and analysis activities. The analysis of the project and the finding of structural relationships being more important than the technology itself led to the development of a next generation learning model. Utilizing students to co-create value for cities by digitizing their infrastructure facilities aids the community and also enriches the students' education and engagement with the community. The model is currently under further testing and refinement as the project is in an ongoing operation phase.

2. Research background

As physical infrastructure assets are vulnerable to disasters, so are the corresponding infrastructure data. We examined relevant literature to identify the need and potential benefits of a community wide geospatial platform to support disaster response and recovery, and the issues in co-creating IT value for smart cities. The literature review leads to the formation of the research question.

2.1. Impact of disasters on coastal communities

The need for private and public sectors to work together is important in areas with frequent disasters such as coastal communities. Natural disasters in these regions are often designated as *Level 3* emergencies, meaning all city departments and resources or a combination of city departments and outside agencies are mobilized to respond to an emergency situation (Drabek & Hoetmer, 1991). In effect, non-emergency personnel are restricted from travel or evacuated from within the emergency area. The coastal region is annually under threat from ocean-borne storms; however, these disastrous storms have not stopped the booming growth of most coastal regions. Projections of population re-distribution indicate that coastal regions will continue to experience tremendous growth. More than half of the global population lived within 120 miles of the coast in 1998, reflecting ongoing trends in coastal population density (UN Atlas of the Oceans, 2007). This is true in the U.S., with over half of the population living in coastal counties (53% or 150 million), up from 28% in 1980 (Crossett, Culliton, Wiley, & Goodspeed, 2004) and projected to increase to 75% of the population by 2025 (Hinrichsen, 1998). More than half a billion people, 8%, of the world's population, reside in coastal areas and are impacted by such disasters (Berke & Beatley, 1997).

Population growth is but one indicator of the importance of our inquiry into disasters; the number of presidential disaster declarations is accelerating, doubling from that of the 1980's, and is accompanied by an increasingly negative economic impact (Burby, 2006). The calculated economic costs of coastal disasters are massive and do not necessarily reflect the social costs, including physical and mental health of socially vulnerable populations (Cutter & Emrich, 2006). The estimated damage in southern Florida resulting from Hurricane Andrew in 1992 was estimated at $24 billion (Berke & Beatley, 1997). Hurricane Katrina in 2005 cost nearly $100 billion dollars in property damages, $200 billion in economic loss, nearly 2,000 lost lives, and total disruption of life in New Orleans, Louisiana (Burby, 2006). In 2008, Hurricane Gustav necessitated the evacuation of the City of New Orleans, followed closely by Hurricane Ike that necessitated the evacuation of the City of Galveston, Texas. Hurricane Gustav caused an estimated $7 billion to $15 billion in damages to homes and other buildings across Louisiana and $2.5 to $5 billion in economic losses (Deon, 2008). Hurricane Ike cost a similar amount of damage in Texas. These coastal areas that are growing in population are no less likely today to avoid these disasters, and, in fact, disaster events are more probable given inattentive public policy and development in hazardous areas (Burby, 2006).

2.2. GIS for disaster response and recovery: Co-creation of value

Coordination mechanisms and complementary investments among the multiple stakeholders are critical to co-create a community wide geospatial platform for use during a disaster. Kohli and Grover (2008) described how different companies with multiple IT systems can join together and create new value. They also stressed the need not to underrepresent IT value and the need to research intangible values in the marketplace. Straub, Rai, and Klein (2004) described the need to develop sophisticated measures of the performance of the entire networks of firms, as opposed to individual firm performance. The same sentiment is echoed in Beinhocker, Davis, and Mendonca's (2009) multi-stakeholder perspective of gauging firm performance. Grover and Kohli (2012) stated that it is critical to further our understanding of IT-based joint creation of business capabilities, products, processes, and services.

Co-creation or co-production among multiple actors in a network is an emerging and potentially beneficial pathway to adding value. The continued developments and accumulated learning among specific information technologies linked together in IS exemplified by global, Internet-based platforms facilitate an environment of widespread co-creative participation. In their unprecedented look into the company-consumer co-production environment in the context of new product development, Füller, Mühlbacher, Matzler, and Jawecki (2010) recognized "[v]irtual co-creation by customers means information sharing with multiple entities in a distributed innovation environment".

