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Triple Feedback Hybrid (TFH) GIS Learning Framework: A Learning-Crime Solution Amalgamation

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Abstract - In the past decades, Geographic Information System (GIS) became a powerful tool in policing. However, a niche in the andragogy of GIS training was found. Thus, a Triple Feedback Hybrid (TFH) GIS Learning Framework was formulated to facilitate the learning process. A GIS utility model (GUM) was developed based on a real and specific problem scenario. Afterwards, the learning objectives of the training module syllabus were conveniently contrived as a simulation of the GUM procedure. In connection, module testing through trainings was conducted to equip police personnel with GIS application. It was found that participant attitude and leadership commitment played a central role in GIS learning and implementation. Moreover, focus groups with staggered phasing of trainings provided more attainable learning objectives, adequate time for mastery, and opportunity for reflective learning. As a result, the implementation of GIS in the Baguio City Police (BCPO) became a policy. Furthermore, the humble start of the research made an imprint as a best practice in rationalizing police operations, enhancing crime prevention, and engaging community policing in the regional and national level.

Keywords - GIS, GIS learning, crime mapping, andragogy, problem-based learning

INTRODUCTION

Geographic Information System (GIS) is being used as a decision support tool in policing for more than a decade. As a decision support tool, GIS facilitated crime monitoring, crime analysis, crime prevention, resource allocation, and planning (Maxfield & Babbie, 2009; Griffin, 2001; Baker, 2009). GIS can be used to simulate the occurrence of crimes for spatial analysis (Vijay Kumar & Chandrasekar, 2011). Emerging technologies like cloud computing and mobile technology and advance spatial techniques like data mining are now shaping a new era of crime prevention and crime analysis (Sukanya,M., Kalaikumaran, T., Karthik, S., 2012, Singh et. al, 2012, Wendt & Exner, 2013) .

In policing, an efficient information system is the key to intelligence led policing (ILP). In a management perspective, ILP revolves around the concept of collaboration and community, intelligence as basis of operation, and problem solving. The utilization of GIS facilitates intelligence led policing as indicated in reports and researches in the US, Europe, Canada, and Australia. In the Philippines, little evidence in the use of GIS in policing was found. Full implementation of GIS in developing countries may be a fantasy (Griffin, 2001). Factors such as limitations in resources, access to technology, and technical know-how are influences GIS implementation. Yet it must be noted that the use of GIS in police intelligence was indicated in the Philippine National Police (PNP) Annual Accomplishment Report 2011.

Environment is considered as a determinant in the commission of a crime. Environmental attributes and environmental design governs a geographic locale as criminal attractor (Tabangin, Flores, & Emperador, 2008; Vijay Kumar & Chandrasekar, 2011; Wendt & Exner, 2013). Environmental criminology is a criminological theory that relates the environment as a motivation for people to commit criminal acts. The spatial sense of crimes gives an opportunity for GIS application.

As per PROCOR Unit Crime Periodic Report (UCPER) 2011, the highly urbanized city of Baguio was chosen as the locale of study for PROCOR reports show that about 70% of crime incidents in the Cordilleras happen here. The top three (3) index crimes were physical injuries, theft, and robbery. BCPO reports a crime solution efficiency (CSE) of 22% as per UCPER 2011. Thus, one of the goals of BCPO WAS to increase CSE. CSE reflects the efficiency of law enforcement agencies in solving cases across a given period of time.

This paper is a product of a research project conducted by the University of the Cordilleras (UC) with the Baguio City Police Office (BCPO) as the beneficiary.

With the positive impact of the project, a Memorandum of Agreement (MOA) was signed between UC and the Police Regional Office – Cordillera (PROCOR) during the 23rd of March, 2012. It must be noted that BCPO is under the umbrella of command of PROCOR. A policy for a region-wide GIS institutionalization was issued by PROCOR on May 2012. After choropleth maps, point maps were sought to represent crime. As a result, the GIS Based Crime Analysis (GIS BCA) was developed as tool to analyze crime. Moreover, a Web Based Crime Mapping (www.procor.pnp.gov.ph/crimemap/) with the aim of promoting crime visualization and awareness to the public was developed by UC in collaboration with PROCOR and was launched December 2012.

