EXPLORING DATA MINING AND GAMIFICATION AS TOOLS FOR POVERTY ANALYSIS AND POLICY FORMULATION: A METHODOLOGICAL FRAMEWORK

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ABSTRACT

Economies are deemed to have automated systems of collecting their respective poverty statistics because the availability of these databases are imperative, which have generated a need for new techniques that will transform the data into useful information that can assist policymakers in formulating effective poverty-reduction policies. An alternative method is the use of data mining techniques – the extraction of hidden patterns of information from large databases, beyond regression, that will allow for the generation of a prediction on the direction and extent of change on the status of a sample. After determining these hidden patterns, the application of gamification can be utilized as a behavior change mechanism particularly for people who are predisposed to engaging in games on issues that are reality-based. The change in behavior gets manifested in their opinions about an issue or problem and subsequently takes positive actions towards a solution to a problem. Various problems besetting poverty stricken households can be solved through change in behavior once they realize the opportunities that can come their way by doing so. The change is much more effective if part of the motivation comes from within the individual and the immediate environment makes it possible for them to see the positive effect this change will bring.

INTRODUCTION

Poverty remains one of the rampant social problems any economy needs to address. With the Philippines' poverty line marked at earnings less than PHP 16,841.00 per individual annually. According to data from the National Statistical Coordination Board (NSCB), 26.5% of the population falls below the poverty line in 2009. Though this figure is a much lower than a comparative figure of 33.1% in 1991, the decline has been slow and uneven, much slower than neighboring countries who experienced broadly similar numbers in the 1980s, such as the People's Republic of China (PRC), Thailand, Indonesia (where poverty level lies at 8.5%) or Viet Nam (13.5%). The Philippines' incidence of poverty remains significantly high as compared to other countries for almost a decade now. The unevenness of the decline has been attributed to a large range of income brackets across regions and sectors. Rapid population growth has also contributed to this predicament (Rivera & See, 2012).

The government planned to eradicate poverty as stated in the Philippines Development Plan (PDP). The PDP for the next six years are an annual economic growth of 7% to 8% and the achievement of the Millennium Development Goals (MDGs). Under the MDGs, Philippines committed itself to halving extreme poverty from a 33.1% in 1991 to 16.6 % by 2015 (Rivera, Pizarro, Aliping & Reyes, 2012).

Poverty assessment and monitoring is one of the focus areas of the United Nations Development Program. According to the United Nations Development Programme [UNDP] (2012), fighting poverty and making progress towards the MDGs requires effective policies to reduce poverty and promote inclusive development. The design and implementation of policies for social inclusion require a good system of information to better understand the problem: what is poverty, what causes it, who does it affect, how does it evolve over time and what impact do development policies and programs have on poverty. Establishing a poverty monitoring and assessment system to answer these questions is fundamental to the design of effective poverty reduction policies. Such systems are also necessary to help governments and the development community to keep track of progress towards the MDGs (UNDP, 2012).

According to the National Anti-Poverty Commission [NAPC] (2012), fiscal constraints in the Philippines have compelled the government to implement targeted interventions directing public resources to the poor and marginalized groups. Identifying who and where the poor are is vital in efficiently and effectively implementing poverty-alleviation programs and projects. The Department of Social Welfare and Development (DSWD) is adopting the National Household Targeting System for Poverty Reduction (NHTS – PR) using the Proxy Means Test (PMT) in identifying their target beneficiaries for their flagship program, the *Pantawid Pamilyang Pilipino Program* (4Ps). The local government units (LGUs) have been encouraged to utilize the Community Based Monitoring System (CBMS) through SDC Resolution No. 3, Series of 2006 and Cabinet Secretary's Memorandum dated 11 March 2008 to target beneficiaries for their poverty programs and to evaluate these programs.

