Chapter 11
Requirements for a Seamless Collaborative and Cooperative MLearning System

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Abstract There is need for mobile learning (mLearning) systems that are capable of spurring seamless collaborative and cooperative learning. Such systems would be instrumental in redefining the way academic and administrative student support services are extended to students who might find themselves situated in different learning spaces and with multiple societal roles. In this chapter, the Mobile Learning Object Deployment and Utilisation Framework (MoLODUF) was used to underpin a study from which requirements necessary for the development of a seamless collaborative and cooperative mLearning system were instantiated. The adduced requirements include the need for communication cost subsidies and putting in place mechanisms for harnessing positive mLearning policy elements. Other requirements relate to human, financial and infrastructural resources for spurring mLearning. The system also requires an authentication protocol to prevent unauthorised use and unsolicited communication. It also requires GSM and GPRS mobile network connectivity so as to embrace low- and high-end mobile phones and mobile and PC interoperability. The system needs to be designed for learners who are located in multiple contexts and with multiple roles. Text and audio media types are ideal for learning objects that are seamlessly interoperable on low- to high-end mobile phones and PCs. The system as well should be cognisant of the need for learning comfort and learning object delivery feedback. These system requirements have been used to develop a prototype seamless collaborative and cooperative mLearning systems using SMS technology.

Background

With the proliferation of mobile devices, users are freed from transacting different processes in tethered environments. In the education sector, learners and their teachers are increasingly using mobile devices for pedagogic services, a learning notion

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L.-H. Wong et al. (eds.), *Seamless Learning in the Age of Mobile Connectivity*,
DOI 10.1007/978-981-287-113-8_11

known as mobile learning (mLearning) (de Marcos et al. 2006). Compared with conventional eLearning, mLearning is a relatively new form of technology-enhanced learning. It entails learners learning at anytime in any place using mobile devices (Traxler 2007). It is a form of eLearning which employs wireless, handheld and portable devices to extend and deliver learning to learners (de Marcos et al. 2006). This chapter conceptualises mLearning as any act of using any services rendered by a mobile device to extend learning or learning support. MLearning benefits from the fact that ownership of mobile devices is now more pervasive than tethered communication devices especially in developing countries of Africa (Muyinda et al. 2011). This is making the design and development of mLearning systems a reality.

MLearning systems can enhance academic and administrative support for open, distance and eLearning (ODeL) students in hitherto contact universities (Muyinda et al. 2011). These universities are opening their doors to ODeL provision as a way of providing access to flexible higher education. For instance, in its 2008/2009–2018/2019 Strategic Plan, Makerere University considers ODeL as one of its strategic actions for fulfilling the core function of teaching and learning (Makerere University 2008). By their very characteristics, ODeL students are disparately located; hence they live in multiple contexts. These attributes place a requirement for a seamless ODeL academic and administrative support system. Innovative technology-enhanced student support systems for seamless learning come in handy.

Seamless learning is defined as a learning model which permits learning at anytime and anyplace either in a formal or informal learning space using mobile devices as mediating tools (Chan et al. 2006 cited in Zhang and Looi 2011). The phenomenon of seamless learning connotes the reception of learning experiences ubiquitously (Milrad et al. 2013). In seamless learning, the learning device adapts learning content to the prevailing learning context of the learner (Uden 2007; Toh et al. 2013). In seamless learning therefore, learners receive equal learning experiences irrespective of their location context.

Literature shows that mLearning has the potential to extend seamless learning. In Muyinda et al. (2010), a mLearning system for seamlessly supporting distance learning students undertaking a field research is reported. Here, the distance researchers are supported variously through text messages. Also, an SMS Broadcast System at Makerere University is receiving wide use from staff wishing to seamlessly provide academic and administrative support services to their students (ibid.).

SAIDE (2008), in a report for the Commonwealth of Learning on using mobile phones for open schooling, has listed several mLearning projects in Africa where seamless learning is evident. These include amongst others: M4girls, where Nokia 6300 phones are loaded with learning objects for supporting and improving mathematics performance of Grade 10 girls in NW province in South Africa; MobilED, which supports informal and formal learning of biology services at Cornwall Hill College and Irene Middle School, South Africa; Dr. Math on Mxit, for collaborative learning in mathematics using instant messaging; MobiDic, for access to dictionary via SMS in South Africa; Eduvision, for access to satellite-distributed content on handheld computers in Kenya; MRSI, for mobile research supervision in Uganda;

Mobi Maths, for learning maths in South Africa; and mobile technology support at the University of Pretoria, for extending academic and administrative support to distance learners. Ford and Botha (2009) have reported on a MobilED project in which learning objects are developed based on the concept of 'mobile audio-wikipedia' (p. 5). This Wikipedia is based on audio mLearning objects. Another project in which audio MLearning objects are developed and utilised is the Hadeda project (Butgereit and Botha 2009). Hadeda is:

> a project where primary school pupils (and even secondary school pupils) are encouraged to practice spelling words using their cell phone. Hadeda allows the language teacher to create spelling lists or vocabulary lists in English and Afrikaans. Hadeda then generates a fun cell phone application using multiple text-to-speech engines to encourage pupils to practice spelling the words. (p. 1)

The development of these and many other seamless mLearning systems have not been underpinned by requirements generated from researched and contextualised MLearning frameworks. Zhang and Looi (2011) and Milrad et al. (2013) have underscored the critical need for researchers and practitioners to put in place effective frameworks and methods for designing, implementing and evaluating innovative learning environments and technologies in different contexts. This is also true for seamless mLearning considering the four (4) questions posed by seamless learning researchers:

- How to design seamless learning activities that support innovative learning practices?
- How to design seamless learning activities that integrate learning across informal and formal settings, with the eventual aim of nurturing autonomous learners?
- How to design learning activities that reflect the cultural diversity of learners?
- How to assess seamless learning in these new educational contexts? (Milrad et al. 2013, p. 7)

Muyinda et al. (2011) have contributed to answering the above questions in their Mobile Learning Object Deployment and Utilisation Framework (*MoLODUF*). The MoLODUF was developed with the aim of guiding system developers to develop pedagogic seamless mLearning systems. As such, this chapter uses the MoLODUF to underpin the generation/instantiation of requirements for the eventual building of a seamless collaborative and cooperative mLearning system for distance learners in hitherto contact universities.