A better focus is needed on the development of a framework that fully enables the potential of GIS to support contemporary pedagogy in crime mapping (Kinniburgh, 2010). Indeed, training police personnel without background in GIS is a significant challenge. GIS requires spatial literacy, which is a distinct intelligence category. Visual-spatial intelligence gets more evident with increased access to television, video games, and the internet (Van Leeuwen & Scholten, 2009).

Aside from being a vehicle for different skills, GIS can enhance spatial thinking (Comber, Buxton, Jarvis, Wellens, and Wood, 2008; Jarvis and Ashfield, 2009). Spatial thinking being a cognitive skill is a blend of the concepts of space, the tools of representation, and the process of reasoning (National Academic Press, 2006).

A problem based learning (PBL) strategy fits into GIS learning (Calvo Melero, 2005; and Drennon, 2005). As an effective learning approach, a PBL environment places the real world problems, data, and field learning experiences at the centre of the learning environment rather than the discipline (Drennon, 2005; Kinniburg, 2010; Car, 2004). The GIS training syllabus developed in the study targeted output maps that reflected real world crime incidences which utilized live crime data. The live crime data were collated reports from the ten (10) police stations of Baguio City. Aside from dealing with live crime data, the GIS training module was strategically scheduled to monitor participant progress and to evaluate participant outputs.

Broad literature search revealed a niche in the andragogy of GIS learning in policing. More researches are needed to reveal the circumstances of using PBL in achieving lifelong learning skills, effectiveness of GIS use in education, and impact of GIS to learning skills (Pawson, Fournier, Haigh, Muniz, Trafford, & Vajockzki, 2006; Van Leeuwen and Scholten, 2009).

OBJECTIVES OF THE STUDY

Integrated Land and Water Information System (ILWIS), an open source desktop GIS software, was installed on existing computers at BCPO. The open source application eliminated problems in hardware and software acquisition. The utilization of GIS depends on the efficacy of GIS learning. Many challenges were identified during the GIS implementation but this paper focuses only in the andragogy of GIS learning in policing. Enumerated are the objectives of the study.

1. Create a GIS learning framework;
2. Evaluate the GIS learning framework;
3. Develop a GIS Utility Model (GUM) in generating thematic maps;
4. Identify the factors that influence GIS learning and its implementation; and
5. Evaluate the efficacy of GIS as a crime solution tool.

The transfer and utilization of GIS in BCPO was aimed. The goal of the GIS training series was to promote lifelong learning skills that were crucial in achieving intelligence led policing.

MATERIALS AND METHODS

The study was an applied research where multi-method approaches (Lazar, Feng & Hochheiser, 2010) were utilized. The research was designed as a case study, however, experimental study was performed to evaluate the training syllabus. Interview and observation were the main data gathering tools.

GUM aimed to provide an approach to a particular policing problem. Crime data for calendar year 2010 were collected for the purpose of developing the GUM. The crime data for calendar year 2011 were intended as a GIS training input data. The GUM was the basis of the learning objectives in the training module. The training module was designed to reflect GIS functionalities that were relevant to police needs.