The NAPC (2012) has emphasized that the NHTS-PR is a data management system that identifies who and where the poor households are. It generates to the public a database of poor households as reference in identifying beneficiaries of social protection programs. Likewise, the system is also envisioned to reduce inclusion of inadvertent beneficiaries and exclusion of intended beneficiaries of social protection programs.

The NHTS-PR utilizes a "paper and pencil" approach in gathering data. It evaluates all households in all deprived areas and those pockets of poverty via house-to-house interviews. It collects information from the Household Assessment Form – a two-page questionnaire with 34 variables of interest. It applies the Proxy Means Test (PMT) – model, which according to NAPC (2012), estimates poverty level of households and ranking them based on provincial poverty thresholds. It is administered using standardized software developed to allow easy input of the household assessment information and homogenous processing of the information. This is to guarantee the quality of the information generated by the system.

A statistical formula computes the households' approximate income using proxy socio-economic variables that would predict household income and allow for objective ranking and classification of households into non-poor, survival poor, and food-poor. The selected variables considered good proxies of income are the following as per NAPC (2012): (1) household

consumption; (2) education of household members; (3) housing conditions; (4) access to basic services; (5) ownership of assets, tenure status; and (6) regional variables.

The CBMS Survey was developed to provide a good information base for policymakers in monitoring the effects of economic reforms to society's vulnerable groups. It addresses the inadequacy of vital yet disaggregated information for poverty analysis and design of appropriate interventions, for targeting of program beneficiaries and for program impact monitoring. CBMS' five objectives, as cited by NAPC (2012) are (1) to diagnose the extent of poverty at the local level; (2) formulate appropriate plans and programs to address problems; (3) provide the basis for rational allocation of resources; (4) identify eligible beneficiaries for targeted programs; and (5) monitor and assess the impact of programs and projects.

Note that the CBMS involves a census of households in a community. It is LGU-based and it fosters community participation by tapping existing LGU personnel/community members as monitors. It has a core set of indicators but the system can accommodate additional indicators. It establishes database at each geopolitical level (NAPC, 2012).

The data, which could be generated from the CBMS, contain the core set of indicators that covers the multidimensional nature of poverty. The core indicators are: (1) Proportion of children aged 0 to 5 years old who died to the sum of children aged 0 to 5 years old; (2) Women deaths due to pregnancy-related causes; (3) Malnutrition prevalence/proportion of children aged 0 to 5 years old who are malnourished to the total number of children 0 to 5 years old; (4) Proportion of households without access to safe water; (5) Proportion of households without access to sanitary toilet facilities; (6) Proportion of households who are squatting; (7) Proportion of households who are living in makeshift housing; (8) Proportion of households with members victimized by crimes; (9) Proportion of households with income less than the poverty threshold; (10) Proportion of households with income less than the food threshold; (11) Proportion of households who eat less than 3 meals a day; (12) Unemployment rate; (13) Elementary school participation rate; and (14) Secondary school participation rate. Other local government (LGU)-specific indicators relating to disabilities, natural calamities, migration, waste management, access to programs, electoral participation and community organization (NAPC, 2012).

In the Philippines, there are at least two separate automated systems of collecting and storing poverty data that are currently operational – NHTS-PR and CBMS. The availability and accessibility of these databases have generated a compelling need for new techniques and automated tools that can intelligently assist policy-makers in formulating poverty reduction policies. Parallel to the idea of Han, Kamber and Pei (2011), new and better ways to automatically analyze, classify, summarize, discover and characterize trends and flag anomalies in poverty data are urgently needed. Transforming the data into useful information and knowledge that will assist in the design of effective poverty reduction policies is imperative.

Data mining has been adopted by many organizations and has been utilized intensively and extensively as a decision-support tool. Yet to date, there has been a dearth of research work in using data mining as a tool in poverty assessment and analysis. Policy-makers often expend a lot of resources in the formulation of poverty reduction policies. However, due to lack of collective accountability, the best policies tend to fall through. Thus, it is important that decision-makers implement poverty reduction policies that are clear, understandable, realistic, consistent and enforceable. Policy-makers should utilize every possible means to convince the citizenry and other

concerned sectors of society of the benefits of the poverty reduction policy initiatives they have formulated. They should find the venue to effectively communicate policy information credibly. They should be able to regularly engage the citizenry and other sectors of society towards the successful adoption and implementation of the poverty reduction reforms.

