Towards the Development of an Alternate Audience Response System within an Educational Living Lab Environment

C Vermeulen, AAK Buitendag, F Hatting, M Lall, and OP Kogeda

***Abstract* - The establishment of Living Labs (LL), for community advancement, though innovative solution development and the practice of co-creation is receiving a lot of research attention as of late. In this paper we present the concept of 'Living Labbing' as a collaborative methodology in the development of an educational mobile tool as part of a university setting. A particular focus was placed on the architectural design and the development process of an Audience Response System, within a Living Lab setting. This study further explores the use of mobile devices such as smart phones, tablets and laptops as an alternative to traditional, radio frequency based clicker response system by developing a substitute response system that takes advantage of tethering technology to connect mobile devices over a Wi-Fi connection.**

***Index terms* - Living Labbing, Living Labs, Audience Response Systems, Mobile learning**

I. INTRODUCTION

The South African educational landscape faces continues challenges impacting the delivery of education across various sectors including that of tertiary education. Some of these problems include: historic inequality, learning deficits, poor educational backgrounds of educators and access to resources [1]. Other problems include issues pertaining to a "knowledge-doing"-gap as described in [2] which involve bridging knowledge boundaries and providing platforms for collaboration and integration. Universities are increasingly being forced to rethink and address the issues of inequities in education, by implementing innovative technology driven solutions [3]. As part of their study [3] also stresses that technology driven or supported lessons lead to better student satisfaction and ultimately better performance.

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Clicker devices also known as Audience Response Systems (ARS) has proven to support students active participate in classroom setting and enhance immediate and anonymous feedback to the teachers. Prior studies relating to the use of ARS support this concept. The fact that the correct use of clickers in conjunction with a Technology engagement teaching strategy (TETS) significantly improved the success rate of a first year mathematics module is illustrated in [4]. The positive impact application of clicker integrated teaching has on a technical university course is discussed in [5]. One of the strategies employed by the faculty of ICT at the Tshwane University of Technology (TUT) is to promote the use of ARS systems as part of standard teaching and learning practices. But the implantation thereof presents various issues and interrelated problems which require the application of a unique approach in the form of a Living Lab.

II. PROBLEM STATEMENT

The implementation of clickers within a rural university setting come with certain constraints and challenges. The biggest drawback towards the implementation of a clicker system pertain to 1) the high cost involved, and 2) technology required in the initial setup process. Clicker systems require the users thereof to have some operational knowledge pertaining to the class setup and the setup of the software to enable interaction. Not all classrooms and venues at TUT are equipped with the needed infrastructure. As pointed out in [6], Institutions and faculty considering the adoption of ARS should become aware of the costs, limitations, and impact towards students learning. These factors lead our investigation towards alternate mobile based ARS systems, which limit dependencies on cost and configuration. Alternate forms of response systems do exist on mobile devices, but require an active internet connection, resulting in higher costs.

The main research questions presented as part of the study are:

- How should an alternate ARS be designed to incorporate available technologies, which require limited data connectivity?
- Which approach in the development of such a system would render the best results?

III. RELATED RESEARCH AND MOTIVATIONS FOR THIS STUDY

Research on the development of mobile tools as an alternate to clicker response systems and investigated the apps currently available to the market and how many features it has to support clicker device functionality is presented in [7]. They also concluded that Smart-Phone clicker apps can promote self-directed positive learning. Researchers such as [8] report that as many students already have smart mobile devices, in particular, smartphones, the cost for purchasing additional and specialized clickers is eliminated. In their research a strong motivation is presented for the future development of such a system. Further studies towards clicker alternates to determine the effect it could have on students use their own devices as it encourages higher levels of personal investment toward their learning when compared to using clickers is suggested in [6].