Pedagogically speaking, collaborative and cooperative learning models enable learners to share information in the form of data, files and messages (Ayala and Castillo 2008; Caudill 2007; Uden 2007). In collaborative learning, learners are required to solve a given task as a group, while in cooperative learning, learners share a common knowledge pool for accomplishing individual assignments. Collaborative learning generates a pool of knowledge contributed by learners from different learning contexts which knowledge can form a repository for use in other forms of learning such as cooperative learning. Collaborative and cooperative learning permit disparately located distance learners to virtually co-locate.

Justification for Seamless Learning

In Milrad et al. (2013), a review of a number of seamless mLearning systems reveals that mLearning orchestrates episodic learning 'across learning spaces that contribute to build[ing] learning progressively across contexts and time' (p. 106). Since seamless learning conjures well with anytime-anywhere learning (Zhang and Looi 2011), such a pedagogy is not only suitable to lifelong learners but also to open and distance learners.

With seamless learning in blended open and distance learning, learners can undertake planned face-to-face learning in the classroom, planned individual or group learning outside the classroom and informal learning in- and outside the classroom (Toh et al. 2013). Also, being learners with multiple societal roles, distance learners can use seamless learning to learn as they tend to different chores in life. Technologies which accompany the learner at anytime in anyplace, while partaking of different societal roles, come in handy to abet seamless learning. Mobile devices are a good mediating tool for seamlessly integrating the different learning spaces and roles a learner may find himself/herself in (Toh et al. 2013).

With seamless collaborative and cooperative learning, learners can scaffold each other in their different Zones of Proximal Development (ZPD). According to Vygotsky (1978), learning occurs through mediation in the Zone of Proximal Development (ZPD). The ZPD is the difference between what a learner knows and can do on his/her own and what he/she needs to know and do with the assistance of a knowledgeable member of their society. Mediation in the ZPD is abetted by tools such as the more knowledgeable member or a tool such as an ICT. In our case, through mobile seamless learning, learners can be scaffolded on any learning activity by knowledgeable peers or teachers using a mobile device at anytime in anyplace.

Scaffolding as a teaching and learning strategy can be accomplished through collaborative and cooperative learning (Vygotsky 1978; Uden 2007). Mobile apps such as WhatsApp are well known as good and popular collaborative mobile systems. Even if such systems have affordances of seamless cooperative and collaborative learning, their design is not underpinned by any pedagogical principles or framework. In addition to being underpinned by collaborative and cooperative learning theories, seamless learning can also be underpinned by HCI theories, participatory design theories, design cycle theories, or the MoLODUF. For a detailed insight into theories for seamless learning, see chapters dedicated to that cause in this book. For this chapter, focus is put on using the MoLODUF to underpin the generation of requirements for instantiating a seamless collaborative and cooperative mLearning system.

The MoLODUF

MoLODUF is the Mobile Learning Object Deployment and Utilisation Framework (Muyinda et al. 2011). MoLODUF was developed using Design Research approach (Reeves et al. 2005). This involves five iterative process steps, namely, *Awareness of the Problem*, *Suggestion*, *Development, Evaluation* and *Conclusion*. In the *Awareness of the Problem* process step, the problem at stake was understood from

literature and learners' and other stakeholders' points of views. The findings from the *Problem Awareness* process step were used to suggest a tentative design of MoLODUF *in the Suggestion* process step. From the tentative design, MoLODUF was developed in the *Development* process step using inductive reasoning. To test for validity, MoLODUF was subjected to expert evaluation. At the end of it all, the experts agreed on twelve (12) MoLODUF dimensions that could be used for building and evaluating mLearning systems. The MoLODUF which is presented in Fig. 11.1 below and described thereafter has been published in Muyinda et al. (2011).

MLearning Costs Dimension Cost is a central aspect in any mLearning dispensation. This dimension recognises that mLearning is untenable if learners are left on their own to foot its associated communications costs. It implores mLearning developers to put in place mechanisms for mitigating the high cost of mLearning for the mLearner and the institution. The mitigation is possible where the unit cost of mLearning has been established and a mLearning cost sustainability plan put in place.

The unit cost of mLearning is derived from the total cost of mobile phone communication (TCMPC) for a mLearner which is composed of two components, namely, the MLearning and non-MLearning cost components. TCMPC is formally expressed as follows:

$$\mathrm{TCMPC} = \mathrm{Call}(\mathrm{L},\mathrm{O})\,\mathrm{T}_{\mathrm{call}} + \mathrm{SMS}(\mathrm{L},\mathrm{O})\,\mathrm{T}_{\mathrm{sms}} + \mathrm{Data}(\mathrm{L}_{\mathrm{du}},\mathrm{O}_{\mathrm{du}})\,\mathrm{T}_{\mathrm{data}}$$