The problem that will be tackled in this study is in determining the extent by which data mining can establish trends in the CBMS database or relationships among data gathered at the household level that would point to specific problem areas in the community. Once the problem areas are identified, information dissemination and behavior change efforts can be instituted by way of the appropriate game design. From this backdrop, this study can explore the following specific objectives.

- Identify problem areas in a specific low-income community using the existing database collected from households (i.e. CBMS) in this area through data mining;
- Develop game designs that would get various stakeholders involved, firstly, in being aware about the community problem(s) and its root cause and, secondly, what appropriate actions they are willing to take towards solving the problem.
- Conduct pre- and post evaluation and cost-benefit studies of the interventions conducted to determine its effectiveness.

ALTERNATIVE APPROACHES TO POVERTY ANALYSIS

Data mining (DM), as seen from Figure 1, is the extraction of hidden patterns of information from large databases. It has been extensively used by various types of organizations: financial institutions, for credit scoring and fraud detection; marketers, for direct marketing and cross-selling or up-selling; retailers, for market segmentation and store layout; and manufacturers, for quality control and maintenance scheduling (Koh & Tan, 2005).

Basically, the goal of data mining is to generate either prediction on direction and extent of change on the status or condition of the target class or description of the subjects' current and past status. Predictive mining performs induction on the current data in order to make predictions. It involves using some variables or fields in the data set to classify, predict unknown values or estimate values of the variables of interest. On the other hand, descriptive mining characterizes properties of the data in a target data set. It involves finding patterns and relationships in the data that can be interpreted. For example, DM tools can spot the frequent occurrence of open dumpsites and pest infestation together (Han, Kamber & Pei, 2011; Syed, 2011).

There are a number of data mining functionalities, which are being used to specify the kinds of patterns to be found in data mining tasks. These include characterization and discrimination; the mining of frequent patterns, associations, and correlations; classification and regression; clustering analysis; and outlier analysis (Han, Kamber & Pei, 2011).

Data characterization, as defined by Han, Kamber and Pei (2011), is a summary of the general qualities of a target class of data. The data corresponding to the user-specified class are collected by a query. Meanwhile, data discrimination, as defined also by Han, Kamber and Pei (2011), is a comparison of the general features of the target class data objects against the general features of objects from one or multiple contrasting classes. A user can specify the target and contrasting classes and the corresponding data objects can be retrieved through database queries.

Figure 1
Data Mining on Poverty – The Process
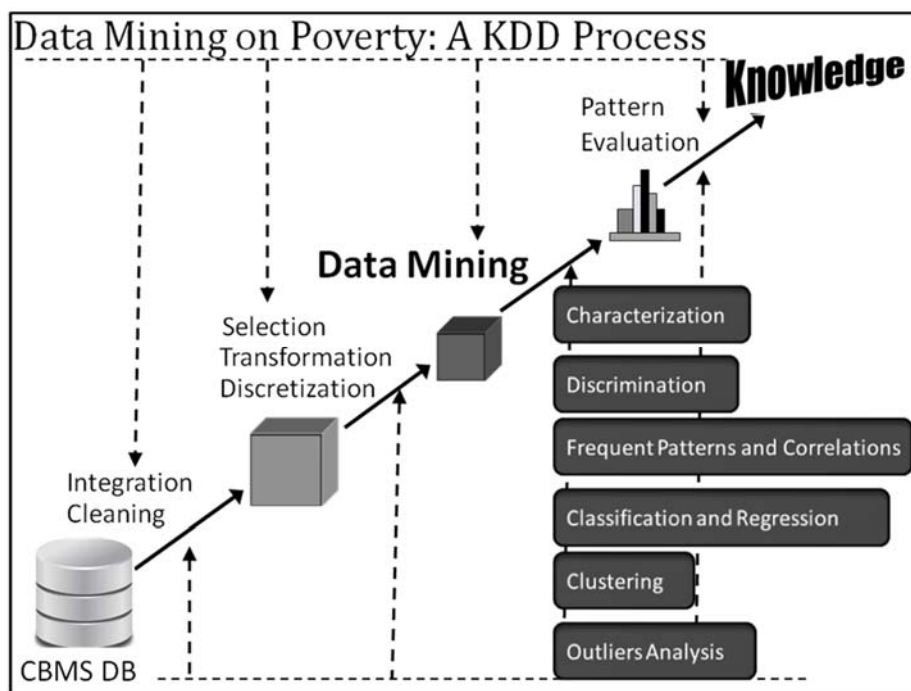
Source: Adapted from Han, Kamber and Pei (2011)

