A scalable implementation model of mobile andragogy through data integration

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Abstract

Quality vocational education and training can be enhanced by technology to be more scalable, effective and efficient as indicated by (Latchem, 2017; Kirkwood et al, 2014). An observation by (Tradoc, 2017) indicates that progressive technological innovations allow the inclusion of a dynamic learning environment to challenge present and future citizens thereby maximizing their lifelong learning potentials. The use of appropriate technology allows facilitators to train individuals and teams at different levels of competence. Some technologies according to (Fominykh & Prasolova-Førland, 2012) allow for the use of a three dimensional (3D) collaborative virtual environments (CVEs). These CVEs enable advanced content manipulation, uploading, creating and sharing 3D objects and other media, such as text, graphics, sound and video. Content in this regard includes "objects, places, learning activities or other relevant experience".

Weak linkages between economic trends and occupational requirements have led to lack of timely information on the quality and quantity of skills that a developing economy needs. In Kenya, the informal sector holds over 80 percent of the country's businesses and entrepreneurs characterized by ease of entry and exit, uncertified and low quality skill mix, reliance on indigenous resources, small scale operation, mobile financial transactions and Labour intensive technology. Enhancing productivity in the informal sector is an important variable since formal employment is not absorbing new entrants at the supply rate.

As observed by (Weber, 2013; Hylen, 2015; Kamtsiou, 2016; Leibowitz, 2017), existing mobile learning platforms lack interconnection between the macro, meso and micro levels in the use of social media for vocational upskilling. This is buttressed by (Nomura, 2017) who observes that skills mismatches can occur at the macro-level, when the overall relevance of workforce skills does not trend with the demands of the Labour market. At the micro-level, it is noted that employers have to deploys expensive hiring processes to identify appropriately skilled candidates. When a country's Labour market and education and training systems have marginal linkages then this is referred to as skills mismatch at macro-level.

Labour market data can be of high volume, velocity and veracity hence a challenge to be displayed in real time. However, the massive data can be conditioned to provide Labour market intelligence according to (Laird et al, 2012; Maher et al, 2015). This can inform the supply and demand trends, emerging occupations and skill requirements in a Labour ecosystem. This chain can catalyze the profiling of job demands through an iterative pipeline process comprising four phases: characterization, extraction, comparison and updating. Properly visualized information can be interpreted by workers seeking opportunities and training providers interested in producing relevant and re-usable training content. As noted by (Wixom, 2016; Northern Research Consortium, 2012; SAS 2017), a society that is progressively digital, requires fast and real time delivery of visualizations to mobile devices while giving people the ability to easily explore data on their own. A smart training system is developed that enables the conversion of visualized real time labor market data into structured content for reusable training objects to enhance mobile skilling of informal sector workers.

Index Terms—Data visualization, re-usable training objects, smart training

I. Introduction to Smart learning

As indicated by (Çinici & Altun, 2018), smart learning environments (SLEs) employ a range of digital technologies in supporting learning, education and training. SLEs further deliver foundations for future learning and competence acquisition environments and therefore offer space for learning environments that are considerably improved to promote better and faster learning (Koper 2014). The driving desire behind the SLEs movement is to transform learning and instruction in productive and desirable ways. One of the key drivers of SLEs is mobile learning.

One of the key features of mobile cloud learning systems is their ability to deliver content and services on-the-go, enabling learners to engage with educational materials at their convenience (Leung & Chan, 2004). Moreover, these systems often incorporate contextual learning, where the learning experience is tailored to the learner's location, environment, and preferences. (Ruan et al., 2009) Additionally, mobile cloud learning frameworks have the potential to facilitate collaborative learning, allowing learners to interact and share knowledge with their peers, regardless of their physical location. (Wang et al., 2014).