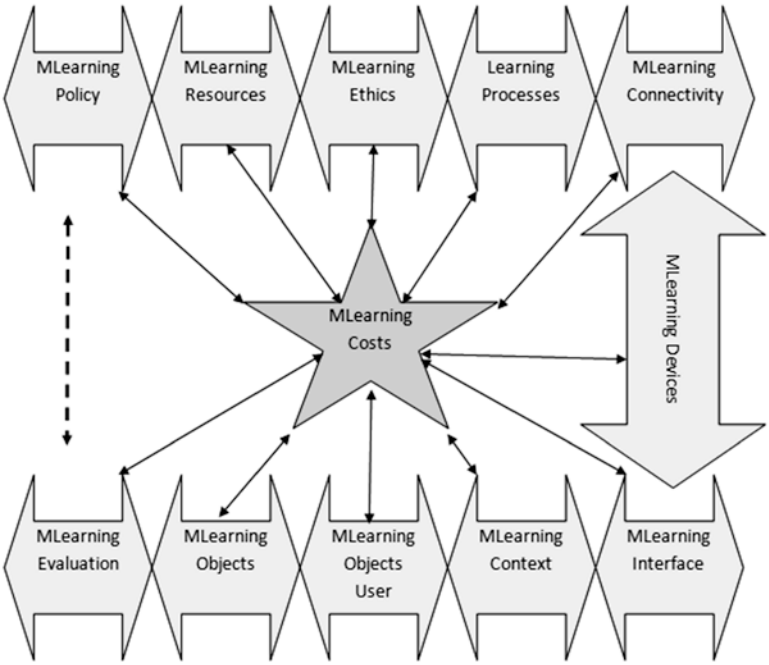

Fig. 11.1 MoLODUF (Adapted from Muyinda et al. 2011)

where

Call (L, O) T_{call} = total cost for calls made for learning and other purposes in a given period

SMS (L, O) T_{sms} = total cost for SMS made for learning and other purposes in a given period

Data (L_{du}, O_{du}) T_{data} = Total cost for data downloaded/uploaded for learning and other purposes

The above formula can be used to disaggregate mLearning costs from other communication costs. Once the actual MLearning cost is ascertained, then a MLearning cost sustainability plan can be implemented.

The mLearning cost sustainability plan (MLCSP) is based on the full commitment to mLearning from telecommunication companies, governments, universities, learners, parents, employers and donors. The plan implores these stakeholders to: provide user-friendly billing and payment mechanisms, empower individual learners to meet their own mLearning bills through provision of part-time jobs, subsidise mLearning services, adopt cheaper communications strategies, provide toll-free mLearning services to registered students, incentivise staff involved in mLearning, showcase unique added learning values in mLearning and have appropriate mLearning policies. When the commitment to this plan is secured from all stakeholders, then mLearning costs can be sustained.

MLearning Policy Dimension MLearning will thrive where there are supportive institutional and government policies. The policies should be able to give guidelines and strategies for using mLearning in universities and other institutions of learning. The mLearning policy dimension seeks to put in place favourable mLearning policies, strategies, regulations and guidelines.

MLearning Resources Dimension This dimension is related to the mLearning cost dimension. MLearning resources include infrastructural, human and financial resources. The infrastructural resources needed for mLearning are servers, fibre-optic backbones, computers, fast Internet connectivity, email, high-end mobile phones, mobile network connectivity, learning management systems (LMS), local area networks (wired and wireless) and mobile applications development software. The human resources needed for mLearning are flexible managers, administrators, lecturers and students willing to experiment with innovations in core educational practices. Other vital mLearning human resources are mLearning researchers and system analysts, mobile application programmers, technicians, instructional and graphic designers and content developers. Financial resources are central for the acquisition, installation and maintenance of all the other mLearning resources. Financial resources are also necessary for sustaining mLearning costs.

MLearning Ethics Dimension This dimension implores developers to take into consideration three ethical issues, namely, amount of cognitive overload anticipated, cultural appropriateness of the content and privacy and security of the m-learner.

Learning Processes Dimension Learning processes are overarching issues in mLearning because they provide all the learning and teaching models commensurate

with mLearning (Traxler 2007). The MoLODUF recognises eight (8) learning processes (teaching and learning models) where mLearning can be employed, namely, Co-Creation of New Knowledge, Knowledge Sharing, Collaboration and Interaction, cooperative learning, Reflective Learning, Problem-Based Learning, Academic and Administrative Support and Communication/Information Exchange. Learning processes specify appropriate mLearning activities and determine whether blended learning is needed and whether human intervention (seeded serendipity) is needed in a given learning activity. It is thus necessary to profile existing learning processes with the aim of determining those which are appropriate for mLearning.

MLearning Connectivity Dimension The ability to deploy and utilise a given media type of learning object on a mobile device depends not only on the capability of that device but also on the mobile networking technology at hand. Mobile connectivity state, mobile networking technology at play, mobile service providers and bandwidth available are important factors to consider before deploying a mobile application.

MLearning Devices Dimension MLearning application developers need to profile the mobile devices for use in mLearning object deployment and utilisation. By profiling the mobile devices in use, their generation order, properties, capabilities and limitations can be determined. Mobile device limitations constrain learning (Grant et al. 2007) because of the discomfort they create. This dimension implores developers to introduce and/or increase comfort while using mobile devices if mLearning is to be accepted.

MLearning Interface Dimension The mLearning interface is a very important factor for mLearning acceptance and use. In order to introduce and/or increase learning comfort in mLearning, it is recommended that a blended approach to learning be adopted. A blended approach means that mLearning objects could as well be deployed and utilised on PC interfaces. This has learning objects design implication in the sense that a learning object should be designed for interoperability between mobile devices (mobile device interface) and PCs (PC interface).

MLearning Context Dimension According to Uden (2007) learning context is an important factor in mLearning. A mLearning application should therefore take cognizance of the learner's context because context can propel or inhibit mLearning.

MLearning Object User Dimension The mLearning object user dimension profiles the users of mLearning objects by looking at the learning object user role, profile and education.

MLearning Objects Dimension What form of content/learning objects are you going to deploy and utilise on a given mobile device? This dimension requires mLearning application developers to model the learning objects to be deployed on targeted mobile devices. It implores developers to look into the learning objects' organisation, granulation, media type, accessibility, utilisation, pedagogy, source and brokerage needed for the given mobile device(s).