IV. LIVING LABS AS CO-CREATION ENVIRONMENTS

Living Lab is defined as an open innovation systems where different ideas and concepts can be explored and validated with different actors, facilitating the exchange of knowledge and technologies [9]. Implementing a LL in an educational community environment such as a university encourages members to engage in the development process, experiment and learn in real-world environments to create innovative solutions to their problems. Living labs move research out of laboratories into real-life contexts such as a classroom, campus or faculty. The living lab methodology is often used in the development of tools, technologies applicable in community settings [10].

A. *Educational living lab factory framework*

The conceptual LL framework used for this research is shown in the figure 1. It consists of four factories, each rendering different types of services, with unique objectives.

- Networking factory (NF) for profiling and registration of community members, which include lecturers, students and other members.
- Knowledge factory (KF) for the application of various research and development strategies in order to help LL members to better understand the environment and to gain relevant knowledge.
- Product factory (PF) for the creation of tools and methodologies for the LL, to enhance education, which could include an artefact required by the inherent community, such as the alternate myMobliClick ARS system presented in this research.
- Service factory for the creation of all the services needed by the community, in the form of software services and components or physical services such as curriculum support services.

This framework also promote the notion that the educational LL is an inherent platform which acts as a test bed for educational products, some of which is internally developed in the LL environment itself.

B. *The tool factory and innovation*

Various co-creation methods such as prototyping and experimentation form part of the LL product factory processes. From this perspective the proposed design of the ARS alternate incorporated an investigation into the current operations of a clicker system and the application of 'Living Labbing' prototyping practices. The practice of 'Living Labbing' also engage and empower the participants to experiment and learn in real world environments and it will assist them to co create innovative solutions to their problems [11].

C. *The product factory development framework*

In a LL platform, in relation to web and mobile development environments, users are encouraged to add value to the tools, services or applications that they create and to collaborate on the sharing of resources and information which promotes the collective intelligence of the group. The sharing of resources sometimes incorporates the utilization of APIs. The various tools could also be created using existing program libraries and components [12]. This notion is in line with the core functionality of an innovation driven open LL which focuses on co-creation.

Figure 2, highlights the idea that various APIs which include LL developed APIs and existing components and tools ,such as own APIs, public APIs (i.e. APIs provided from Web 2.0 and Web 3.0 platforms) and third party APIs (provided from vendors) are utilised in the development of LL specific tools and products. The development of the new applications or software published as part of the LL product factory is a direct result of the internal LL research and development processes supported by the knowledge factory and is rendered by utilizing services identified as part of the LL network factory. As indicated, the LL methodology also incorporates the use of third parties and external partners in the development of services and solutions.

V. THE DEVELOPMENT OF THE myMobiClick SYSTEM

This section presents the prototyping process used in the development of the myMobiClick system which subsequently required three iterations of the process before a workable prototype were obtained.

A. *The first prototype design iteration*

The initial problem or situation was to develop an alternative mobile response system that addresses current issues in utilizing a clicker response system. Requirements gathering

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was done through research on current response systems and by evaluating shortcomings or disadvantages of current ARSs and mobile enabled alternates. As part of the first iterative design process it was decided that the myMobiClick design should at minimum provide the functionality that is expected from an ARS, which include aspects such as multiple connections and reusable group configurations. In addition, it should allow for the creation of a poll or question and enable collecting responses from the various mobile devices. The initial design involved various community members such as technical assistants, a final year student and some lecturers from the department of computer science at the Tshwane University of Technology. The first prototype development focused on a simple design to send a poll and receive response over a Wi-Fi network. The evaluation of the first prototype presented a successful connection towards the host client and a Wi-Fi connected device, which could receive a poll and collect a response.

B. Second design iteration

One of the problems experienced with the first design is that the connection to the host application was lost after a certain amount time this required a reconfiguration of the existing code to automatically manage timeouts and reconnections. The initial design was also expanded to include additional functionality which enables the lecturer to view a summary of results, and additional options to select a question from a previous question bank.

The second iteration of the design also included senior programming subject students and database desigh students. A module was also created to enable the lecturer to display live results of the polling as the various responses are captured, by utilizing graph components to display a live summary of responses. The evaluation of the second built prototype was done in a mock environment. The prototype functioned according to expectations and modifications towards the design of the lecturer host application was done.