2.3. Summary

Within the multi-organizational and multi-stakeholder perspective of an overall geographically defined community, the interdependent public and private sectors are both affected by community-wide disasters. The community may benefit by employing a community wide geospatial platform and further, co-creation is a potentially valuable mechanism to span the distributed network of stakeholders. This research seeks to address the question: *How can students and educational institutions working with other organizations create smart coastal cities of the future?* We describe the research approach used to address this research question next.

3. Research approach: Action research and a contextual focus

The research question is answered by designing a participatory action research approach that balances rigor and relevance while accomplishing both practitioner and academic ends (Kohli & Kettinger, 2004; Mårtensson & Lee, 2004; Lingren, Henfridsson, & Shultze, 2004; Street & Meister, 2004). The research was conducted in the southeastern United States, where natural disasters are serious emergencies and require a combination of city departments and outside agencies to be mobilized to handle the situation (Drabek

& Hoetmer, 1991). An action research approach was used to perform the activities conducted by a GIS project team during the 2006 to 2014 time period. The action research approach is evaluated based on theories of IT adoption and co-creation of IT value in a multi-organizational setting. Ultimately, the results of this action research approach led to development of a next generation learning model that demonstrates how IT value can be co-created for multiple organizations in a coastal community. Furthermore, the participation of researchers in the project during 2006 to 2014 provided added contextualism to the research design by observation and active engagement of interactions among the actors within their environments (Pettigrew, 1987, 1990; Walsham & Waema, 1994; Walsham & Sahay, 1999).

3.1. Geospatial action research project overview

The project is described using four major phases: problem identification using focus groups, initial implementation using a pilot project, extensive implementation using a funded project, and sustenance of the project. The project includes two primary coastal communities of Orange Beach and Gulf Shores, Alabama, selected by the criteria of their openness to collaboration with researchers, their vulnerability to ocean-borne storms, and their direct experience following Hurricane Ivan making a direct landfall in 2004. Phase I, from February 2006 to December 2007, included a content analysis of two focus group discussions held among disaster-experienced stakeholders in these two coastal cities. A prescriptive recommendation was made to community officials and other stakeholders at the end of this phase. In Phase II, extending from January 2008 to May 2008, a group of ten researcher-supervised university students conducted a project and collected critical community infrastructure data alongside local GIS personnel with handheld geographical positioning system devices. These data were entered into an instantiation of ESRI's *ArcView* GIS software platform, as maintained by the City of Gulf Shores' IT department. In Phase III, starting from June 2008 to 2012, funding was obtained to continue the collection of infrastructure data for other coastal communities so that it can be stored in a centralized, disaster resilient repository, and retrievable by appropriate stakeholders during and following a disaster event. The results of this project led to development of a next generational learning design. During Phase IV, a Geospatial Research and Applications Center (GRAC) was created at Auburn University whose mission is to implement the new learning design so that students obtain experiential learning during school and help in changing the coastal and other cities to be smarter.

Data collection activities are listed in Table 1 according to these project phases, the type and dates of activities, the locations (*On Site* includes the City of Orange Beach; City of Gulf Shores, IT department offices, and City Council Chambers; while *On Secondary Site* and *Remote* includes Panama City, Florida and Forrest and nearby counties in Hattiesburg, Mississippi), and lastly the number and grouping of participants. The numerous participants represented nine groups – County Public/Private Group, Municipal Government, County Government, Regional Government, State Government, Private Industry, University Student Project Team, University Outreach, and Action and Observational Researchers – and are listed with specific job titles in Table 2.

3.2. Phase I – Initial problem identification and diagnosis

Through a process of stakeholder meetings, including the results of a rigorous content analysis performed on the transcribed discussions of two separate expert groups, the researchers studied the problem faced by coastal communities in the Southeastern United States and formulated an initial problem diagnosis within a traditional IS perspective.