The smart training system will comprise three major parts namely; a real time labour market information processor (RTLMI) where data from labour market is converted to real time visuals to feed into a re-usable training objects module (RTOM) where content developers create open and re-usable training objects anchored on Visual-Auditory-Kinesthetic (VAK) learning styles. The learning styles takes cognizance of Multiple Intelligence (MI) theory which indicates that there are at least seven learning styles including Interpersonal, intra-personal, kinesthetic, visual/spatial, logical/mathematical, verbal/linguistic, and musical/rhythmic. Part three will be a Mobile Training Content Interface (MTCI) where beneficiary trainees access the open training content on flexible skilling levels required.

The smart training system utilizes the ThinkBoard software to create training content in light videos. These will be delivered on a creative mobile phone downloadable application copyrighted and trademarked as "FundiiView". The system can be scaled up to include online assessments for work based learning certifications. The integrated system comprises three major parts namely; a real time labour market information processor (RTLMIP) using ArcGIS. The ArcGIS operations dashboard provides a real time location-aware data visualization and analytics for operational view of services and events. This feeds into a re-usable training objects module (RTOM). The Mobile Training Content Interface (MTCI) enables beneficiaries to access the open training content on a "Fundiiview" App modelled on Think Board software. Figure 1 shows the conceptual framework of the smart training system that includes five modules namely; data visualization platform, re-usable training object development template, developed training module platform, free abstract content view module connected to a mobile payment system that leads to a full content course content training interface.

