Participatory Action Research in Software Development: Indigenous Knowledge Management Systems Case Study

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Abstract. Participatory action Research In Software Methodology Augmentation (PRISMA) is a software development methodology which has been amalgamated with Participatory Action Research (PAR). This paper justifies the inclusion of PAR in software development, and describes the PRISMA methodology vis-à-vis a case study. Specifically, the case study encompasses the development of eToro, an Indigenous Knowledge Management System for the Penans, a remote and rural community in Malaysian Borneo.

Keywords: Participatory Action Research, Software Development, PRISMA, Penans, Indigenous Botanical Knowledge Management, Remote Malaysian Borneo.

1 ICTs for the Underserved

It is generally acknowledged that providing Information and Communication Technologies (ICTs) to remote and rural communities can help in alleviating poverty and/or improving the socio-economic status of the communities. Among the many benefits of providing ICTs include giving access to unlimited knowledge (e.g. e-learning), providing health-related services (telediagnosis), offering businesses opportunities (e-commerce), employment opportunities, and access to government services (e-Government websites) [1]. Evidence suggests that rural dwellers have more to gain than urban dwellers from any increase in the density of communications capability [2], but the absence of relevant experience, local content and skills are major barriers for rural ICT usage [3,4].

Of importance is the need to build good quality and relevant ICTs (software included) which addresses the communities' needs. The local communities have their own concepts of knowledge and forms of communicating. As such, it is necessary that they should be able to use ICTs in such a way that their cultural identity is not compromised [5]. Furthermore, to prevent irrelevant "alien" conceptualizations from being carried forward into the implementation, the design and evaluation process need to be fully appropriated by the user community [6].

M. Kurosu (Ed.): Human-Computer Interaction, Part I, HCII 2013, LNCS 8004, pp. 470–479, 2013.

2 Problem Background

Literature is littered with failures and short term successes in the deployment of existing technologies that is mainly designed for urban settings but implemented in rural communities. These technologies would not work given that the target community of urban dwellers is very much different. For example, those living in the urban areas are more likely to be literate, have achieved a higher level of education, and have greater exposure to the use of technology. On the other hand, those who live in the rural (and remote) areas, are more likely to be illiterate, given the limited access to education, and lower exposure to technology-use. In addition, the context of use would be very different as well. With little or no technology appropriation, i.e. absence of input from local culture in the design of the system (be it hardware or software), the system has a greater likelihood of failure [6].

Furthermore, focus of technology appropriation must also be placed on the methodologies employed to build these ICTs. However, those methodologies invariably originate from the West (developed nations of North America and Europe) and are tailored towards the development of products and services for urban users in their urban settings [5]. Given the origin and the target markets, the context and cultural elements of urban developers and users would have been "infused" in the methodology and design.

The challenge is identifying and employing methodologies which allow development of relevant software for rural communities. The methodologies should not only encompass the technological aspects but also the complexities of the rural users, the contexts as well as addressing the needs of the target audience. As shown in projects involving target users [7-10], the acceptance and usage of technology would be greatly improved particularly if the community is involved in the process.

In the next section, we introduce the solution, and justify the use of Participatory Action Research in software development in the solution. In Section 4, we describe the solution vis-à-vis in the development of an Indigenous Knowledge System for a community in the remote area of Long Lamai in Malaysian Borneo.

3 Participatory Action Research in Software Development

Given the inappropriate methodologies, we propose using PAR amalgamated with a software development methodology. We believe community participation in rural projects is important, and more so in the development of technologies such as software which are to be used by indigenous communities. In this paper, the amalgamated methodology mooted is called Participatory action Research In Software Methodology Augmentation (PRISMA).

PAR has also been used successfully in numerous rural development projects such as in IDRC [14] and in Universiti Malaysia Sarawak's (UNIMAS) eBario Project and its replications [15]. As such, PAR provides the collaborative process of research and action targeted towards positive social transformation [16]. PAR established a two-way communication, which allows the researchers to be involved with the

community and vice-versa; the researchers and community are actively involved in the development activities, to seek information, ideas, and generate knowledge to guide [17].

In PAR projects involving ICT development, we believe there are two goals. One is of course to develop the technologies or software (technology element), while the other is to learn and understand as much as possible from the implementation or deployment (knowledge element). With sufficient evidence from replications, best practices may then be developed which would be of use to other similar projects. Given the high costs of projects in rural areas, there is a need to maximize outputs and learnings from rural projects. Researchers also have to keep in mind, PAR is appropriate as it has a research component that seeks to engender positive change; and that participation "requires the equal and collaborative involvement of the 'community of research interest." [13].