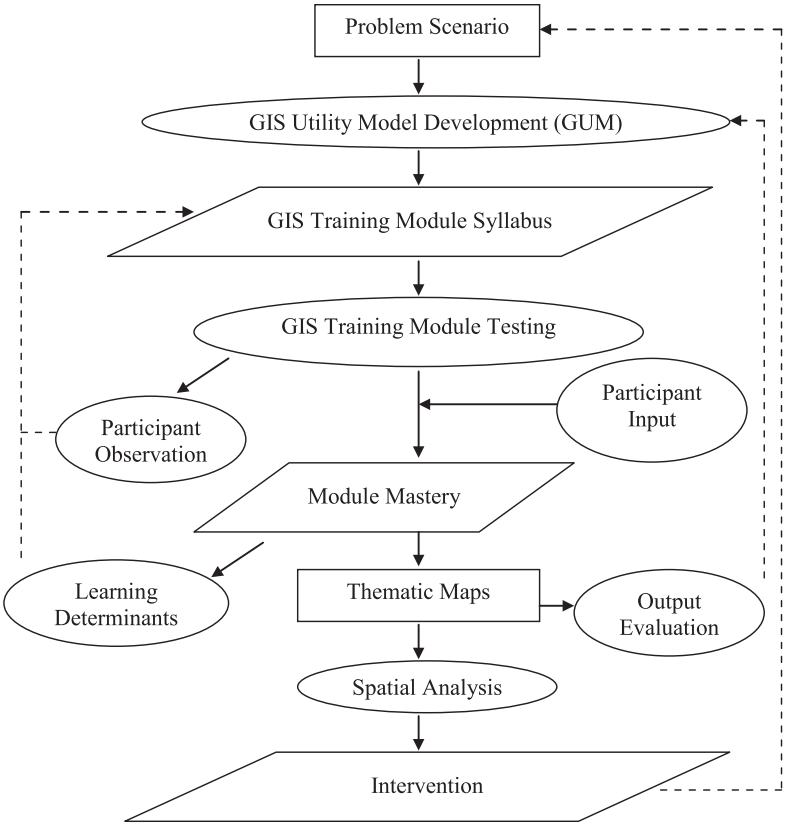

Figure 1. Triple Feedback Hybrid GIS Learning Framework

Figure 1 shows the Triple Feedback Hybrid GIS Learning Framework. The model combined the essentials of problem based learning, outcomes based learning, student centered learning, and participatory learning. A triple feedback mechanism guarantees dynamic GIS learning environment and rational evaluation technique. The learning model was developed and applied during the police trainings. GIS learning started with specific problem scenario. The approach resembled a problem based learning where realistic problems were tackled (Pawson et al., 2006).

A GIS Utility Model (GUM) was first developed, and a module was created. It must be noted that the GUM was based on a policing problem. A requirement in the GUM was the acquisition of digital maps and crime data. The digital maps were digitized and georeferenced. Moreover, relevant crime data based on the policing

problem were gathered. The crime data utilized came from the BCPO UCPER (2010-2012).

The GIS training module syllabus outlines the learning objectives. The learning objectives were focused on certain GIS concepts and functionalities. The actual procedure performed in the GUM was simulated in the training module. The teaching approach was more realistic, and an error troubleshooting was eased.

Trainings were conducted to test the GIS training module. The results of the observation served as an input to the first feedback loop. Participant observation is a clear-cut technique (Clark, Monk, & Yool, 2007). Herein, the syllabus was evaluated and revised. During the training, inputs from the participants were noted and integrated. After the module was mastered, learning determinants were derived. Through an interview, the learning determinants were the next input to the syllabus revision.

The main output of the training was the creation of thematic maps. Outcome based learning was used as an approach. The thematic maps summarized the compliance of the participants to various learning objectives. Output evaluation was used to reconcile actual learning outcomes vis a vis ideal learning outcomes as prescribed in the GUM. The output evaluation served as an indicator of the efficacy of the GUM.

Spatial analysis was an analytical technique performed to determine the spatial distribution to derive relationships and associations. Spatial analysis uses geospatial techniques such as map overlay, raster analysis, geostatistics, and neighborhood operations.

Spatial analysis gave a deeper understanding on the characteristic of a certain phenomenon. Interventions formulated to solve a certain problem scenario were based on spatial analysis. The intervention was evaluated vis a vis the problem scenario. Did the intervention solve the problem scenario? If yes, then the GUM and consequently the training attained the desired goals. If not, then adjustments are mandatory in the GUM.