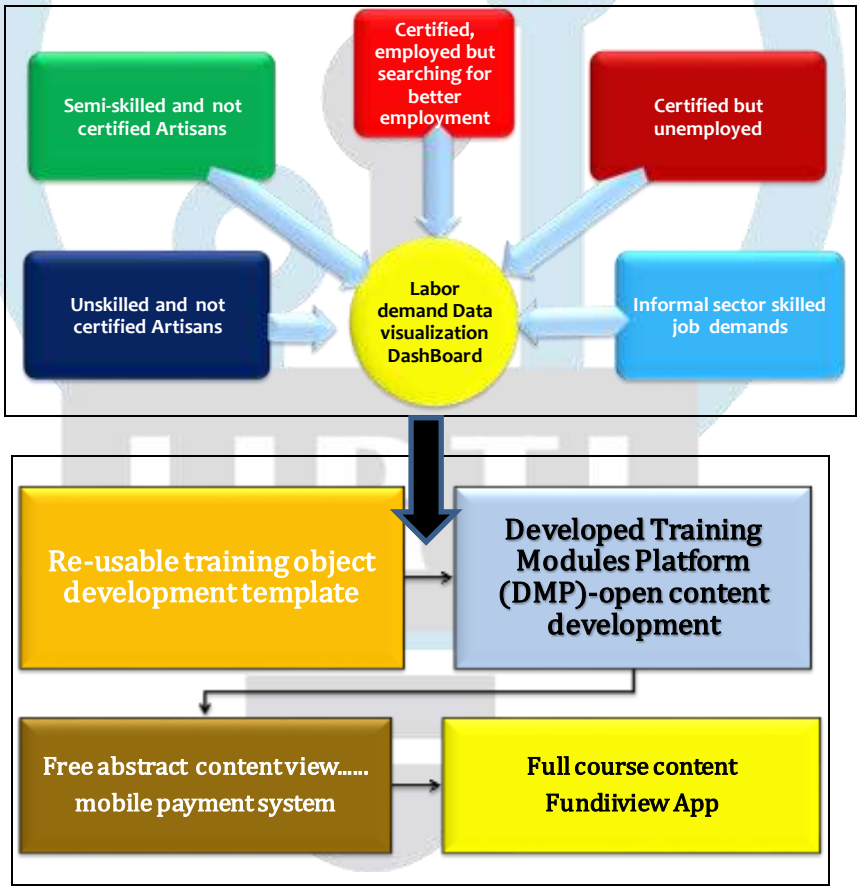

Fig 1. Frame work of modules of the smart training system

II. Mobile learning

From (Ali, 2013), there are three important factors which need to be put into consideration when dealing with mobile learning (m-learning) systems. These are mainly to ensure that these systems have the desirable level of quality. These include learning style, mobile applications and learning content. Learning style refers to an individual's characteristics and consistent approach to perceiving, organizing and processing information and may be a clustered behavior from diversified learner levels. As described by (Elmorshidy, 2012), mobile learning environment possesses many unique characteristics including; flexibility of location and time to learn, interactive knowledge acquisition, efficiency due both to re-use and feedback, situational instructional activities and integrated instructional context. Mobile applications are the cornerstone of mobile learning environments and should be robust to deliver learning content in an efficient way to meet learners' needs. Other factors are highlighted by (Bidin et al, 2013) and mentioned by (Makoe, 2010) include self-regulation where learners are at the center of the learning process and play an active role starting from determining their goal until the evaluation stage.

According to (Mindila et al, 2014), ICTs through blogs and podcasts support collaborative sharing of inter-disciplinary content. However, the informal sector enterprises have not extensively used blogs and podcasts as a way of knowledge sharing but rather mobile phones for basic references. This shows their preference for knowledge- on- the- go, probably because of the nature of work. Competence acquisition can only occur when a practical use is made of created content through collaboration. Content can be generated at either an individual level or collective level, with collective level being preferred because it promotes innovation and sharing of knowledge.

Koole's Model for Framing Mobile Learning (2009) called Framework for the Rational Analysis of Mobile Education (FRAME) highlights three major aspects of mobile learning indicated in the figure 1 below.

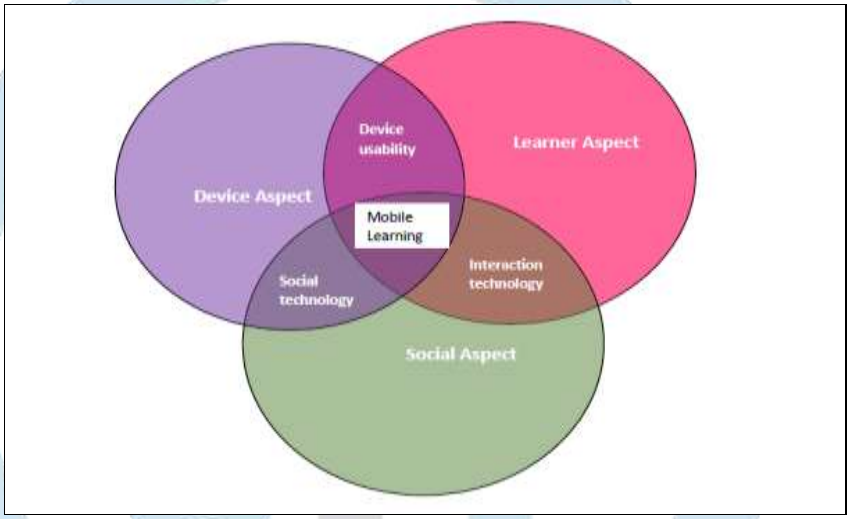

Fig 2. mobile learning framework-adopted from Koole's FRAME

The model in Figure 2 reveals that Koole decribes mobile learning in terms of three distinct aspects: device, learner, social, and an intersectional derivative of the three aspects. This model indicates that mobile learning has a different accepted definition now than it did even when iPhone was released as the first very-popular smartphone that ushered in the social aspect.