C. Third design iteration

The third design iteration presented the requirement to modify the design to allow the lecturer to manage, the class setup and save responses for later evaluation to the database. Additional reporting functionality was also included and the option to evaluate the response times of students per question also added. The development and design was also done in conjunction with students. The evaluation of the prototype was done against the basic functionality which an ARS must present and it was found that this requirement was met. We present the designs of the myMobiClick system next.

D. The myMobiClick ARS

The myMobiClick Response System as a deliverable is made up of three sub deliverables: 1.) a mobile app, used by students, that emulate a clicker device on a mobile device such as a smartphone, 2.) a desktop application, used by the lecturer, from where questions are posted to the mobile application and 3.) A database that stores question and response information from the mobile devices. Figure 3 presents a conceptual architectural designs of the system

The activity diagram as presented in figure 4 shows the activity and process flows of connecting a mobile device to the system and participating in a poll or taking a test. The app starts by asking the user for a key to connect to a tethering manager. If a Tethering Manager is found and the keys match the user is connected. From here the user can login or proceed to questions. If the user is logged in he's/her answers are logged to the database.

E. The myMobiClick ARS in operation

This section describes some of the basic operations of the myMobiClick system with the focus on proposing questions and responding through the mobile app. Figure 5, highlights the interaction between the various entities.

Mobile users are authenticated by using a key that must match the lecturer's desktop application's key. Once paired with the lecture's desktop application, the app user can participate. At this moment all responses are still anonymous. A lecturer can request all users to sign in before answering any questions to make response non-anonymous. The lecturer can start a new question or select a question from a previously created question bank. Questions are in a typical multiple choice format. When the question is broadcasted, the question displays on each of the connected devices with the available answer options. As students are responding to the question, a graph with the results is displayed on the desktop. The graph updates with each response received from cnnected mobile devices. The results are captured in the MsSQL database. Various reports can be pulled and also exported to Excel. One of the reports available is to get an overall result on the question.

The MyMobiClick system can log the student attendance. The lecturer opens a new register on the desktop application. Once a register is opened students can sign the register from the mobile app. Students are required to sign in before being allowed to log their attendance to the register.

VI. CONCLUSIONS

The process of involving various stakeholders in the development of the MyMobiClick system as part of the Living Lab process did have some positive effects not directly related to a mobile clicker response system. Different members and entities in the Living Lab was empowered on different levels as they were allowed experiment and learn in real-world environments to create innovative solutions to their problems.

As the students who would eventually use the mobile clicker response system was directly involved at all levels of conceptualization and development they developed a sense of pride and entitlement towards the final product. An extra level of motivation was also added due to the fact that many of their peers would directly rely on what they produced. New student's voluntarily joined the Living Lab process as they could see a direct result of their peers work as the system was tested in real live class situations.

For the lecturers involved and overseeing the process new unique teaching opportunities was created as students was exposed to real live situations and the work students produced would have an actual impact on the rest of the stakeholders in the Living Lab.

As a Living Lab is not limited to a certain type of stakeholder or as stakeholder with specific knowledge a wider community of users was involved in the project creating opportunities for learning beyond the student's current field of interest and for Lectures to network and explore research opportunities with colleagues from other departments and faculties.

Developing a mobile clicker response system that communicates over Wi-Fi should cost much less than current technologies. By running the software on student's mobile phones or tablets reduces the cost of buying additional clickers. Also, by communication over Wi-Fi eliminates the overhead cost of data to communicate over the internet. The reliability of the system depend heavily on the quality of the device that enables the Wi-Fi communication such as the router.

One recommendation for further research is to compare traditional RF signal based clicker systems with smart clickers. As proven clickers hold up to their promise to improve learning in the classroom, but how does the different clicker systems compare to each other?