Frequent patterns are patterns that occur habitually in data such as frequent item sets, sequential patterns, and frequent substructures. Mining of frequent patterns leads to the discovery of interesting associations within data (Han, Kamber & Pei, 2011).

On the one hand, classification is the process of finding a model that describes and distinguishes data classes. The models are derived based on the analysis of a set of training data. The model is used to predict the class label of objects for which the class label is unknown. Whereas, classification predicts categorical labels and regression models continuous-valued functions – regression is used to predict missing or unavailable numerical data values rather than discrete class labels. The term prediction refers to both numeric prediction and class label prediction. Regression analysis is a statistical methodology that is most often used for numeric prediction, although other methods also exist. Regression also comprises the identification of distribution trends based on the existing data (Han, Kamber & Pei, 2011).

On the other hand, clustering can be used to generate class labels for a group of data. The objects are clustered based on the principle of maximizing intra-class similarity and minimizing interclass similarity – clusters of objects are formed so that objects within a cluster have high similarity in comparison with each other, but are dissimilar to objects in other clusters. Each cluster formed can be viewed as a class of objects, from which rules can be derived. Clustering can also facilitate taxonomy formation – the organization of observations into a hierarchy of classes that group similar events together (Han, Kamber & Pei, 2011).

As accentuated by Han, Kamber and Pei (2011), a data may encompass objects that do not conform to the general behavior of the data – outliers. Various data mining methods discard

outliers as exclusions. However, the sporadic events can be more interesting than the more regularly transpiring ones. The analysis of outlier data is referred to as anomaly mining. Outliers may be detected using statistical tests that assume a distribution for the data, or using distance measures where objects that are remote from any other cluster are considered outliers. Rather than using statistical or distance measures, density-based methods may identify outliers in a local region, although they look normal from a global statistical distribution view.

Data mining is a powerful new technology with great potential Alexander (n.d.). With respect to poverty reduction, it can help policy-makers focus on the most important information in poverty databases. The application of data mining functionalities can enable the prediction of future trends and behaviors in poverty data, thereby allowing decision-makers to make proactive, knowledge-driven decisions towards poverty reduction and advancement of human development (Adeyemo & Kuye, 2006). Data mining tools can scour poverty databases for hidden patterns that poverty experts may miss because they lie outside their realm of regular expectations (Alexander, n.d.).

GAMIFICATION: TURNING POLICY INTO ACTION

According to Zicherman and Cunningham (2011), the idea of using game-thinking and game mechanics to solve problems and engage audiences isn't exactly new. The military has been using games and simulations for hundreds, if not thousands, of years, and the Unites States of America (USA) military has been a pioneer in the use of video games across branches. They also say that play and games are enshrined in our cultural record, emerging with civilizations, always intertwined; and that we are hardwired to play, with researchers increasingly discovering the complex relationships between our brains, neural systems, and game play. Gamification is the use of game design techniques, game thinking and game mechanics to enhance non-game contexts such as poverty. Typically it applies to non-game applications and processes, in order to encourage people to adopt them, or to influence how they are used. It works by making technology more engaging, by encouraging users to engage in desired behaviors, by showing a path to mastery and autonomy, by helping to solve problems and not being a distraction, and by taking advantage of humans' psychological predisposition to engage in gaming. The technique can encourage people to perform chores that they ordinarily consider boring, such as completing surveys, shopping, filling out tax forms, or reading web sites (Herger, 2012).