RESULTS AND DISCUSSION

In 2011, BCPO was still developing its geodatabase; thus, the digitizing of relevant data, and data import were performed. The problem scenario was the representation of crime data from an excel file to a GIS generated thematic map. Formosa (2012) emphasized the challenges in obtaining crime data, digitizing, data cleaning, geocoding, and the establishment of spatial baseline dataset.

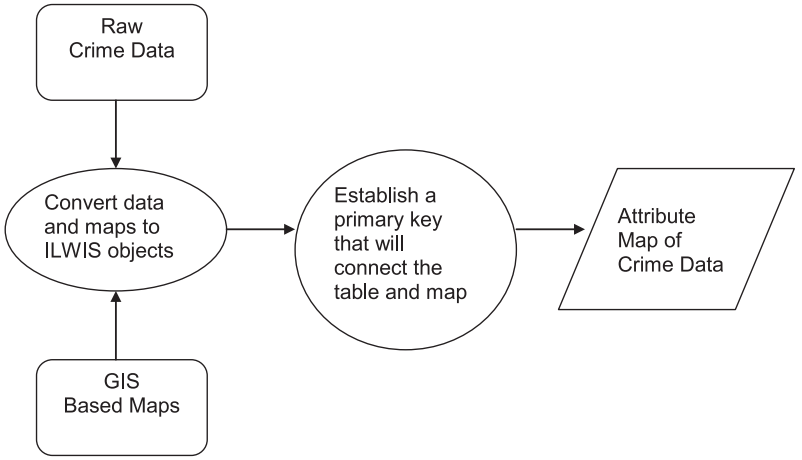

Figure 2. GUM for representing crime data from an excel file
to a GIS generated thematic map

The GUM is a set of procedure in converting crime data in excel tables to digital crime maps. Beforehand, the community map was retrieved from the City Planning and Development Office of Baguio City, and crime data were gathered from collated reports at BCPO. Raw crime data were encoded as an excel file. The excel file was formatted as shown in Figure 3. ILWIS has the functionality of importing external database. Thus, the excel file was then imported and formatted using the functionalities of Microsoft Access 2007. The access file was converted as an ILWIS object. Moreover, the primary key that connected the table to the map was the barangay ID. Finally, thematic maps showing crime data were produced using ILWIS.

	B	C	D	E	F	G	H	I	J	K	L	M	N
1 2 3	BARANGAY_ID	BARANGAY_NAME	MUR	HOM	PHYSICAL_INJURIES	RAPE	ROB	THEFT	CARNPG	CATTLE_RUSTLING	TOTAL_INDEX	NON_INDEX	CRIME_VOLUME
4	nr 10	Campo Filipino	0	0	6	0	8	0	0	0	14	7	21
5	nr 54	Dominican Hill-Mirador	0	0	9	1	4	6	0	0	20	8	28
6	nr 51	Fairview Village	0	0	8	0	2	7	0	0	17	11	28
7	nr 9	Lourdes Subd., Extension	0	0	6	0	0	2	0	0	8	4	12
8	nr 38	Lourdes Subd., Lower	0	0	0	0	0	1	0	0	1	1	2
9	nr 39	Lourdes Subd., Proper	0	0	1	0	2	0	0	0	3	2	5
10	nr 30	MRR Queen of Peace	0	0	3	0	1	3	0	0	7	6	13
11	nr 8	Quezon Hill Proper	0	0	3	0	1	4	0	0	8	2	10
12	nr 52	Quezon Hill Subd., Middle	0	0	2	0	1	1	0	0	4	5	9
13	nr 53	Quezon Hill Upper	0	0	4	0	1	1	0	0	6	6	12
14	nr 5	San Luis Village	0	0	3	0	3	6	0	0	12	9	21
15	nr 6	San Roque Village	0	0	6	0	1	5	0	0	12	9	21
16	nr 7	Victoria Village	0	0	1	0	0	1	0	0	2	3	5
17	nr 89	Alfonso Tabora	0	1	4	0	1	3	0	0	9	1	10
18	nr 11	Andres Bonifacio	0	0	3	0	1	1	0	0	5	0	5
19	nr 63	Camdas Subdivision	0	0	5	0	4	2	0	0	11	3	14
20	nr 47	Cresencia Village	0	0	4	1	1	11	0	0	17	4	21
21	nr 49	Dizon Subdivision	0	1	2	0	5	3	0	0	11	1	12