As shown in Figure 1, PRISMA comprises two parts, a social change process (dotted circle) and software development process (solid line circle). The software development process encompass the formal and "hard (technological) aspects" which includes the formal components of software development, tools and techniques to carry out the requirements analysis, design, implementation, and testing. More important is the "soft (humanistic) aspects" which encompass the change the community wants, the reasons they want it, as well as the roles for people inside the indistinct world of political and social systems, multiple disciplines, environments and multiple stakeholders [17]. The soft aspects tend to be fuzzy, and will be outlined in detail. If we fail to address these non-technical factors, the user requirements may be affected, resulting in poor system design, un-usable user interfaces, over budget and delays in the project. The overlap between the social change and the software development involves merging of processes of both the hard and soft aspects.

PRISMA is a work in progress. In [13], PRISMA was described to augment the conventional Software Development Life Cycle employed to develop software for rural communities. A rural e-health initiative was developed using PRISMA [17]. Not all the phases of PRISMA was utilized in [13] and [17], however in this case study, the processes are further refined. For example, the first two steps of PRISMA in [17] are expanded to four steps in this paper.

4 Development of Indigenous Knowledge Management System, eToro

To illustrate PRISMA, we will apply its use in the development of an Indigenous Knowledge Management System. Before describing the different steps in PRISMA, we define some of the eToro terms that will be used within the context of developing software for a rural community. Typical stakeholders in the project include: Community (the group in which the project will be helping); researchers (those who are implementing the project and also trying to learn from it); sponsors (ones who are providing the funds, such as government agencies or industries).

eToro project is a collaborative effort of the Institute of Social Informatics and Technological Innovations (ISITI-CoERI), UNIMAS and the local community of Long Lamai, Sarawak. The project goal is to preserve the traditional knowledge of the community, given that the older generation is slowly dying out, knowledge is not being transferred to the younger generation. Also, the young are not as interested in learning and retaining the traditional knowledge. The community involved is located in Long Lamai, a very remote and rural village in Malaysian Borneo, situated near the Kalimantan border. From the nearest city, the journey comprises a 10-hour 4-wheel drive journey over logging road, and an hours' boat ride upriver. The community at Long Lamai consists of Penans, a small indigenous community which lives on subsistence farming. There are about 450 villagers [28]. There is no 24-hour electricity supply and no telecommunication service. Some families have generator sets to generate power, but few families can afford this. The Penans in Long Lamai were nomadic, but have settled down in the area for over 50 years. They still return to the forest to hunt and to gather jungle produce. There are still Penans in other villages who are nomadic, and depend totally on the forests for their livelihood.

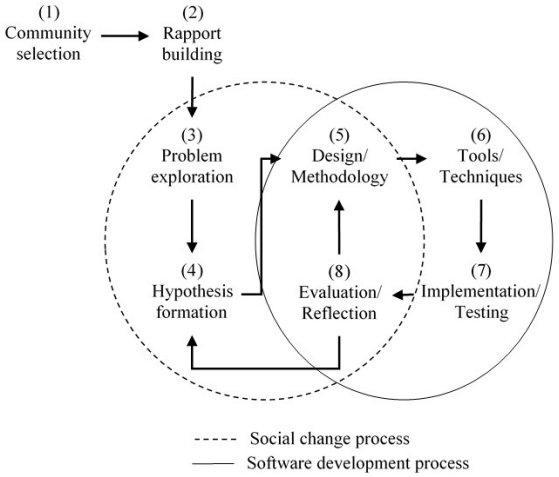

Fig. 1. Participatory action Research In Software development Methodology Augmentation (PRISMA)

4.1 PRISMA in eToro

The details below describe the use of PRISMA in developing eToro. Please refer to Figure 1 for the steps in PRISMA.

Step 1: Community Selection. The community was selected in 2007 to take part in a telecentre project. The Long Lamai community was chosen as it is a cohesive community, and it met the remoteness criteria (difficult to access and lacking infrastructure and communications).

Step 2: Rapport Building. There exists good rapport between UNIMAS and the community given the telecentre project. There is mutual respect between the two; both parties contributing their respective knowledge and expertise. The Long Lamai community has access to the Internet since 2009 after the inauguration of the eLamai telecentre. The majority of the younger generation are active users of Internet while the community elders consider the telecentre as major catalyst in boosting the local economy. The idea of documentation of Indigenous Knowledge (IK) has been initiated by the community elders during one of our visits in August 2011; they were aware that ICTs may be able to assist them to preserve their IK.