The proposed smart training system comprises three major parts namely; a real time labor market information processor (RTLMI) where data from labor market is converted to real time visuals to feed into a re-usable training objects module (RTOM). In this module, content developers create open and re-usable training objects anchored on Visual-Auditory-Kinesthetic (VAK) learning styles. The learning styles take cognizance of Multiple Intelligence (MI) theory which indicates that there are at least seven learning styles including Interpersonal, intra-personal, body/kinesthetic, visual/spatial, logical/mathematical, verbal/linguistic, and musical/rhythmic. Part three is a Mobile Training Content Interface (MTCI) where beneficiary trainees access the open training content on flexible skilling levels required.
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A model for integrating cloud technology proposed by (Ghadirli et al 2012) has two components; intelligence and mobile learning, and a system derived from mobile cloud computing architecture. It comprises a learning system, using an expert system recognizes and offers the appropriate educational content based on user's talent, prior knowledge and characteristics. However, the proposed cloud system does not quantify the relationship between quality of service (QoS) and quality of experience (QoE) as a benchmark for measuring the performance of cloud-based system.

(Guo et al 2014) propose an interdisciplinary approach for design and development of mobile applications in the cloud. This approach includes front service toolkit and backend service toolkit. The front service toolkit packages data and sends them to a backend deployed in a cloud computing platform. The backend service toolkit manages rules and workflow of web services, supports fault tolerance and then transmits required results to the front service toolkit. The design has the merits of; improved software availability and expansibility, reduced application development costs, improved availability and expansibility of mobile learning applications. However, the model requires improvement to; enhance the functionality of the system according to user preference, enhance analysis of the responses from students for learning performance evaluations and to shorten the response time between the front and the backend service toolkit.

III. Education 2.0 and andragogical approach to vocational upskilling

In the same space as Web 2.0, Education 2.0 permits interactivity between the content and users, and between users themselves. Under Web 2.0, users have the capacity to directly interact with the content through commenting, remixing, and share via social networks in addition to accessing information and content. Web 2.0 also provides for both synchronously and asynchronously communication. Similar to Web 2.0, Education 2.0 includes more interaction between the facilitator and learners, learners and learners and learners to content and expert. Education 2.0 focuses on the three Cs - communicating, contributing, and collaborating.

Education 2.0 is anchored on the technologies of Web 2.0 are used to enhance traditional approaches to education. Education 2.0 involves the use of blogs, podcasts, social bookmarking and related participation technologies but the circumstances under which the technologies are used are still largely embedded within the framework of Education 1.0. Education 2.0 therefore takes on the characteristics of an andragogical, more constructivist teaching orientation where the principles of active, experiential, authentic, relevant, and socially-networked learning experiences are built into the class or course structure. Andragogy has been described for teaching adult learning, but basic principles can be extracted from andragogy and applied to the teaching of most age groups. The goals of andragogical or self-directed learning (SDL) include assisting learners develop the capacity for self-direction, supporting transformational learning, and promoting "emancipatory learning and social action".

Within transformational learning, learning occurs along a self-directed path; as the learner matures and reflects on life experiences in relation to their self-perception, beliefs, and lifestyle, the learner perspective is adjusted and transformative learning can occur. The role of the facilitator in an andragogical approach is that of tutor and mentor, with the instructor supporting the learner in developing the capacity to become more self-directed in his or her learning. The instructor shows learners how to find information, relates information to the learner experience, and places a focus on problem-solving within real-world situations (McAuliffe et al., 2008). Instructors establish objectives and curriculum based on learner input and guide students along the learner path, while the responsibility for learning lies with the learner.

In self-determined learning, learners acquire both competencies and capabilities (McAuliffe et al., 2008). Competency can be understood as proven ability in acquiring knowledge and skills, while capability is characterized by learner confidence in his or her competency and, as a result, the ability "to take appropriate and effective action to formulate and solve problems in both familiar and unfamiliar and changing settings". Self-determined learning can be anchored on open and distance education. Distance learning is in a unique position for creating learning environments for supporting an andragogical teaching and learning approach. As indicated by (Lisa Marie Blaschke, 2012), specific characteristics of distance education that align themselves with andragogical include the symbiotic relationship with technology in which implications of technology on distance learning are recognized. Andragogy has been identified as a potential theory for applying to emerging technologies in distance education and has other characteristics including a performance profile of the distance learner and learner autonomy.