MLearning Evaluation Dimension 'Evaluation is a reflective learning process' (Lin et al. 1999, p. 43). MLearning evaluation should be done so as to establish whether a mLearning object user has achieved from the content presented in the mLearning

object, whether there is learning comfort, whether there is learning equity and whether a deployed learning object actually reached its intended recipients.

The Approach

Quantitative and qualitative research methods underpinned by MoLODUF were employed to collect and analyse data that would eventually contribute to the requirements for seamless mLearning. These included a field survey of learners, interviews/focus group discussion with key stakeholders and review of mLearning literature.

The Field Survey

A survey was undertaken amongst open and distance learning students of Makerere University. Distance learners were preferred because they are always on the move and are to be found in varied contexts (Traxler 2007). The sample size (n) was determined using Calder's (1998) sample size determination formula indicated below:

$$n = \frac{\left(\text{desired confidence level}\right)^2 * \left(\text{standard deviation}\right)^2}{\left(\text{desired level of precision}\right)^2}$$

According to Calder (1998), the standard deviation to be used in his sample size determination formula should be assumed from a standard deviation earlier on calculated on some variable in a related previous study involving the target survey population. Using this assumption, we adopted a standard deviation derived from an evaluation study of the Mobile Research Supervision Initiative (MRSI) at the Department of Open and Distance Learning, Makerere University (Muyinda et al. 2010). Results of the evaluation indicated that a standard deviation of four (4) months was computed on the variable that asked students, who collaborated on mobile phones, to provide the duration they took to complete their field research project paper. We used Calder's assumption and assumed a standard deviation of four (4) in the sample determination formula. Then we chose a confidence level of 95 % ($P<0.05$) to yield a value of 1.96 in normally distributed data. The desired precision level was set to 0.5. Therefore, at a confidence level of 95 % ($P<0.05$) and desired level of precision of 0.5,

$$\text{Sample Size}\left(n\right) = \left(1.96 * 4\right)^2 / \left(0.5\right)^2 = 245.86 = 246.$$

The desired minimum sample size was 246. Since surveys are known to have a high non-response rate of even up to 80 % (Burgess 2001), so as to get a return of

a minimum of 246 responses, questionnaires were distributed to a sample five times (1,230) the required minimum size of 246. At the end of the survey exercise, 435 fully filled in questionnaires were returned, representing a response rate of 35 %. This was above the 20 % response rate that Burgess (2001) estimated and well above the 246 minimum responses anticipated in Calder's (1998) sample size determination formula.

Multistage sampling involving quota sampling (based on regions) at stage one and stratified random sampling (based on districts) at stage two were employed to select the respondents. Uganda was divided into five regions/quotas (Eastern, Western, South Western, Central and Northern) and then stratified based on districts in each of the regions. From each region we anticipated to draw 252 respondents. The distance learning students' distribution in each of the regions was determined based on the student location register. From each stratum, simple random sampling was used to select the respondents.

Using a self-developed questionnaire underpinned by the dimensions of the MoLODUF, a survey of selected respondents was undertaken. For ethical consideration, the top cover of the survey questionnaire clearly explained to the respondents the purpose of the research and how the results would be treated.

The survey, amongst others, sought to investigate the support services provided to the students by the university and fellow learners, types of mobile phones owned by the learners, their capabilities, the uses they were being put to, possible mLearning activities and mobile networking technologies accessible to the learners.

Interviews/Focus Group Discussions

Interviews and focus group discussions were administered to get qualitative data on learner support activities, intricacies of porting third-party systems into the infrastructure of existing telecommunication companies, factors that could motivate the use of mobile phones in learning and capabilities of mobile phones. Twenty-six (26) key stakeholders were interviewed. The key stakeholders were drawn from students, university academics and administrators, mobile telecommunication companies, telecommunication regulators and SMS aggregators.

Review of Literature

In order to get a better understanding of the requirements for a seamless mLearning system, a literature review was undertaken of existing mLearning systems.

Towards Requirements for a Seamless Collaborative and Cooperative MLearning System

Since the research was underpinned by the MoLODUF, the candidate requirements are adduced from the results of the research following the twelve (12) dimensions of the MoLODUF.

Requirements from the MLearning Costs Dimension

Cost is a critical factor for the success of mLearning. To determine their total cost of mobile phone communication (TCMPC), learners were asked to provide their average monthly airtime cost. The results are presented in Fig. 11.2 below.

Figure 11.2 shows that the learners' monthly airtime cost ranged from USD 0 to 129 per month. The majority of learners (88 %) were able to afford airtime worthy between USD 0 and 24.9 per month, implying that this was the modal class. On average, a student spent USD 13 per months on airtime. Results further indicated that a USD 0 expenditure on airtime was incurred by 9.4 % of the learners and the maximum of USD 129 by just one learner. An airtime expenditure of USD 0 means that the 9.4 % of the learners owned mobile phones but did not top them up with airtime. They used their mobile phones to only receive calls and SMSs. Also, the average monthly airtime expenditure of USD 13 is on the lower side for sufficient collaboration and interaction needed in seamless learning. With an average monthly airtime expenditure of USD 13, a learner subscribing to the a mobile network with a tariff plan of USD 0.19 per minute of voice call and USD 0.08 per text message would have 68 min of voice calls or 162 text messages in a month. This airtime is insufficient considering the fact that mLearning competes with other non-mLearning communication needs as is depicted in the TCMPC formula. Here, the mLearning cost subsidy requirement is adduced.