Step 3: Problem Exploration. Like other indigenous communities, the rapid change of the Penans' way of life has largely accounted for the loss of their IK [25]. Among other causes, elders were reluctant to transmit IK to younger generation who were not interested in learning and preserving the IK [26]. The community selected four elders and four youths as representatives to negotiate, discuss and help in the development of eToro. Through a series of meetings, the problem on IK was confirmed. They also discussed ways to capture and transfer the IK from old to the young, and settled on the idea of using the concept of Toro, which is familiar to the Penans. The Penans depend on the forest for hunting and for collecting various forest products. *Toro* is a joint activity of Penan family and it also works as an activity-based knowledge sharing and mentoring journey of the forest which links community elders to members of the younger generations in grooming future guardians of the rainforest. Mentoring includes lessons on livelihood combined with a notion of stewardship, incorporating conservation ethics and ownership. The journey is performed by a family including the parents and children. Normally, the parents do not bring children below the age of seven. There are six activities in the Toro journey. The activities start from leaving the *lamin toto* (house in the village) and finding the place in jungle which has enough food such as fruit trees, fishes in nearby river, sago plants, and animals for hunting. When a family finds the place, they establish their *lamin Toro*, or traditional temporary hut. The next activities are extracting sago, cooking food, catching fishes and hunting.

Step 4: Hypothesis Formation. Further discussions were held to decide which type of IK to focus on. They decided upon Indigenous Botanical Knowledge (IBK) and refer to it as the identity of the Penans. According to Garen Jengan, a local champion, "*if you don't know about the plants, you are not a Penan*". Another perceived benefit of eToro is to cover the knowledge gap between the young and old generations. The youths have ICT skills. Thus, they will be more confident in helping in the documentation process; ultimately, they will be a part of the learning cycle. The collected data, pictures and videos can also be used in tourism promotion activities. eToro can also help in training of young people so the community will have more trained human resource as guardians of the rainforest.

The researchers who were interested in the preservation of IK agreed on the focus on IBK. The research question used was: can an Indigenous Knowledge Management Sytems (eToro) be developed to capture the IBK, involve the young and is usable to

the community? Expected outcomes of this exploratory study would include identifying current knowledge structures, existing/traditional intergenerational transfer processes, as well as, identifying how existing ICT knowledge can be employed in the development of eToro. The community will benefit (all going well) from having a system which would allow them to preserve the IBK, as well as an opportunity to bring the young and old together.

Step 5: Design/Methodology. Two activities, the design of the solution and identifying the approaches to achieve the solution, are conducted in this Step. The resulting design has to be acceptable to both the community and the researchers/developers; that the developers can build the eToro, and that the eToro will actually be used. In further discussions, it was realized that Penans are quite sensitive about their plants' knowledge and there is a strong social belief system which governs the knowledge management processes in the community. Through the various deliberations, a number of items was agreed upon. This discussion involves not only the community and researchers, but also software developers, knowledge engineers, botanists, environmentalists, as well as the diaspora of Long Lamai. The output of discussion includes the types of users of eToro, the access to this information (refer to Table 1), types of plant data to collect, as well as the processes needed for the collection, classification and verification of the plants.

Table 1. IKMS user types

User type	Rights.
IKM Manager	Full access.
Community elders	Browse all information.
Youth	Browse all information but have limited access to piousness plants information
Botanist	Browse the Pictures of the plant and enter the scientific name

From the researchers' perspective, a series of formalized methodology was identified (for details see [29]). These are: (1) Designing Process Flow Diagrams: For understanding processes, roles, actions & rights of stakeholders; (2) Developing Cultural Protocols (Free, Prior and Informed Consent agreement and guidelines): For community, researchers and data engagement. (3) Designing Data Instruments: For eliciting community needs and acquisition of IBK management system. (4) Developing Prototypes for Indigenous Knowledge Management System: For digital data collection and indigenous content management; the formats of the data (text, video, sound, images) and (5) Capacity Building Program: For participatory digital data collection and processing.

The researchers and developers also determined the datasets required, the Dublin Core [27] elements, and meta-data structure of IBK (which was translated to Penan, as not all Penans are literate and/or speak English or Malay, the national language of

Malaysia). The design of eToro will accommodate the characteristics of Penans IBK and also incorporate the social, cultural and belief systems which governs the Penans IBK.

Step 6: Tools and Techniques. Given the design, requirements and methodologies from Step 5, the tools employed and the techniques in the development and data collection processes were identified in Step 6. For instance, in data collection, we used Android based Tablet PCs and Open Data Kit (ODK). ODK is an extensible, open-source suite of tools designed to build information services for Android system. Created by developers at the University of Washington's Computer Science and Engineering Department and members of Change, Open Data Kit is an open-source project available to all (opendatakit.org). The Data collection form has been manually designed by the community so ODK is used to build function help in integrating the manual data collection form into the digital ODK survey form for mobile device.