Table 1
Phase I to III data collection activities

ACTIVITY	DATE(S)	LOCATIONS	PARTICIPANT GROUP	NO.
Phase I				
Initial Problem Meeting	2/2006	On Campus	County Public/Private Group Observational Researchers University Students	10
Exploratory Focus Group	2/5/2007	On Site	Municipal Government County Public/Private Group Private Industry Observational Researchers	15
Confirmatory Focus Group	11/30/2007	On Site	Municipal Government County Public/Private Group Private Industry Observational Researchers	12
Phase II				
Project Team Briefing	1/15/2008	On Campus	Municipal Government Action Researchers University Students	20
Post Disaster Recovery Planning Meeting	1/24/2008	Secondary Site	Municipal, Regional Government Private Industry Observational Researcher	~15
Discovery Interview	1/25/2009	Secondary Site	Municipal Government Observational Researcher	4
Student Project Team Field Visit	2/22-24/2008	On Site	Municipal Government Observational Researcher	11
Discovery Interviews	2/22/2008	Remote Visit	Regional Government Observational Researcher	2
Student Project Team Field Visit	2/29/2008 to 3/2/2008	On Site	Municipal Government Private Industry University Students	7
Phase II-III (transition)				
City Council Presentation	4/23/2008	On Site	Municipal Government Private Industry University Students	~30
Phase III				
Utility meter reader ride-along	Spring 2009	Remote Site	Private Industry Action Researcher	2
Proposals Development	Fall 2008-Summer 2009	Remote	Municipal, County Government Private Industry Action Researchers	15
Receipt of Funding, Memoranda of Agreements	9/2009			6
Project Implementation	Fall 2009 to Fall 2012	On Site Campus Remote	Any/All Stakeholders	200+

Table 2
Action research participants listed by participant group

Group	Members
County Public/Private Group	County Economic Development Alliance Executive
Municipal Government	City Council Members, City Administrator, Public Safety Officials, Building Official, Chief Inspector, Planning Commission Chairman, former and current Public Works Director, Utility Board General Manager, Planners, Special Projects Coordinator, Flood Plain Administrator, Engineering Environmental Services, Public Works Inspector, IT director, GIS specialist
County Government	County Extension Service Agent, Public Safety Officials
Regional Government	Regional planners and representatives, West Florida Regional Planning Council, South Alabama Regional Planning Commission
State Government	Executive of a state geospatial training and outreach center
Private Industry	Engineer Contractors, Engineers Contractors specializing in storm-related forensic investigation, roof consultancy, Executive of commercial building reconstruction business, product testing and certification service provider representatives, Private utility representatives
University Student Project	Student team with a semester-long project of ten interdisciplinary students
University Outreach	Management scientists from a university technical outreach center
Action and Observational Researchers	Academicians representing the Colleges of Business, Engineering, Sociology, and Geography

A focus group discussion among ten key disaster response and recovery personnel from Alabama's storm-embattled coastal communities revealed many group perceptions as to why available disaster response strategies were not effectively used to limit the damages from ocean-borne storms. The results of this research were presented to a second focus group, discussed and later analyzed according to prescribed guidelines of a rigorous content analysis procedure (Neuendorf, 2002). The subsequent analysis refined the problem to include contextual-rich understanding, in the words of a focus group panelist, the costs and shortcoming of disaster response and recovery:

> *One of the biggest issues with these commercial businesses, mostly condominiums, we have on our coast is the downtime and loss of rental income. So when you have to stop and have certain structural issues redesigned, the roof system redesigned, you have downtime and loss of rental income. As far as actual reconstruction goes, you are dealing usually with* [underground] *utilities. That's where you really suffer when you don't have as-built type drawings. I'd say the largest financial impact is loss of use of the facility, that's the length of time it takes to restore the property.*

Along with the unavailability of needed information—the *structural designs, as-built drawings, surveys,* and the like - the results of the focus group indicate the need of public/private partnerships and the convergence of Business Continuity (BC) and

Emergency Management (EM). The progress on the research project is illustrated in Fig. 1, where the relationships among Disaster Recovery (DR), BC, and EM are shown as they impact community stability. Community instability shares a symbiotic relationship with organizational failure. Within the context of this study, delays in infrastructure recovery inhibit restoration of business operations that, in turn, inhibit the community's ability to effectively restore infrastructure.