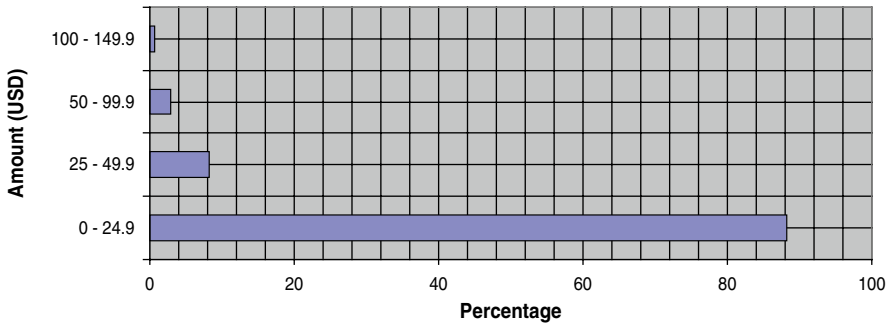

Fig. 11.2 Learners' monthly airtime cost

Requirements from the MLearning Policy and Context Dimensions

The policy environment/context for mLearning was determined by establishing the existing mLearning motivating factors. Through interviews, respondents were asked, 'what do you think are the factors that could motivate the use of a mobile phone for learning?' Numerous responses were received and coded around six (6) themes. The six themes were then ranked from the most frequent (1 being the most frequent, 2 the lesser frequent and so on) to the least frequent. The themes are presented in Table 11.1 below.

Results in Table 11.1 indicate that a favourable policy environment and context for mLearning exists. Thus, a seamless mLearning system should have mechanisms for harnessing the positive policy regime and context.

Requirements from the MLearning Resources Dimension

Results from interviews and focus group discussions revealed the infrastructural, human and financial resource requirements for seamless mLearning. The requirements were categorised into two – (1) those needed by the institution and (2) those needed by the m-learner.

As far as institutional infrastructure requirements are concerned, seamless mLearning requires servers for hosting the back-end database, mLearning system and learning management system, local area network, high-speed Internet connectivity, personal computers/laptops, mobile phones and mobile applications development software. As for the students, the infrastructures needed to integrate mLearning into their pedagogical processes are smartphones and GSM/GPRS mobile network connectivity.

For human resources, the study confirmed that the institution requires mLearning system analysts, researchers, programmers and technical support at the back end. At the front end, the institution requires flexible managers, administrators, lecturers,

Table 11.1 Factors that could motivate mLearning

Factors	Frequency	Rank order
Increasing permeation of mobile phones amongst the populace	67.7 % ($n=18$)	1
Increasing coverage of mobile telecommunication networks	64.6 % ($n=17$)	2
Government policies on telecommunication investments	57.4 % ($n=15$)	3
Existing eLearning infrastructure	44.8 % ($n=12$)	4
Emerging of distance learning units in conventional universities	21.3 % ($n=06$)	5
The emerging of mobile applications	4.5 % ($n=01$)	6

Source: Primary data

m-instructional and graphic designers, m-content developers and students willing to experiment with innovations in core educational practices. Human resource requirements from the students' viewpoint relate to a well-sensitised student body about the benefits and challenges of mLearning.

As for financial resource requirements, the institution requires to: (1) procure and subscribe to SMS and USSD codes, (2) pay for SMS aggregation services, (3) pay for USSD hosting services and (4) meet costs for in- and outbound traffic. The students require financial resources to fund in- and outbound traffic.

Requirements from the MLearning Ethics Dimension

Respondents were wary about a learning system which would jeopardise their security and privacy. One of the lecturers interviewed said, '… if mLearning is not going to interfere with my freedom to rest at night, then I will accept it'. A respondent from the communications regulatory commission said, '… it is against the law to push unsolicited text messages to people'. Therefore, to abide by the regulations, the mLearning system should enable people to voluntarily subscribe and unsubscribe to/from it at will. This will enable them to belong to groups they prefer and therefore avoid information overload which is a receipt for cognitive overload.

Requirements from the Learning Processes Dimension

Under this dimension, the study profiled the learner support activities provided by the university and those provided by learners themselves. For support services provided by the university, the study established that distance learning students at Makerere University interfaced face to face with their lecturers and fellow learners for a period of four (4) weeks in a semester of fifteen (15) weeks. In the remaining eleven (11) weeks, they were left on their own but had to be virtually or physically supported. Table 11.2 below provides the support services provided to the ODL students by the university.

Besides providing face-to-face support at the main campus for 4 weeks in a semester of 15 weeks, the university also provided academic, administrative and social support to students. According to findings in Table 11.2 below, the number one support that students receive from the university was provision of information about different learning events. This information was provided through fliers, notice boards, radio and at learning centres. According to one of the interviewees, '… this support helps us connect distance learners to their university'. Mobile notice board, where learners can push and pull information, would suffice in implementing most of the elements in Table 11.2 below.

Likewise ODL learners supported themselves during self-study periods. Table 11.3 below provides the student-student support services that occurred. From this table, it is evident that peer-to-peer support amongst distance learning occurred

Table 11.2 Support services provided to distance learners by the university

Support services	Yes	No
Provision of information about different learning events	66.7 % ($n=290$)	33.3 % ($n=145$)
Provision of coursework advice	56.6 % ($n=246$)	43.4 % ($n=189$)
Provision of guidance on learning materials	30.1 % ($n=131$)	69.9 % ($n=304$)
Provision of administrative information	24.6 % ($n=107$)	75.4 % ($n=328$)
Provision of support services through the LMS	16.3 % ($n=71$)	83.7 % ($n=364$)
Provision of study materials	12.4 % ($n=54$)	87.6 % ($n=381$)
Provision of tutorials at study centres	10.8 % ($n=47$)	89.2 % ($n=388$)
Provision of guidance and counselling services	10.3 % ($n=45$)	89.7 % ($n=390$)
Provision of registration services	9.9 % ($n=43$)	90.1 % ($n=392$)
Provision of academic consultations	9.7 % ($n=42$)	90.3 % ($n=393$)

Source: Primary data

Table 11.3 Peer-to-peer support services amongst distance learning students

Support services	Yes	No
Accomplish group assignments/coursework	77.7 % ($n=338$)	22.3 % ($n=97$)
Undertake group discussions	77.0 % ($n=335$)	23.0 % ($n=100$)
Keep one another updated on learning events	66.7 % ($n=290$)	33.3 % ($n=145$)
Help each other in accomplishing individual assignments	56.6 % ($n=246$)	43.4 % ($n=189$)
Help each other in understanding difficult content	30.1 % ($n=131$)	69.9 % ($n=304$)
Give one another examination/test tips	28.3 % ($n=123$)	71.7 % ($n=312$)

Source: Primary data

mainly for the purpose of group learning activities, which included: accomplishing group assignments (77.7 %) and discussions (77.0 %). Individual support was also evident where students informed their friends about different learning events at the main campus (66.7 %), tutored each other on individual assignments (56.6 %) and difficult to understand content areas (30.1 %) and gave each other examination/test tips. This support could be enhanced by systems that seamlessly spur group and individual learning. Group learning is mainly achieved through collaborative learning while individual learning is mainly achieved through cooperative learning (Ayala and Castillo 2008; Caudill 2007; Uden 2007).