The gamification of poverty, an example of which is the game "Spent" by Nicholson (2011) as mentioned by Coren (n.d.) can show that "what games can accomplish is empathy." Acording to Mims (2011), it may be a vehicle to "allow the player to live a life of adverse poverty, through an immersive experience of tough decisions" (Lopez, 2011). It can bring all major players of poverty reduction together and through regular and continuous engagements, the participants may discover new paths out of poverty. It may encourage participants to give back to the less fortunate. It may assist activists in getting their message across. And in the end, it may perhaps motivate the less fortunate in our society to improve their lives and negotiate their way out of poverty.

It is the stage to engage and enable the participants to imagine the best-case scenario outcome for real-world problems such as poverty. It is a means by which people can be empowered to make the outcome a reality by giving them the means to achieve victory (McGonigal, 2010). Gamification as a complete concept is still in its infancy (Zicherman & Cunningham, 2011). It can

be challenging to think about how they can be applied to world-changing and world-saving applications such as poverty reduction. In terms of altering behavior through the use of gamification, an example cited in Coren (n.d.) and Nicholson (2012) is a "physical therapy visualization tool that allows the patient to see how the body is changing as he/she does each repetition can allow each patient to set a different goal that is meaningful. The therapist can help the patient set goals through constraints, and by exploring those constraints, the patient can understand how the physical therapy connects to the exercise goals. By giving the patient information and control over goals, the patient is much more likely to find the internal meaningful connections to be able to continue the therapy away from the therapist."

The benefits of gamification can also be seen in its impact on benefactors. One such game is the Community Impact Platform gamifying a user's experience where giving back becomes an engaging experience. The fund raising game competition "encouraged employees to create personal fund raisers that tap into their unique network. The companies they work for, in turn, challenge parameters, select non-profit targets, match donations and create customized pages to promote among their social media network, fostering a grassroots cause marketing for the company that also amplifies its social impact" (Scott, 2012).

METHODOLOGICAL FRAMEWORK

With the use of data mining techniques/procedures, identify trends and relationships between a community households' demographic make-up and the problems that beset the community. The succeeding procedures are as follows:

- Utilize such relationships to determine specific problem areas that can be addressed through community based action programs or policy reforms. If community based programs or policy reforms already exists, then there will be a need to enhance the effectiveness of delivery of service and dissemination of information on the benefits of availing public service through behavior-changing games.

- Survey on the extent of usage of Internet cafes and cell phones by a sample of households within the community, to determine if this mode of information dissemination as well as data collection is feasible within the community. The lack of usage of this form of technology may warrant the need for alternative forms of information dissemination that can be made available in barangay or health centers assisted by personnel adept with the use of the technology. The surveys will also have to cover the area of literacy due to the need for this to make the technology usable to the community, particularly with reference to gamification. Participants will then have to be divided into two groups: those who can do the game by themselves and those who will have to be assisted.

- A game is developed to address the issue affecting the community that would require behavior change. As in any gamification effort, the participant will have to be rewarded with some form of point system redeemable and exchanged into some basic need (like commodity) of the household. This would also entail the development of a reward system that would sustain the participants' interest in the game until the objective of the game is fulfilled.