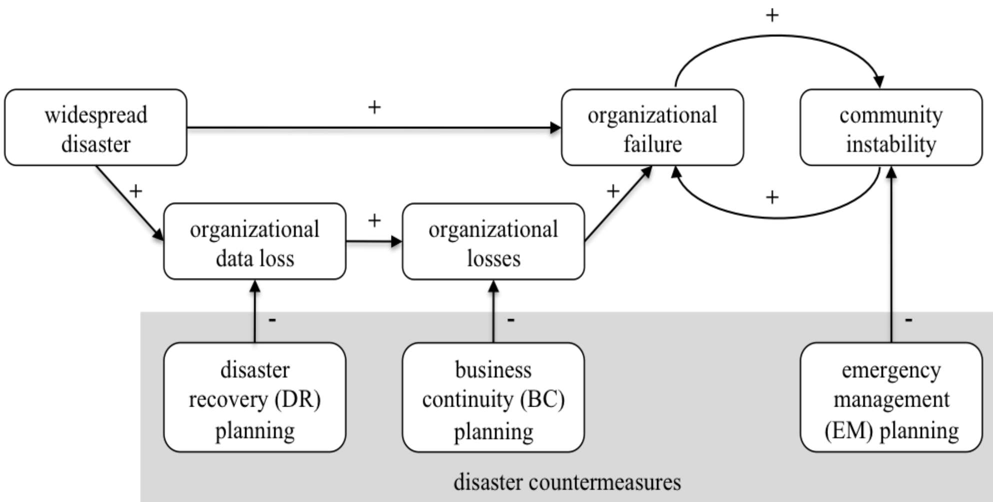

Fig. 1. The relationships of DR, BC on EM planning on community in/stability

A thematic content analysis of the two focus group discussions resulted in the identification of three prominent adoption-related factors from classical innovation diffusion theory (Rogers, 2003): network interconnectivity, value and need compatibility, and relative advantage (Cumbie & Sankar, 2010). For response and recovery personnel, the community wide adoption of disaster countermeasures, such as a comprehensive, co-creative GIS, is inhibited by the lack of *network interconnectivity* among the diverse groups of stakeholders that comprise a community. Critical community infrastructure asset information is dispersed among many community stakeholders: utility (water, power, and communication) organizations, both public and private, as well as supporting organizations that provide engineering, architectural, and related construction services in addition to the real estate and insurance industries.

The members of these networks share common interests in the welfare of the community; however, they tend to have varied *values and needs*. Despite the disconnection among the network of community stakeholders and their varied values and needs, an identified third factor supported the adoption of a comprehensive GIS solution. The participants' emphasis on *perceived relative advantage*, that is, "the degree to which an innovation is perceived as being better than the idea it supersedes" (Rogers, 2003, p. 229), showed that the benefits of adopting of a comprehensive GIS solution far outweigh the costs.

Despite the explicit recognition of the advantage of purposefully utilizing critical community infrastructure information relative to not using it, this realization in itself is not sufficient to overcome the barriers of this task. For one, the network of community stakeholders responsible for infrastructure information are loosely affiliated and such a solution, even one recognized as advantageous, comes only with significant upfront investment and ongoing maintenance. Furthermore, the *organizational slack*—that is, those "…resources [that] give the firm leeway in managing changes in response to a changing environment," (Sharfman, Wolf, Chase, & Tansik, 1988, p. 601; Cyert & March, 1992) is frequently absent in organizations like local governments. Their focus is on the business continuity activity of resumption of *normal operations* (Harris, 2008), including recovering from previous disasters and remaining solvent during economic downturns.

This phase of the project led to the realization that the solution needs to go beyond a straightforward adoption issue and include a multi-organizational perspective that affects nearly all participants in a geographically defined community. The analysis of the focus group discussions further refined pre-conceived notions about the project and introduced a new idea: *recovery efforts following a disaster inflict additional damages to critical community infrastructure and this may contribute to half of the total reconstruction costs*. Furthermore, these damages are avoidable if geospatial information regarding the critical community infrastructure is available at the time of response and recovery. This result led to the second phase of the project.