Requirements from the MLearning Connectivity Dimension

Even if a learner owned a mobile phone with high-end features, the capabilities of the mobile networking technologies availed by the telecommunication service providers dictated the media form of content that could be accessed on such a mobile phone. Learning content can be expressed either as text, audio, video, graphics

or mixed media. Interviews with telecommunication service providers revealed that Bluetooth, Wi-Fi, GSM, GPRS, 3G, WiMax (cellular broadband) and EDGE networking technologies were available to their clients but the most common connectivity was gained via GSM. This dictates that the seamless mLearning system should be based on GSM connectivity.

Requirements from the MLearning Devices Dimension

ODL students were profiled for ownership of mobile phones and technical capabilities and limitations of those phones. The results revealed that 97.7 % of the students surveyed owned a mobile phone while 100 % of them had access to a mobile phone service. There were a myriad of mobile phone types and models with low- through to high-end features. Their technical capabilities and limitations varied. Table 11.4 below shows the capabilities of learners' mobile phones.

For learners to be able to connect to the Internet and access any learning resources and services using their mobile phones, the GPRS feature is considered the most important and relevant of all features on the phone. From Table 11.4 below, it can be seen that 56.3 % of the learners surveyed had the GPRS feature on their mobile phones. About 34.0 % of the learners did not have the GPRS feature while 9.4 % were not sure whether their mobile phones had a GPRS feature. On average, 18.2 % of the learners were not sure of the presence of high-end features on their mobile phones while only 32 % of the learners had mobile phones with high-end features. Low-end mobile phone features are synonymous with most basic mobile phone, e.g., Nokia 1110, while high-end mobile phones features are to be found in smartphones. Since the majority of the learners owned low-end mobile phones, a seamless mobile application in this context should be portable on low- through to high-end mobile phones. MLearning systems are influenced by the capabilities and limitations of mobile devices (Caudill 2007; Grant et al. 2007).

Table 11.4 Capability of learners' mobile phones

High-end mobile phone features	Available	Not available	Not sure
General packet radio service (GPRS)	56.3 % ($n=245$)	34.3 % ($n=149$)	9.4 % ($n=41$)
Bluetooth	28.0 % ($n=122$)	55.9 % ($n=243$)	16.1 % ($n=70$)
Wireless Access Protocol (WAP)/ Wireless Fidelity (Wi-Fi)	33.6 % ($n=146$)	53.8 % ($n=234$)	12.6 % ($n=55$)
Global Position System (GPS)	18.9 % ($n=82$)	56.3 % ($n=245$)	24.8 % ($n=108$)
Radio frequency identification (RFID)	23.4 % ($n=102$)	48.7 % ($n=212$)	27.8 % ($n=121$)
Average	32.0 % ($n=139$)	49.8 % ($n=217$)	18.2 % ($n=79$)

Source: Primary data

Requirements from the MLearning Interface Dimension

The study established that tutors and administrators of distance learning students at Makerere University had access to mobile phones and Internet ready personal computers. On the other hand, only 23 % of the distance learners could get hassle-free access to tethered Internet ready PC. For the tutors and administrators, a seamless system should be interoperable between mobile and PC interfaces, while for learners, the main interface for the seamless system should be based mainly on a mobile phone interface.

Requirements from the MLearning Object User Dimension

The study found out that distance learners had multiple social and economic responsibilities and were more mobile than their counterparts, the conventional students. A seamless mLearning system would be more beneficial to distance learners than conventional learners.

MLearning Objects Dimension

MLearning object deployment is greatly influenced by the possible functionalities/capabilities of the learners' mobile devices and what they use them for. These are presented in Tables 11.5 and 11.6 below.

Table 11.5 Possible functionalities on learners' mobile phones

With my mobile phone I can …	True	False
Make/receive voice calls	100 % ($n=435$)	0.0 % ($n=0$)
Send/receive text messages	100 % ($n=435$)	0.0 % ($n=0$)
Record audio and play it back	43.2 % ($n=188$)	56.8 % ($n=247$)
Access the Internet	42.1 % ($n=183$)	57.9 % ($n=252$)
Send/receive emails	41.6 % ($n=181$)	58.4 % ($n=254$)
Take/send/receive a photograph	40.5 % ($n=176$)	59.5 % ($n=259$)
View documents and images	34.3 % ($n=149$)	65.7 % ($n=286$)
Use Bluetooth technology	27.8 % ($n=121$)	72.2 % ($n=314$)
Record and view videos	22.3 % ($n=97$)	77.7 % ($n=338$)
Install mobile applications on it	19.3 % ($n=84$)	80.7 % ($n=351$)
Interact with the applications installed on it	18.4 % ($n=80$)	81.6 % ($n=355$)
Read, edit and handle computer files	15.9 % ($n=69$)	84.1 % ($n=366$)

Source: Primary data

Table 11.6 Possible mLearning activities currently partaken of by students on their mobile phones