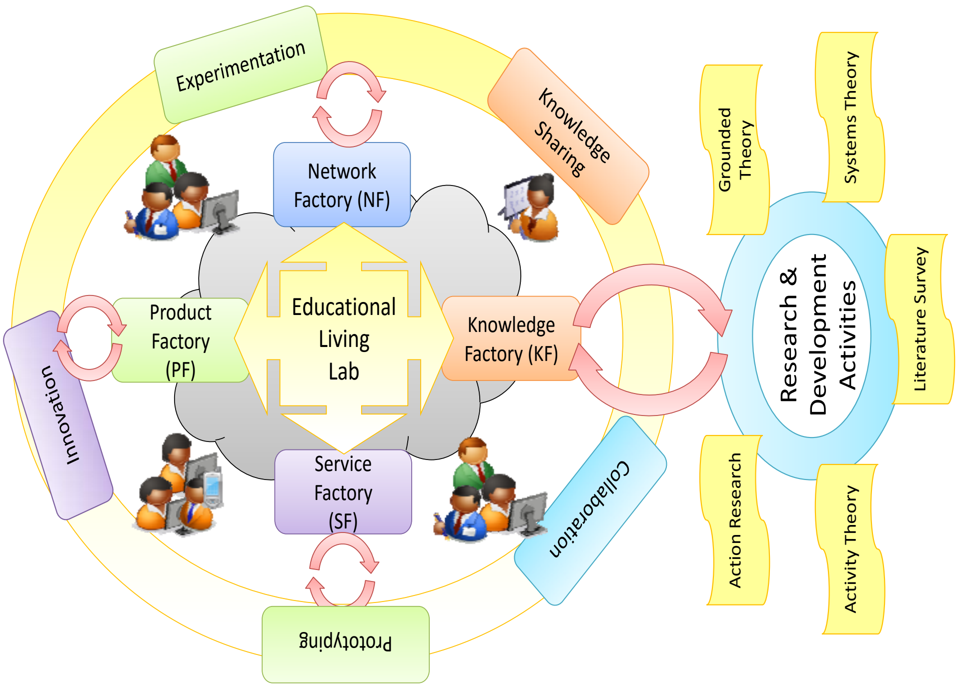

Fig. 1. Educational Living Lab framework.