- Post-game evaluation on behavioral change is conducted to determine effectiveness of the game in addressing the community's problems and the modifications needed to improve the game in fulfilling its purpose if it can be used in other communities.
- Consider the development of other games as may be deemed necessary to address other pressing issues within the sample community to sustain the success (if ever) and advantages put forth by previous gamification efforts.
- Introduce a data collection mechanism for data collectors (researchers), possibly also in the form of a game, to be able to extend the reach of data collection to as many households. This would involve the collection of quality data which is more accurate and which is updated constantly on a regular basis so that the community can easily move forth with programs attuned to immediate needs.
- A cost-benefit analysis is also to be conducted to compare the effectiveness of the intervention proposed and determine how the proposed intervention can complement existing services being delivered in the community.

The prospects on behavior change that gamification brings can easily extend to areas that tend to plague informal dwellers and poverty stricken sectors that can assist in addressing health issues, fertility, sanitation, peace and order, employment, livelihood and subsequently, poverty.

The system of monitoring, assessing and data-update with the use of gamification and data-mining for policy research will be compared to the current system in terms of monetized as well non-easily monetized costs and benefits that accrue to the implementing unit. Some questions CBA try to answer include: (1) Does gamification and data-mining provide the government unit substantial benefits; (2) should implementation of the new technology be applied in other areas that serve the sector involved; (3) if there are other means to address the concerns of the community, this shall be compared with the proposed one. The CBA is also seen to be able to establish links between inputs and outputs, determine underlying assumptions on program implementation, as well as the identification of 'opportunity' cost with the non-implementation of the new technology.

The Proposed System and Data Mining

The proposed system architecture is shown in Figure 2. It consists of three main modules, namely, Data Mining, Policy Reforms Recommender System and Gamification of Poverty. The Data Mining module would involve data pre-processing, attribute selection, application of data mining algorithms, pattern evaluation and knowledge presentation. Researchers can utilize existing data mining system (i.e. WEKA or Rapid Miner) or develop their own algorithms as deemed appropriate to generate interesting data patterns. The application of various data mining functionalities can be investigated such as characterization and discrimination; the mining of frequent patterns, associations, and correlations; classification and regression; clustering analysis; and outlier analysis.

Figure 2
System Architecture
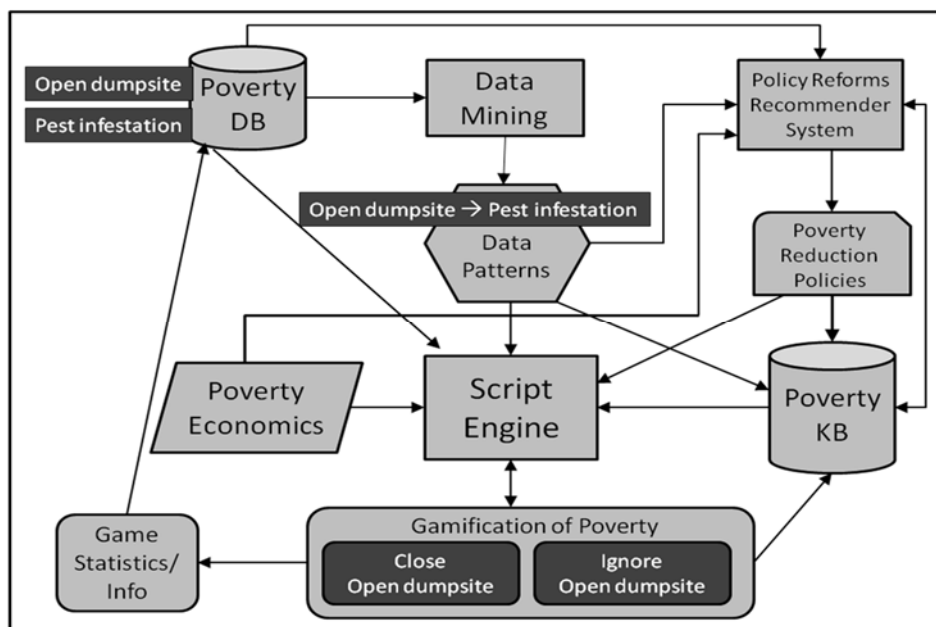
Policy Reforms Recommender System for Future Research