I have ever used my mobile phone to:	Yes	No
Interact/be in touch with my classmates	77.7 % ($n=338$)	22.3 % ($n=97$)
Send/receive reminders of learning events	66.7 % ($n=290$)	33.3 % ($n=145$)
Send/receive coursework advice to/from classmates	56.6 % ($n=246$)	43.4 % ($n=189$)
Be in touch with university officials	39.3 % ($n=171$)	60.7 % ($n=264$)
Receive guidance on learning activities from lecturers	30.1 % ($n=131$)	69.9 % ($n=304$)
Send/receive examination/test tips to/from classmates	28.3 % ($n=123$)	71.7 % ($n=312$)
Receive administrative messages from the university	24.6 % ($n=107$)	75.4 % ($n=328$)
Discuss topics covered in a given course	23.2 % ($n=101$)	76.8 % ($n=334$)
Access/deliver online learning material/content	16.3 % ($n=71$)	83.7 % ($n=364$)
Supplement print-based learning materials/ content	12.4 % ($n=54$)	87.6 % ($n=381$)
Undertake simple multiple choice quizzes	10.8 % ($n=47$)	89.2 % ($n=388$)

Source: Primary data

Table 11.5 above shows that all (100 %) learners who had mobile phones could place and receive voice and text messages. These are functionalities which cut across the continuums of all mobile phone generations, brands and families. Table 11.5 further indicates that high-end mobile phone functionalities were possible on mobile phones of between 15.9 and 43.2 % of the learners as is shaded in Table 11.5 above. Since the majority of learners have low-end mobile phones, seamless mLearning for such learners should be presented using learning objects that are compatible with low-end mobile phones. Such learning objects can take the form of SMSs/text and audio media. Lee and Tynan (2009) have used audio podcasts for supporting distance learning students.

So as to compare the mobile phone functionalities with the kind of use put on them, learners were asked to provide learning activities they partook of on their mobile phones. The results are presented in Table 11.6 above.

Table 11.6 above shows that learners were using their mobile phones to partake of different learning objects. The learning objects partaken of were mainly for extending learner support activities. For instance, the majority of students (77.7 %) were enabled to interact/be in touch with each other. This interaction could abet collaborative and cooperative learning. Also, since the survey participants consisted of distance learners, the mobile phone reduced the loneliness of 77.7 % of the learners. Thus, a seamless cooperative and collaborative system would be most beneficial to distance learners.

Requirements from the MLearning Evaluation Dimension

This dimension is intended to inform the developer about the consequences of his/her development in as far as learning is concerned. Do learners understand the content presented therein? Is there learning comfort? Is there learning equity in seamless learning? Do all learners receive the content intended for them? Mechanisms for imparting learning comfort in mLearning and for informing the lecturer/administrator about learning object delivery to intended recipients are vital in a seamless mLearning system.

Summary of Requirements

From the findings above, the requirements in Table 11.7 below are adduced.

Seamless Collaborative and Cooperative MLearning System Prototype

From the requirements adduced, a prototype for a seamless mLearning system capable of offering academic and administrative support has been developed. The prototype's academic component is underpinned by the collaborative and

Table 11.7 Summary of adduced requirements

Dimension	Requirements
MLearning costs	Communication cost subsidies
MLearning policy	Mechanisms to harness the positive policy elements
MLearning resources	SMS code, SMS code aggregation and hosting, mobile telecommunications network backbone, hardware and software, programmers, mLearning system analysts, lecturers, administrators
MLearning ethics	User authentication
Learning processes	Collaborative and cooperative learning
MLearning connectivity	Connectivity via GSM or GPRS
MLearning devices	Low- to high-end mobile phones and PCs
MLearning interface	Mobile and PC interface
MLearning context	Mechanisms to harness the positive context
MLearning object user	Distance learners, lecturers, administrators
MLearning objects	Text and audio media types
MLearning evaluation	Mechanisms for learning comfort, mechanisms for learning object delivery feedback

cooperative learning paradigm because findings indicated these as being the most easily achievable mobile learning processes and most beneficial to the distance learner. On the other hand, the prototype's administrative component is underpinned by the push and pull information access strategy because findings have indicated that distance learners used their mobile phones mainly for information access and interaction.

The Prototype Collaborative MLearning Component

The teaching and learning strategy (learning process dimension) underpinning this component is collaborative learning. It was implemented in a component dubbed Collaborative Virtual mLearning (Colla VmLearn). The component is aimed at enhancing collaborative working amongst disparately located distance learning students (mLearning object user dimension). For devices, it utilises a range of low- through to high-end mobile phones since the study established that learners had a multitude of mobile phones (mLearning device and context dimensions). It also restricts itself to the use of text messages as the learning objects (mLearning objects dimension) because these are portable across the continuum of all mobile phone interfaces (mLearning interface dimension). The component is accessible through GSM and GPRS mobile connectivity (mLearning connectivity dimension). Learners have to enrol themselves onto the system and join different groups before being allowed to use the system (mLearning ethics dimension). To participate in collaborative learning, learners are charged per SMS sent and the feedback SMS is charged on the institution (mLearning cost dimension). The component is supported by an SMS short code acquired and subscribed to at fee (mLearning resources dimension). An SMS aggregator aggregates all traffic to and from different telecom companies at a fee (mLearning resources dimension). The component was piloted for feedback (mLearning evaluation dimension). The Colla VmLearn interoperates between mobile phones and personal computers (mLearning interface dimension).

The Colla VmLearn prototype works in the following way. Using a PC interface, a lecturer sets a question for group discussion. For example, 'Why are radians preferred to degrees?' The system is programmed in such way that it automatically assigns a code (say 000001) to each discussion question set and is sent as an SMS to a designated group of learners.

The message received on the learners' mobile phone will look like this:

Why are radians preferred to degrees? – 000001

The learners in the group can then compose a short answer and package it as an SMS to be sent back as a response to the question.