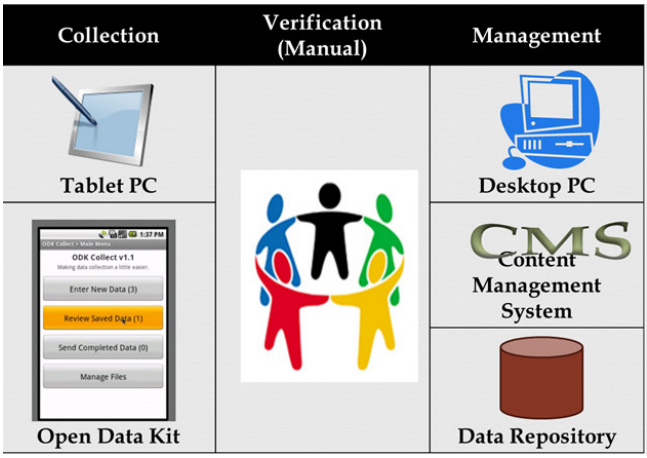

Fig. 2. Components and Services of IKMS

Step 7: Implementation and Testing. This step involves the implementation and the testing of the system. Figure 2 shows the components and services of eToro project which was implemented. The documentation activities consist of three phase. In the first phase, the young community members travelled to forest with the old folks to collect and document about plants data. Here the data is considered as part of knowledge which is shared by the old folks during the process of documentation. This data includes the text, images, video and Global Positioning System (GPS) coordinates of the plants. In the second phase, the collected information is manually verified in community meetings and in the third phase, an indigenous Content Management System (iCMS) is used to store the data on an external hard drive with e-*insitu* approach. The e-*insitu* approach is the facility for the community to have the physical control of the data and storage device in addition to logical data protection mechanisms.

Under e-*insitu* approach the hard drive would be kept under custodianship of a community appointed member.

After the prototype development, both the data collection software and iCMS have been tested on real data by collecting 30 plants information in three cycles (10 plants per cycle). The test has been conducted to confirm the usability of the software's functions. In the first two cycles, we accompanied the team in the data collection and data management process. The third cycle is performed in the absence of researchers. As the community language do not have a standard spelling system, in first cycle of data collection, 8 errors spellings have been reported in the data collection form. In second cycle, only 3 errors were reported and in the third cycle, no errors were reported; i.e. they are improving and learning to work independently.

Step 8: Evaluation/Reflection. The evaluation conducted in this step determines whether it has achieved the goals set. For example, the software is evaluated to detemine if it is usable and accepted by the target community. In general, the team members for eToro were satisfied with the processes and features of eToro; as 67% of their responses are 'strongly agree' indicating that they were satisfied with eToro, while 15% 'agree', 11% 'undecided'. The responses of 'disagree' and 'strongly disagree' were negligible, as less than 1%. Among some of the feedback received, was that the system could be more interactive, and that it should be used deep in the jungle (i.e. need to resolve the power problem). From the researcher's response, the key difficulties were to understand how the local system works. There was also the language barrier, and the lack of equivalent terminology in Penan to describe the ICTs. The elders also had to be open to changes; not all community members were privy to all the data collected. Thus, with the system, the elders now had to explicitly state who should have access to what information.

eToro showed that an Indigenous Knowledge Management Systems (eToro) can be developed; and it can capture the IBK, involve the young and is usable to the community. Reflecting on how the project went, this study showed that ICTs can be employed to not only develop the IKMS but also with the right processes, develop a product that is accepted by the community, as well as bringing the young and old together. The project also underlined the importance of having a local champion to help to move the project along, and the importance of elders in supporting the project. The rapport UNIMAS has with the community also ensured that discussion about typically sensitive information was made available due to the trust that exists between the two parties. Community participation is also crucial, without whom, the project design would be unacceptable, and do not address the community's needs. Multidisciplinary teams were needed as the project involved not only IK experts, but also botanists, environmentalists in addition to the ICT experts.

5 Conclusion and Future Directions

This paper has demonstrated that working with the Penans, PRISMA can be employed to develop a usable Indigenous Knowledge Management System; a system

that the community can and are using. PRISMA may also be applicable to other indigenous communities and be used to develop solutions in different domains. The next steps include refining the steps further, especially social component of PRISMA.

Acknowledgements. The authors are grateful for the institutional support and *Dana Principal Investigator* research funding from Universiti Malaysia Sarawak, as well as acknowledge and thank the continuous support from the community of Long Lamai.

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