The Policy Reforms Recommender System will automatically and intelligently generate poverty reduction policies. It will attempt to identify different poverty reduction alternatives such as programs or spending priorities. It will use impact or cost-benefit analysis, and apply poverty economic principles to select and recommend which among those identified will be adopted. Machine Learning algorithms and Artificial Intelligence techniques will be investigated and applied in crafting poverty reduction reforms. These algorithms will intelligently analyze and assess as many areas of potential policy impact as possible, to mitigate the risks that a given policy will have unexpected or unintended consequences.

Gamification of Poverty

The gamification module involves a reality-based poverty game system. It is envisioned to produce real-life game scenarios by using existing information contained in the poverty database and knowledge base. The script engine will generate stories and adapt game scenarios according to the participant's characteristics, sentiments, personal interests and community interests.

Figure 3
Game Participants
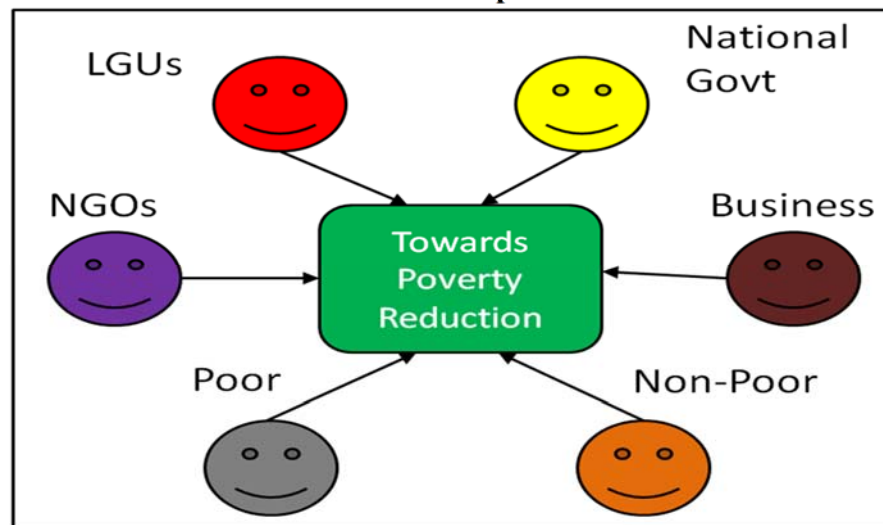
For poverty, the framework of Mechanics, Dynamics and Aesthetics (MDA) can be explored in the game design. As emphasized by Zicherman and Cunningham (2011), mechanics compose the functioning sections of the game that allow the game designer ultimate control over the levers of the game, enabling the ability to guide player actions while dynamics are the player's interactions with those mechanics. They determine what each player is doing in response to the mechanics of the system, both individually vis-à-vis other players. Aesthetics of the system are how the game makes the player feel during interaction. Game aesthetics can be regarded as the multifactorial outcome of the mechanics and dynamics as they relate with and generate emotions. The poverty gamification system can adopt game theory principles and multi-agent systems' concepts of collaboration, cooperation, and competition. We will treat every participant as an agent who engages collaboratively, cooperatively or competitively with other game participants, as shown in Figure 3, as they negotiate and achieve poverty reduction.

CONCLUSIONS

The use of gamification has always been associated with entertaining users by way of engaging them in games. However, gamification has been utilized in other countries as a behavior change mechanism particularly for people who are predisposed to playing games on the internet on issues that are reality-based. The change in behavior gets manifested in their opinions about an issue or problem and subsequently takes positive actions towards helping solve the problem. Researchers can explore to identify, via data mining techniques, relationships and trends from the CBMS database of household demographic and other relevant data for problem areas encountered by the community. Game design would be developed to help engage the members of the community to try to address different problem areas encountered.