Figure 3. Formatted and Import Ready Crime Data Excel File

Figure 4 shows the crime hotspots of Baguio City for 2010. The generated map was a choropleth map. The values represented in the choropleth map got its value from the formatted excel file. It must be noted that there are 128 barangays (village, district, or ward) in Baguio City, thus, only a portion of the table was captured. The GUM shows crime hotspots as per crime type and crime volume.

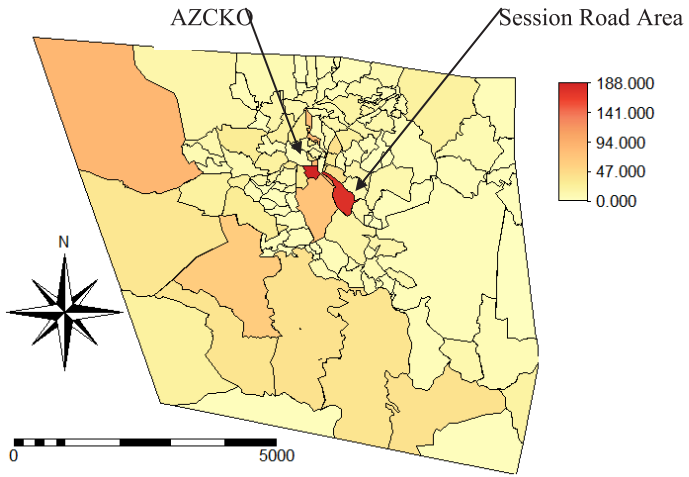

Figure 4. Crime Volume Map for Calendar Year 2010

Based on the GUM, a GIS training module syllabus was developed. The syllabus reflects the competencies needed in the GUM. There were two modules, file import and attribute map creation. In connection, the following learning objectives were set.

1. Import the excel file as an access file
2. Convert the access file to an ILWIS object
3. Create an attribute map of a table

Indeed, it was very convenient to create a module and a set of learning objectives when the GUM was in place. GIS skills were introduced when the problem unfolded to give an opportunity to problem solving (Drennon, 2005). The police trainees have no background in GIS and a little on geography. As a resolution, engaging the trainees in a real world setting facilitated the learning process (Drennon, 2005).

One day training with 35 participants was conducted for a large group as means to test the module. However, it was observed that the given time was not adequate, and the learning objectives were hardly met. The participant observation gave a crucial revision to the syllabus. In the second module test, training was conducted to a smaller group in BCPO – Operation Department. The training was conducted in five (5) sessions, at two (2) hours per session, in a span of a month from July-August 2011. The participants stressed the effectiveness of attaining specific learning objectives with ample time for mastery. Moreover, the participants cited the benefits of training a smaller group because queries were easily answered and troubleshooting was easily facilitated. An outcomes based feedback mechanism was performed during the trainings. It was pointed out by the participants that the outcomes based approach motivated them to master the module.

Substantial learning outcomes were achieved during the second testing. It was observed that the participants were intensely engaged during the training. The observation indicates the benefit gained in dealing with a real world problem and the efficacy of a problem based learning. Furthermore, the learning model was reinforced with participatory learning where the participants gave significant inputs to the GIS learning process. The participants noted errors and queries that they have encountered during the exploratory stage, and suggested deadlines in meeting some learning objectives. The exploratory stage, about five (5) to seven (7) days gave an opportunity for a self directed learning. A similar approach was reported to be effective by Comber et al. (2008) in a paper entitled: "Developing Spatial Literacy Secondary Education: GIS Practicals for Key Stage 3". Finally, the combination of the different learning techniques led to the mastery of the module.