IV. Re usable training objects

A learning object (LO) constitutes the smallest unit of instructional content that can stand alone to meet a learning objective. Learning objects consist of information objects, which in turn consist of raw content, such as graphic, audio, or text files. The 'material' in a learning object can be documents, pictures, simulations, movies, and sound. Learning objects are assembled into lessons, which are then assembled into courses. Working with learning objects rather than lessons as units of learning has the advantage that individual learning objects can be reused and rearranged for uses in multiple lessons and courses. Such learning objects are called Reusable Learning Objects (RLOs). A Reusable Training Object (RTO) is a derivative of an RLO. Whereas RLOs provide a holistic range of transformation anchored on a complex phenomenon integrating interaction among a number of parameters such as: individual differences, background knowledge, context, motivation, readiness, RTOs are directed towards improving a person's performance related to job environments by providing instruction and may include the following an intent, a design, means and media and formalized assessment or certification capability.

RLOs and RTOs are anchored on the standard SCORM (Shareable Content Object Reference Model). This is a collection of standards and specifications for the packaging and sequencing of learning and assessment material in the form of shareable, reusable content objects. To be effective, SCORM recognizes the quality of reusability where content must be independent of the learning context, appropriate for use in different situations, for different audiences, on different delivery platforms with different applications or tools. A re-usable training object template is developed to prescribe elements of content development compliant with national regulations. In this development, the RTO template is designed to include six elements as indicated in Fig.3 below.

Index	RE-USABLE TRAINING OBJECTS SCHEDULE
1.0	Introduction to re-usable training module elements
1.1	Kenya National Qualifications Framework (KNQF) level
1.2	Statement of applicable (KNQF) qualification level descriptors
2.0	General Training Plan
3.0	Assessment standards and pass regulation
4.0	Introduction to course
4.1	Learning outcomes
5.0	Detailed content matrix
5.1	Delivery and learning guide
6.0	Assessment objects

Fig 3. Elements of a re-usable training object template

V. Open source data visualization for processing real time labor market information

Real time Labor market data visualization is a key module in this system to deliver three components namely; stacked bar graphs, pie chart and heat map. The application is developed using HTML5, CSS3, PHP language and MySQL database management system (DBMS). Pilot secondary data from Informal sector training in Nairobi County is analyzed in terms of trade demands, youth placement and Master craftsmen distribution per sub-county in Nairobi county. The Lavarel PHP framework for web artisans used is an open-source software licensed under the MIT license. The features that enable this PHP framework to deliver web tasks more easily include; powerful dependency injection container; multiple back-ends for session and cache storage; database agnostic schema migrations and real-time event broadcasting.

The pilot data is uploaded in csv format and properly formatted for precise results. The designed order of the attributes are; beneficiary name, youth training by gender, trade area chosen by youth and location of master craftsman offering training in that exact order. The demand for Trade Area Per Gender, per trade and per sub county are visualized using the horizontally stacked bar graph implemented using the Javascript library High charts. A bar graph is derived Javascript library Highcharts. Figure 4 shows the percentage of demand per trade area in Nairobi county. The percentage per trade area = (youths placed in the trade area / total youths placed in Nairobi County) * 100