3.3. Phase II – Pilot critical infrastructure data gathering

The city identified that resources were simply not available to collect geospatial information about its infrastructure resources and requested the researchers to move from an "independent observer" to "active participant" role. In January 2008, the research team joined the IT director of the City of Gulf Shores, and a local private engineering firm with expertise using geospatial tools in order to form a project team. The team formulated a plan to gather critical infrastructure data within an approximately one and one-half mile stretch of the beach along the City of Gulf Shores' coastline. A ten-member student team was briefed on campus by the action research team on general disaster recovery and the specific problems of the community. The student team, under supervision from the action research team, was assigned the following tasks:

- Interview city resources and industry representatives to identify critical data types and sources,
- Learn the use of GPS handheld devices and collect GPS coordinates in a pre-defined coastal study area for all visible utilities and structures,
- Obtain AutoCAD-based data from utilities and import to the GIS platform,
- Upload and integrate critical data collected from the study area to the GIS platform,
- Prepare a process document and training document for using the GPS devices together with the GIS software, and
- Report activities, findings, and recommendations to the action research team and city decision makers.

The student team took action, gathering project requirements prior to two on-site weekend-long visits. The students worked alongside the GIS specialist to integrate data collected with handheld GPS devices and a GPS-enabled digital camera within an ESRI *ArcView* GIS software platform, as maintained by the City of Gulf Shores' IT department.

The student team reported its activities to City of Gulf Shores council and project team members on April 23, 2008; the results were received favorably and resulted in a lively discussion on how to proceed further. The student team reported gains in project management skills and team working skills. The council members requested the research team to further extend the implementation of this project so that it could greatly enhance the area's economic development and societal wellbeing.

From a practical standpoint, the student team was able to provide the needed resources to assist the City of Gulf Shores and effectively broke ground on the project, albeit in a limited, pilot scope. The difficulties of coordinating across the multi-organization environment were a major challenge faced by the team and they were unable to accomplish cross-organizational integration or to address the training of the first responders in a disaster environment. Even though economic advantage was envisioned, none of the stakeholders were keen to spend funds to extend the project further. The City of Gulf Shores hired a part-time student worker to train the first responders on the GIS technologies to better prepare when and if an ocean-borne storm strikes. No more infrastructure data were collected during May 2008 to June 2009.

The shift toward participation in the project enabled the continued discovery, observation, and now, participation congruent with the contextualism approach. The previously identified adoption constructs – *network interconnectivity, value and need compatibility,* and *perceived relative advantage* – manifested themselves during the student project. The *perceived relative advantage* of a geospatial solution was present among team members and community representatives yet lacked the impetus to forge networks or align the goals. Participation remained centralized to the municipal government; however, the integration of university students served as a proxy to collaboration from the community.

The field experience of the students and participation of the researchers lent itself to first-hand manifestations of the theoretical factors at work. The diagnosis at the inception of the second project phase indicated the central and authoritative role of the city government and for mandated policy as the apparatus to effectively connect disparate stakeholders. The student project team's pilot project established technological feasibility to an extent yet could not co-create the procedures among community stakeholders that would establish a policy framework. This led to the Phase III of this project.

3.4. Phase III – Regional model of shared geospatial infrastructure information

Recognizing the need for long-term solutions to the disaster recovery problem, the action research team submitted proposals for funding and received funding support from the Economic Development Administration during 2009. The project, titled, "Helping Build a Disaster-Resilient Alabama Coastal Economy using Geospatial Mapping," had three primary goals.

The first goal of this project was to strategize and come up with a regional model of data sharing. The Phase I and Phase II results showed that the data that needs to be backed up and recovered for a city cannot be assembled in isolation by a city government. This issue becomes even more complex when the data has to be assembled for a county that consists of several coastal cities. Issues of who owns the data, who will maintain the data, and who will assure security need to be resolved. The second goal of this project was to collect, store, and retrieve infrastructure data from multiple partners for selected damage-prone coastal areas in Alabama. Using hand-held GPS units, the infrastructure data can be collected by students in coastal areas of Alabama with sub-meter precision latitude and longitude intersections and uploaded to a GIS platform. The data can then be accessed using popular web browsers with secure protocols. This allows first responders to immediately locate critical infrastructure for inspection and repair and mark their locations to avoid the costly additional damage to these assets during the debris-removal process. The third goal of this project was to train the first responders and county personnel on effective use of the geospatial data.