The response SMS syntax looks like this:

A <Question Code> <Response to Question>

or after fitting in the syntax

A 000001 rad are commonly used SI units as opposed to degrees

where 'A' is a prefix indicating to the system that it is an answer

The response SMS above is then sent to a designated short code (say 8004). The short code is given to the learners in advance.

The answers from the different discussants are rerouted (via an SMS aggregator), as SMS messages, to the different learners subscribing to the target group. The answers are also aggregated as response discussion threads in the LMS for learners to see later when they get access to an Internet connection and access the LMS either via their Internet ready mobile phones or Internet-connected PCs. The responses in the thread can then be aggregated by the group secretary to form an essay for the group. This way, collaborative learning/working is achieved.

The Prototype Cooperative MLearning Component

The teaching and learning strategy (learning process dimension) underpinning this component is cooperative learning. This component was implemented in a component dubbed Cooperative Virtual mLearning (Coop VmLearn). The component was aimed at enhancing knowledge sharing amongst disparately located distance learning students (mLearning object user dimension). Just as the Colla VmLearn, the design of the Coop VmLearn was also underpinned by the requirements adduced from the research.

The Prototype MLearning Administrative Component

This component was built following the push and pull information access strategy. It subsumes the functionality of a physical notice board. The component was dubbed the Virtual mLearning Notice Board (VmNoB). It saves distance learners from the hassle of travelling to the main campus to get information from physical notice boards. In this component, an administrative information repository is built for learners to seamlessly access with their mobile phones on demand. Its implementation can be based on USSD technology, but in the prototype under caption, it was based on SMS technology due to high cost of acquiring and subscribing to a USSD code (mLearning resources dimension). Figure 11.3 below shows the architecture of the VmNoB.

From the architecture in Fig. 11.3, a Bachelor of Education (BED) learner wishing to establish the contact information of his/her head of department will compose an SMS and send it to the given short code (in the case of this study 8004) as is seen in Fig. 11.4 below.

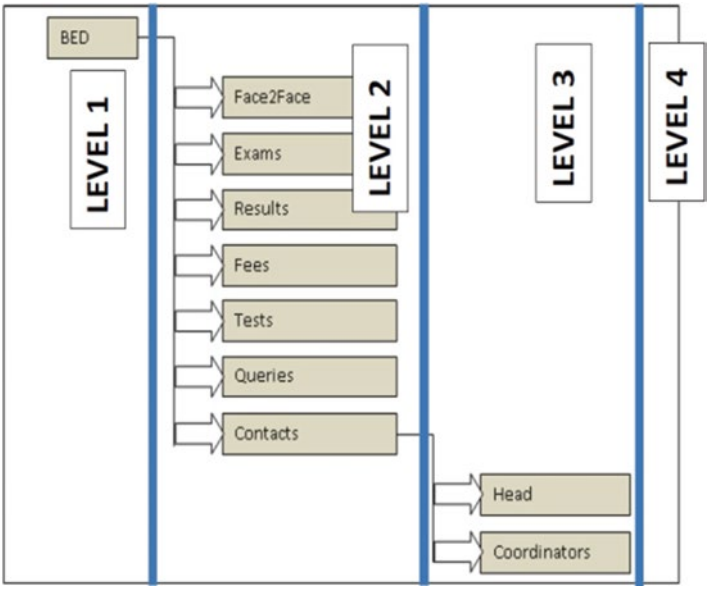

Fig. 11.3 The VmNoB architecture

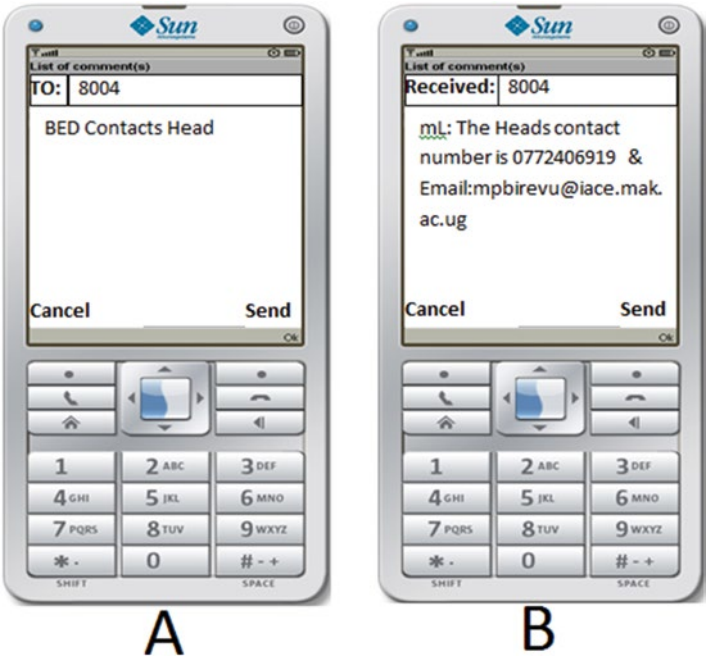

Fig. 11.4 The VmNOB syntax

The success of the VmNoB depends entirely on the richness of information repository created by an institution for access through the mobile phone. As is seen in Fig. 11.4 above, the keyword levels in the syntax architecture can be expanded.

Summary and Conclusion

This chapter has shown that MoLODUF can be used to instantiate requirements for a seamless collaborative and cooperative mLearning system. It has answered four pertinent questions in the field of seamless learning. It has shown that seamless collaborative and cooperative learning practices can be achieved through requirements generated using the MoLODUF. It has also demonstrated that learning activities that integrate learning across formal and informal contexts are achievable through mobile collaborative and cooperative learning. Also through group solutions derived from collaborative working, a reflection of the cultural diversity of learners is made apparent. All in all, the MoLODUF presents a robust method for developing seamless mLearning systems. Further research is recommended in the area of determining the learning achievements gained out of the seamless learning attained from the collaborative and cooperative mLearning systems instantiated from the MoLODUF.

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