For social relevance, many of the problems besetting poverty stricken households can be solved through change in behavior once they realize the opportunities that can come their way by

doing so. The change is much more effective if part of the motivation comes from within the individual itself and the immediate environment makes it possible for them to see the positive effect this change will have in their lives.

For the anticipated societal impact of implementation, the creation of more change agents in the community will greatly assist local government units in bringing into the community projects that could further improve the general well-being of everyone residing in it, particularly in the area of peace and order, sanitation and health and livelihood and employment.

Studies bringing technology very close to the grassroots level, particularly the poor and the marginalized sectors, are rare. Likewise, it seems to be the case that much of the developments seen with technology only seemingly address the needs of middle and upper income brackets of society. But the trickle-down effect can be hastened with studies of this nature so that hopefully other communities can learn from it. If technology can be introduced with ease that come with some form of entertainment to sustain interest in the challenge for all stakeholders, but keeping one eye to its ultimate poverty-alleviation purpose, data-collection is then done with ease, metrics-processing becomes efficient, results-generation more accurate and interventions more timely and effective.

The research design is highly experimental and would involve the following: (1) With the use of data mining techniques/procedures, identify trends and relationships between a community households' demographic make-up and the problems that beset the community; (2) Utilize such relationships to determine specific problem areas that can be addressed through community based action programs or policy reforms. If community based programs or policy reforms already exists, then there will be a need to enhance the effectiveness of delivery of service and dissemination of information on the benefits of availment of public service through behavior-changing games; (3) Survey on the extent of usage of internet cafes and cellphones by a sample of households within the community, to determine if this mode of information dissemination as well as data collection is feasible within the community. The lack of usage of this form of technology may warrant the need for alternative forms of information dissemination that can be made available in barangay or health centers assisted by personnel adept with the use of the technology. The surveys will also have to cover the area of literacy due to the need for this to make the technology usable to the community, particularly with reference to gamification. Participants will then have to be divided into two groups: those who can do the game by themselves and those who will have to be assisted; (4) A game is developed to address the issue affecting the community that would require behavior change. As in any gamification effort, the participant will have to be rewarded with some form of point system redeemable and exchanged into some basic need (like commodity) of the household. This would also entail the development of a reward system that would sustain the participants' interest in the game until the objective of the game is fulfilled; (5) Post-game evaluation on behavioral change is conducted to determine effectiveness of the game in addressing the community's problems and the modifications needed to improve the game in fulfilling its purpose if it can be used in other communities; (6) Consider the development of other games as may be deemed necessary to address other pressing issues within the sample community to sustain the success (if ever) and advantages put forth by previous gamification efforts; (7) Introduce a data collection mechanism for data collectors (researchers), possibly also in the form of a game, to be able to extend the reach of data collection to as many households. This would involve the

collection of quality data which is more accurate and which is updated constantly on a regular basis so that the community can easily move forth with programs attuned to immediate needs; and (8) A cost-benefit analysis is also to be conducted to compare the effectiveness of the intervention proposed and determine how the proposed intervention can complement existing services delivered in the community.

The prospects on behavior change that gamification brings can easily extend to as many areas that tend to plague informal dwellers and poverty stricken sectors that can assist in addressing health issues, fertility, sanitation, peace and order, employment, livelihood and subsequently, poverty reduction.

ENDNOTES

[1] This study was presented at the International Conference on Business, Economics, and Information Technology (ICBEIT) 2013 – *Doing Business in the Global Economy: Economic, Political, Social, Cultural and Technological Environments* held last 18-19 March 2013 at the Pacific International Hotel, Cairns, Queensland, Australia. **Disclaimer:** The findings, interpretations, and conclusions expressed in this work do not reflect the views of the author's institutional affiliations and its Board of Executive Directors. The contents of this work shall not be construed as a commitment by the author's institutional affiliation excet where provided for in a formal written agreement. The other usual disclaimer applies.

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