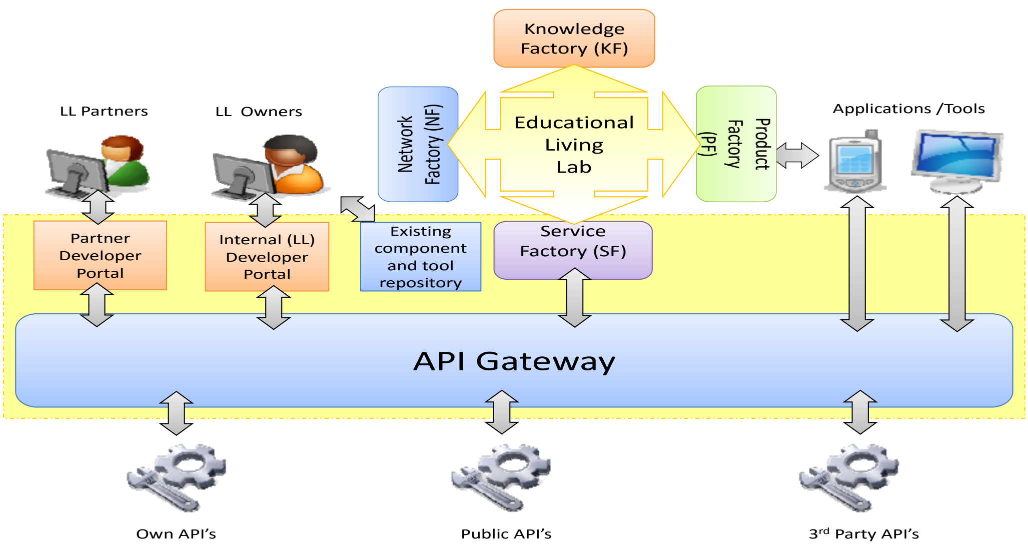

Fig. 2. Product factory development framework

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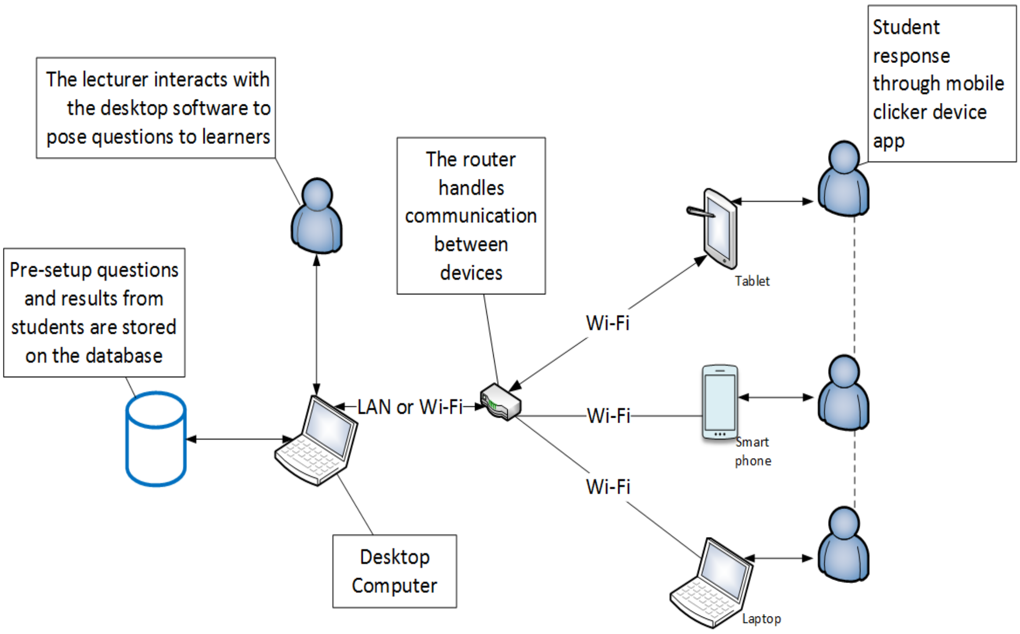