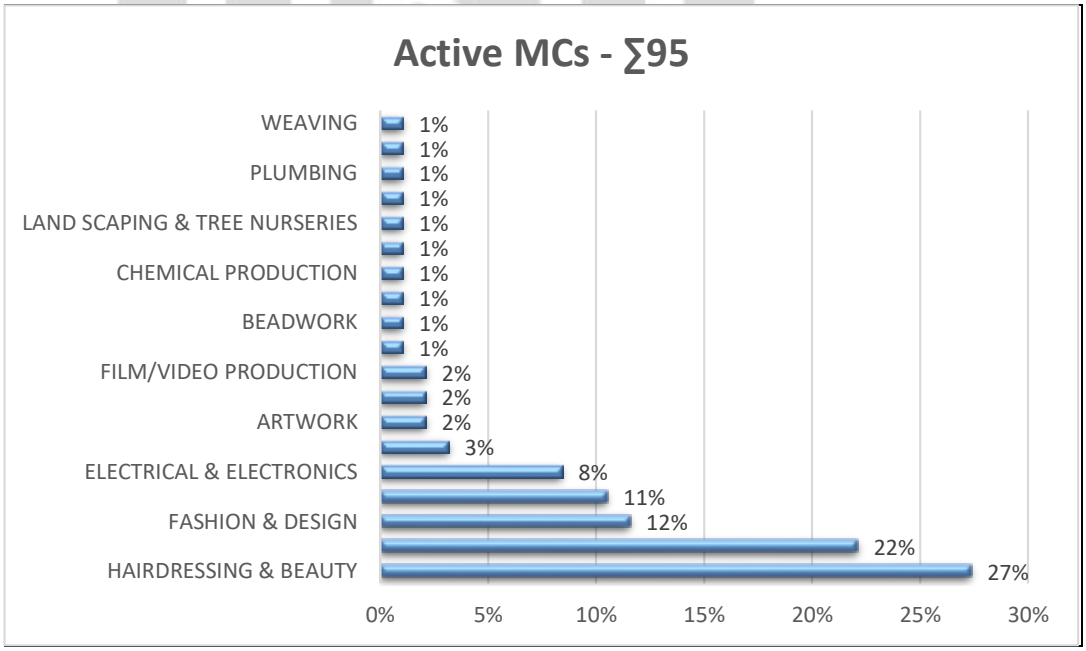

Fig 4: Spread of trade offers by the active Master craftsmen, Nairobi, Kenya (2018)

VI. Heat Map

This is an interactive GIS heat map created using QGIS, Leaflet Js, Leaflet-Heat Map JS plugin, Mapbox Imagery, and Open street map. The heat map component is used to compare the distribution of youth placement in the various sub-counties in Nairobi county. The map is made up of three layers; The base layer (powered by open street map and imagery by Mapbox); the polygon layer (made using QGIS and plotted using Leaflet js) and the Heat Map Layer (plotted using Leaflet JS and Leaflet Heat map JS plugin).

The base layer loads and renders tile layers on the map from tile servers. Mapbox and Open Streep Map tile servers used to plot the base layer in the map. The Vector/Polygon Layer loads the polygon of all the sub-counties in Nairobi county. It is created using QGIS and in GeoJSON format for it to be rendered in Leaflet JS on the fly without having to use a plugin. The Heat map layer renders heat maps indicators in the sub-counties. The heat map layer is loaded using a leaflet-heatmap.js plugin and heatmap.js JavaScript library.

VII. Pilot heat map of informal sector training demands in Nairobi County

Fig.5 Pilot dash board showing heat map depicting demand levels for trades in specific locations in Nairobi County -2018

The dashboard in Figure 5 provides a visual representation of the skill demand locations of informal service providers where the red spots show the highest demands and the green spots are the second-level demand locations within Nairobi sub-counties. Re-usable training objects module (RTOM)

This module provides content developers with an environment to create open and re-usable training objects anchored on Visual-Auditory-Kinesthetic (VAK) learning styles. The expected indicator is a percentage increase in the development of open data driven re-usable training content from visualized labor market information. It is designed such that content developers have the liberty to pilot regulated training content but consumers of the information have financial responsibilities for full access. Table 1 provides a summary of the elements of the proposed re-usable training objects template.

VIII. Commercial viability

This smart learning system is being developed towards commercialization to benefit informal and formal sector employers and employees to gain mobile access quality labour market information, customized and affordable training. A crosscutting portfolio of employers will be encouraged to pay for accessing and acquiring rated employees on demand. Furthermore, content developers will be motivated to design and to sell re-usable training content on demand. We expect training providers to market demand driven programs on this platform and to demand for customized mobile training platforms given cost effective, enhanced and mobile quality delivery.

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