In total, over 100 students participated in the project and mapped 12,960 facilities along the coastal areas in the Cities of Gulf Shores, Orange Beach, Bayou La Batre, and Dauphin Island. In the July 2011 meeting with community representatives, the project team discussed where the digital information collected in this project will be stored in addition to a central repository (Bain, 2009). The cities and utilities decided to store the information either in an ArcGIS file or as printed maps. As part of the project, mapbooks were created for each of the cities and delivered to the cities of Gulf Shores and Orange Beach as digital files and as actual books of maps for the cities of Bayou La Batre and Dauphin Island. Similar maps in digital and/or physical form were provided to all the cities and utilities involved in this project.

3.5. Analysis of the three phases of the project

The three phases of the action research project yielded many learning opportunities from both academic and practitioner standpoints. Each phase began with a problem diagnoses and concluded with a reformulation of the diagnosis that segued to the next project phase. Research activities included frequent interactions with the variety of stakeholders representing public and private organizations and included a Delphi study, an exploratory and confirmatory focus group, a quantitative and qualitative content analysis of focus group discussions, and a survey to detect stakeholder’s perceived value of GIS infrastructure’s data co-creation.

The survey instrument was distributed to the officials of the cities and utilities following a meeting in order to assess the value of this project. The surveys were distributed during face-to-face meetings, negating non-response. Respondents represented public and private organizations ranging from public and private utilities, emergency management, economic development, and municipal government. Table 3 lists the summary of the responses, including the items that correspond to each factor. The items were all measured on a 5-point Likert scale (-2 to 2), with some items reverse coded. Positive values indicate favorable agreement, scores between 0 and 1 indicate slight agreement, and scores between 1 and 2 indicate strong agreement. Inferential statistical analyses were not used due to the low number of responses.

Table 3
Summary of survey results (N=30)

Factor	Items (Total)	Average	Std. Dev.	Agreement
Overall Value	1 through 6 (10)	1.19	1.14	Slight-Strong
Value to Organizations	1.1, 1.2, 1.3, 3 & 5 (5)	0.95	1.28	Slight
Value to the Community	2.1, 2.2, 2.3, 4 & 6 (5)	1.43	0.93	Slight-Strong
Need for Partnerships	8 (1)	1.73	0.58	Strong
State of Infrastructure Information	7 (1)	0.30	1.16	None-Slight

The results in Table 3 show that the participants perceive that the state of infrastructure information is not conducive to developing a smart city immediately (value of 0.3), whereas, the need for partnerships to achieve a smart city status is high (1.73). The resulting value to the community is also perceived to be high (1.43).

The results of the three-phased action research project and the survey led to the following findings in answering the research question *How can students and educational institutions working with other organizations create smart coastal cities of the future?*

4. Discussion

The findings are:

(a) Although found valuable, it is difficult to get organizations to participate,

(b) External agencies might add significant value to the partnerships,

(c) There is a need for change in mindset of first-responders, and

(d) A model of Co-Creating IT Values needs to be developed.

4.1. Although found valuable, it is difficult to get organizations' to participate

Network interconnectivity, an antecedent to adoption as identified from Innovation Diffusion Theory, was found to be a relevant factor in a community-wide disaster countermeasure adoption (Cumbie, 2008). Network interconnectivity, is perceived as an inhibitor to adopting a GIS to effectively use critical infrastructure information for disaster response and recovery purposes. No single community stakeholder is charged with maintaining this information for this purpose. Resultantly, the information exists among a dispersed group of stakeholders with presumably varied values and needs.