Fig. 3. myMobiClick Architectural design

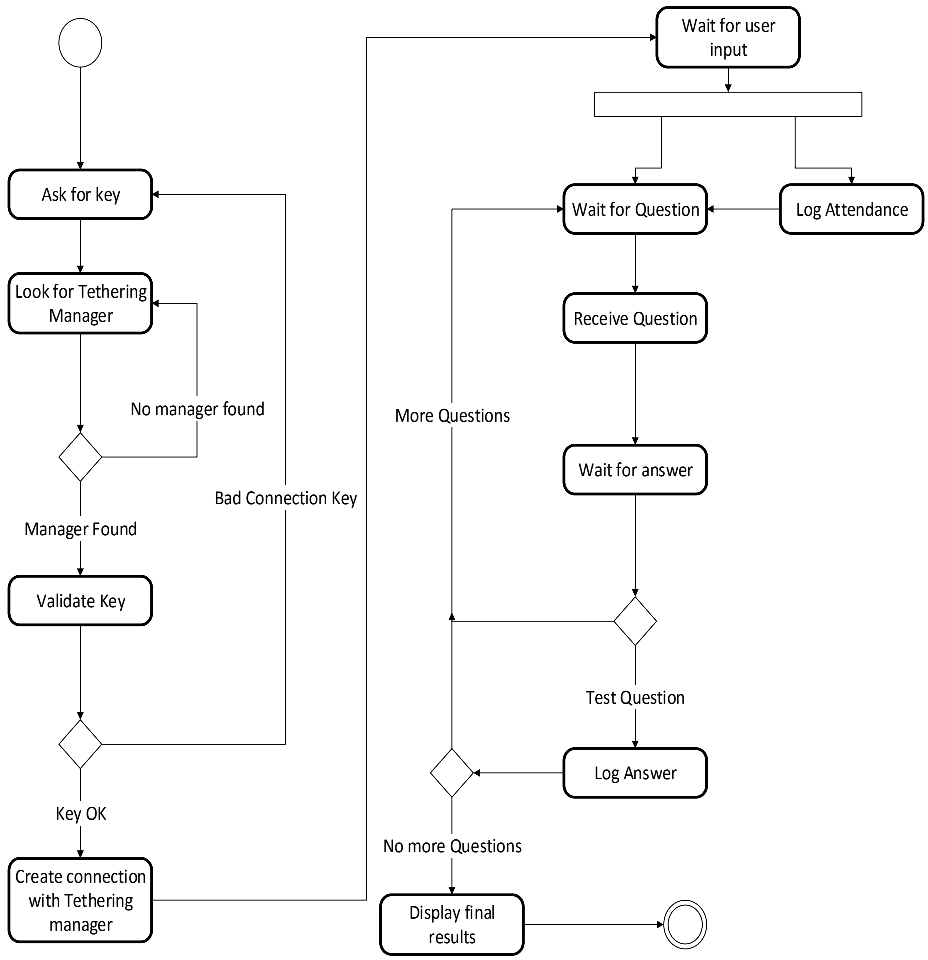

Fig. 4. myMobiClick activity diagram

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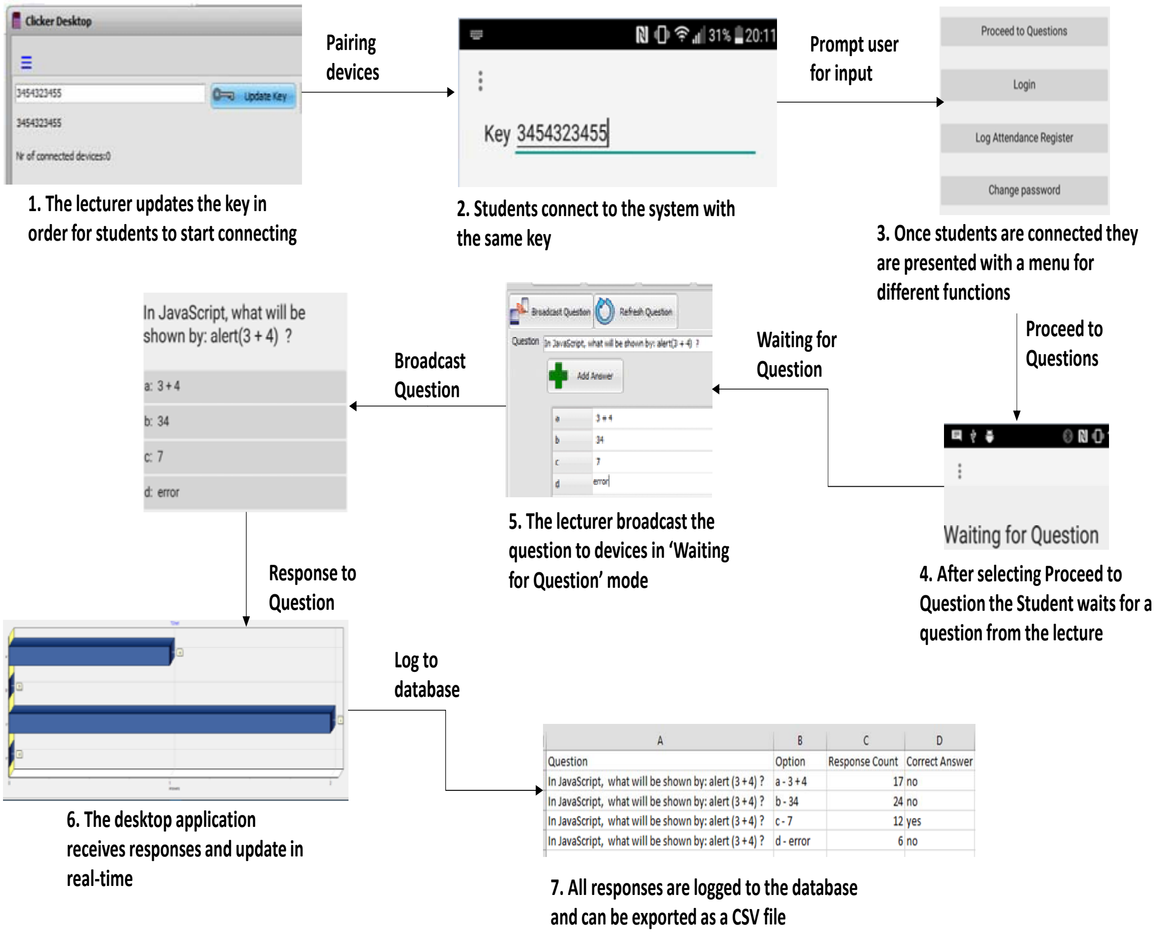