Through an interview, the learning determinants were noted. It was found that

attitude and leadership played a central role in successful module mastery. Attitude such as interests and initiative were stressed as crucial elements for module mastery. On the other hand, leadership through the commitment of the department heads and directors were cited as compelling factors for a successful GIS implementation.

Simple spatial analysis was performed by determining the crime patterns. Choropleth generated crime maps showed vivid crime patterns as to crime type and crime volume. By time series analysis, it was observed that theft cases were concentrated in Session Road Area and physical injury cases in AZCKO. Choropleth generated crime gives a rapid approach in identifying geographic clusters of crime problems, and concentrations of crime (Maxfield and Babbie, 2009).

As shown in Figure 4, the dominantly red areas highlights Session Road Area and AZCKO. It must be noted that physical injury and theft are the top index crimes in Baguio City. Thus, as an intervention BCPO increased police visibility in these communities. Policing strategies like manpower allocation can be facilitated using crime maps (Vijay Kumar & Chandrasekar, 2011). Furthermore, it was through this circumstance that community policing was facilitated because of the shortage of police manpower. PROCOR reports a police to population ratio of 1:697 whereas the ideal ratio must be 1:500. Thus, force multipliers were tapped from the Barangay Peacekeeping Action Team (BPAT), PROCOR, and the Armed Forces of the Philippines (AFP) Counterparts.

Finally, the third feedback loop was designed to evaluate the efficacy of the said intervention. The GIS generated thematic crime maps also served as an evaluation tool for the said intervention. Surprisingly, BCPO records indicated a significant decrease in crime incidences and a marked increase in CSE. Figure 5 shows the physical injury cases for the 1st quarter of 2011 and 1st quarter of 2012. On the other hand, Figure 6 shows the theft cases for the 1st quarter of 2011 and 1st quarter of 2012.

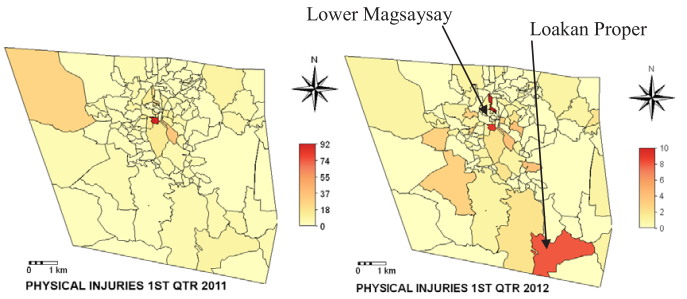

Figure 5. Physical Injury Cases 1st Quarter 2011 (left) and 1st Quarter 2012 (right)

Figure 5 clearly shows a nine (9) fold decrease in physical injury cases in hotspots from 92 cases to just ten (10) cases. Based on PROCOR records, the whole of Baguio City experienced a steep drop of physical injury cases from 602 cases in 2011 to 102 cases in 2012. In 2011, 92 physical injury cases were concentrated in AZCKO but in 2012: Lower Magsaysay leads with ten (10) incidences, followed by AZCKO with nine (9) incidences, and Loakan Proper with eight (8) incidences. Furthermore, police interventions resulted to a six (6) fold decrease in theft cases in AZCKO, from 57 cases in 2011 to 10 cases in 2012.

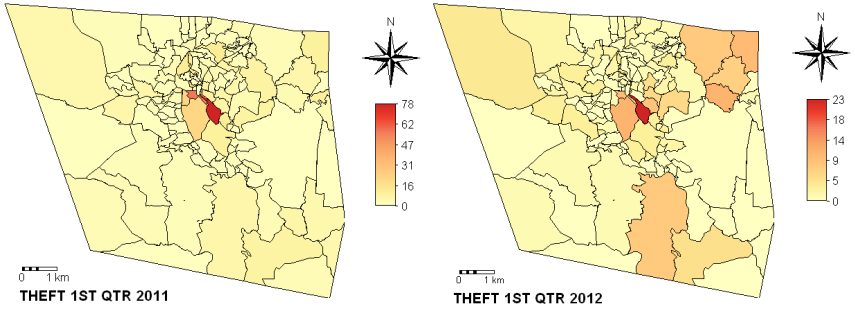

Figure 6. Theft Cases 1st Quarter 2011 (left) and 1st Quarter 2012 (right)