During the course of the action research project, the team contacted many utility providers. The team found limited support among the various stakeholders about the current state of their information on critical infrastructure. They did find that what information is available is in varied formats, including both paper-based and other GIS formats and GPS coordinate standards, and in different states of update. Some of the stakeholders provided information on infrastructure assets, but they did not have geospatial information and requested the help of the research team to collect this information. The restriction of information flows among the network of stakeholders demonstrates the role of network interconnectivity. No existing procedures, let alone workflow software, have been established for the purposes of utilizing critical community infrastructure information.

Analysis of responses to individual items in Table 3 indicated the strongest agreement to the value to the community of a platform for the purposes of disaster response and recovery. This item also had the least amount of variance among responses, indicating the group was most unified in their responses to this item. The group indicated the next strongest agreement for three items: value to organizations for disaster response and recovery, value to the community of a shared GIS system that would be used for the good of the community, and the need for partnerships to attain the value of a shared GIS system.

The only single item that the group indicated negative agreement for is related to their willingness to contribute their information to a shared platform. The next weakest level of agreement, although still a positive level of agreement, is related to the concern of a shared GIS system threatening the overall security of a community. Despite the perceived value, some of the stakeholders were skeptical about contributing their organization's critical community infrastructure information. They did not necessarily believe that contribution would diminish their competitiveness and believed that partnerships are necessary to achieve the value of a shared community wide geospatial platform. There was no statistical difference detected between responses from representatives of public versus private organizations. This finding raises the question of the feasibility of sharing information among the different agencies/ companies/ communities in smart cities.

4.2. External agencies might add significant value to the partnership

IT Value co-creation research (Dhar & Sundararajan, 2007; Kohli & Grover, 2008; Sharaf, Langdon, & Gosain, 2007) states that the separation of information from its artifacts alters the fundamental economics of a number of industries. In a similar manner, digitization of the infrastructure records might stimulate a new kind of economy where trade in this virtual information about the smart cities might become prevalent. The academic community might help these coastal communities since they have the ability to collect digital information about the infrastructure data, train the first-responders to mark them before reconstruction, and provide needed support. At the same time, the providers and maintainers of infrastructure in these communities (such as builders, utility companies, and contractors) might become much more a part of the IT industry than in the past (Gurbaxani, 2003). More powerful infrastructures can allow participants to build new interfaces much more easily. It is possible that in the future, condominium owners, utility providers, and city mangers might be able to digitally track the damage done to their units from safe distances using the technologies offered by such a project when the infrastructure data becomes commoditized and is available quickly and inexpensively (Dhar & Sundararajan, 2007).

IT-based co-creation of value among the multiple partners in this project leads to a need for theories on integration of disparate IT resources, alignment of IT investments and relationship structures, incentives and bargaining positions on proprietary IT resources, and models to co-create IT-based value (Kohli & Grover, 2008). The role of agencies such as the Federal Emergency Management Association (FEMA) and the Department of Homeland Security changes from provider of physical resources during emergencies to an equal provider of digital and physical resources during emergencies. This need for *IT-embeddedness* among the agencies leads to a need for research on identifying digital resources during emergencies, managing changing roles of these agencies, and measuring contingencies under which digitization is considered to be successful in developing smart cities.

4.3. Need for change in mindset of first-responders

The *information mindset* of first-responders needs to change from dealing strictly with crises effectively to aligning the crisis management with information capabilities available to them. This leads to a need for research on improving pedagogy for teaching IT in K-12 and undergraduate classes and developing next generational learning designs to train the first-responders on how to effectively integrate information capability with their physical training. The stakeholders of this project had their *values expanded*, realizing the importance of collecting, storing, and retrieving infrastructure geospatial data. This leads to a need for research to classify types of IT-based value, assess social, economic, and financial models of value when geospatial data is used differentially by communities, and determine IT-based value when a disaster strikes and when there is no disaster (Kohli & Grover, 2008).