Fig. 5. myMobiClick generic operational screens.

REFERENCES

[1] N. Spaull, "Poverty & privilege: Primary school inequality in South Africa," *International Journal of Educational Development*, vol. 33, no. 5, pp. 436-447, 2013.

[2] K. J. Esler, L. Downsborough, D. J. Roux, J. Blignaut,, S. Milton, D. Le Maitre, and M. P. de Wit, "Interdisciplinary and multi-institutional higher learning: reflecting on a South African case study investigating complex and dynamic environmental challenges," *Current Opinion in Environmental Sustainability*, vol. 19, pp. 76-86, 2016.

[3] L.L. Spark, and D. de Klerk, "Using Clickers in Lectures: A Study of First Experiences," in *Proc. 9th Annual Teaching and Learning in Higher Education Conference,* pp. 199 - 205, 2015.

[4] S. Simelane, and P. M. Skhosana, "Impact of clicker technology in a mathematics course," *Knowledge Management & e-Learning: An International Journal (KM&EL)*, vol. 4, no. 3, pp. 279-292, 2012.

[5] C. J. Louw, "Projekte om wiskundeprestasie aan'n tegniese universiteit te verbeter," *Suid-Afrikaanse Tydskrif vir Natuurwetenskap en Tegnologie*, vol. 28, no. 4, 2009.

[6] D. Noel, S. Stover, and M. McNutt, "Student perceptions of engagement using mobile-based polling as an audience response system: Implications for leadership studies," *Journal of Leadership Education*, 2015.

[7] J. H. Bae, and S. K Kim, "Research on educational use of smart-phone applications with smart clicker technique," in *Proc. Advances in Computer Science and its Applications*, pp. 597-602, 2014.

[8] C. Cheong, V. Bruno, and F. Cheong, "Designing a mobile-app-based collaborative learning system," *Journal of Information Technology Education*, vol. 11, pp. 97-119, 2012.

[9] D. Schuurman, B. Baccarne, L. De Marez, C. Veeckman, and P. Ballon, "Living Labs as open innovation systems for knowledge exchange: solutions for sustainable innovation development," *International Journal of Business Innovation and Research*, Vol.10, pp. 322-340, 2016.

[10] K. De Moor, I. Ketyko, W. Joseph, T. Deryckere, L. De Marez, L. Martens, and G. Verleye, "Proposed framework for evaluating quality of experience in a mobile, testbed-oriented living lab setting," *Mobile Networks and Applications*, vol. 15, no. 3, pp. 378-391, 2010.

[11] J. S. Van der Walt, A.A. K. Buitendag, J. J. Zaaiman, and J.J. van Vuuren, "Community living lab as a collaborative innovation environment," *Issues in Informing Science and Information Technology*, vol. 6, pp. 421-436, 2009.

[12] I. Lee, and C. Torpelund-Bruin, "Geographic knowledge discovery from Web 2.0 technologies for advance collective intelligence," *Informatica*, vol. 35, pp. 453-461, 2011.