Figure 6 clearly shows a three (3) fold decrease in theft cases in Session Road Area, from 78 cases to just 23 cases in 2012. Based on PROCOR records, the whole of Baguio City experienced a steep drop of theft cases from 657 cases in 2011 to 223 cases in 2012. It was observed that theft cases emanated in ten (10) other barangays with six (6) to 11 theft cases. Furthermore, police interventions resulted to a nine (9) fold decrease in physical injury cases in Session Road Area, from 34 cases in 2011 to just four (4) cases this in 2012.

The decrease of crime incidents subsequently increased the CSE for physical injury and theft. For physical injuries, BCPO reports about fourfold increase, from 7.64% in 2011 to 26.53% in 2012. On the other hand, about a three fold increase for theft from 9.44% in 2011 to 25.13% in 2012.

The data gathered for the evaluation of police intervention came from the Unit Crime Periodic Report (UCPER) of BCPO. The results of the study were presented during the First Quarter Command Conference of 2012 held in PROCOR headquarters in La Trinidad, Benguet. The command conference was attended by the regional director, city police director, department heads of PROCOR, chief of police of the different BCPO stations, and other key police officers. Operational reports of

BCPO continue to show a downward trend of crime with the full implementation of GIS Based Crime Analysis (GIS BCA) since October 2012. However, a more detailed assessment of the impact of a GIS based crime mapping, secondary phase of time series analysis, and identification of other possible factors in the crime trend should be researched further.

CONCLUSIONS

A GIS learning framework was created with a triple feedback loop mechanism and a hybrid of learning strategies. Traditional GIS learning sticks on a generic approach which might downplay learning and motivation. The GIS learning framework proved to be effective GIS learning tool and iterative mechanism. Aside from GIS learning, the framework proved to be an effective evaluation tool for police intervention. The combination of problem based learning, outcomes based learning, student centered learning, and participatory learning exhibited complementary roles in the overall learning process. Other benefits include rationalization of learning objectives; facilitation of training module, and analytical tool. The GIS learning framework is resilient and can act as a learning-solving template for a wide array of problems. However, the learning framework can still be improved by making further studies in other fields.

A GUM based on the problem scenario was developed. The actual procedure performed in the GUM was simulated in the GIS training module. Based on the findings, specific learning objectives, and training modules were conveniently prepared because of the GUM. Also, GUM aids in anticipating difficulties and minimizing errors during the training.

The factors that influence GIS learning and its implementation were evident in the participant observation, participant input, learning determinants, and output evaluation. Based on the results, participant attitude and leadership commitment played a central role in GIS learning and implementation. Moreover, attainment of learning objectives with an ample amount of time for mastery and focus group were crucial factors during the training stage. However, the conduct of focus group with staggered phasing of trainings was expensive and time demanding. Large group trainings can still be administered yet follow up trainings will still be necessary.

Police visibility and community policing were interventions made by BCPO as a result of the GIS spatial analysis. As an applied research, the most useful crime maps will showed patterns that can help analysts and police decide what sort of action to take (Maxfield and Babbie, 2009). The interventions were administered in AZCKO and Session Road Area, the two top crime hotspots. By making a comparison of the 1st

quarter crime statistics of 2011 and in 2012, a significant decrease in crime incidences, and a marked increase in the crime solution efficiency (CSE) were observed. Indeed, GIS is a program evaluation tool. The facts undoubtedly highlight the efficacy of GIS as a crime solution tool. However, an in depth research is recommended to reveal undiscovered truths on phenomenon that transpired.

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