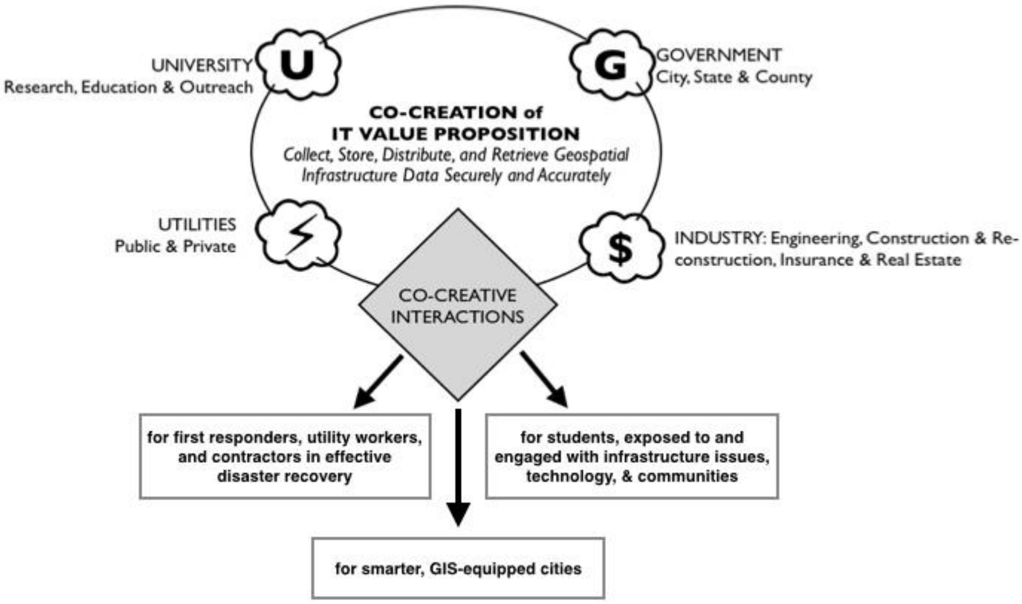

Fig. 2. A model of co-creation of IT value: Next generation learning design

4.4. Development of a model of co-creating IT values

Based on the action research, a research model was developed (Fig. 2) based on past research (Ramaswamy, 2008). The model shows that value is created by interactions among multiple partners including collection, storage, retrieval, access, training, availability, security, accuracy, and integrity of geospatial infrastructure data. These partners might be utilities, counties, cities, and universities, who work together to co-create the geospatial data for communities. Effective co-creating interactions among these organizations have the ability to provide valuable experiences to those who are involved in disaster recovery both during and after the disaster. The effectiveness of these co-creative interactions will impact the speed with which the different communities can recover from disasters.

5. Next generation learning model and ongoing project

During 2011, a Geospatial Research and Applications Center (GRAC) was created at the College of Business, Auburn University. This center followed the model shown in Fig. 2 and has created partnerships with the Cities of Gulf Shores and Opelika, Riviera Utility, and Berntsen International, Inc. Berntsen International Inc., is a producer of RFID tags and is working with the center to investigate how to use their Inframarker tags to better identify infrastructure facilities.

Each semester, fifty students from an introductory MIS class visit a site and investigate use of alternate technologies in mapping and/or retrieving facility information using GPS and RFID technologies. This experiential learning activity has been well received by students and has resulted in a publication (Wu & Sankar, 2013) and receipt of the 2013 Best Paper Award from the Society for Information Management. These projects are ongoing and describe an instance of the model of co-creation shown in Fig. 2. Such an endeavor could form a blueprint for a next generation learning design.

6. Conclusion

Despite benefits from unilateral external resources that flow from federal agencies and charitable organizations following a disaster, communities usually do not gain an overall benefit, and a low percentage of external resources stay within the community after the initial influx (Cumbie, 2008; Chang, 1984). Proactive communities, therefore, look toward to comprehensive plans that include post-disaster redevelopment and development as smart cities (Berke & Campanella, 2006).

This paper contributes by providing the details of a project that uses IT to co-create value in a coastal community by students collecting infrastructure data using geospatial mapping technologies. By working with companies and communities, these students contribute to the communities and at the same time, receive valuable experiential learning. Such a project can serve as a blueprint for a next generation learning design where students co-create value in smart cities. In the end, smart technologies such as GIS are valuable tools but by themselves are insufficient. The keys to success are smart *relationships* that need to be continually cultivated and re-affirmed so as to effect change. Exposure and engagement by today's learners to the infrastructure issues and challenges is a step toward developing tomorrow's smarter cities.

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