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Own Device-Based Mobile Learning in Personal Cloud Environment: A framework to address Digital Divide

Susanta Mitra[1], Somsubhra Gupta[2]
[1,2] Amity University, Kolkata, India.
[1]susantamit@gmail.com
[2]gsomsubhra@gmail.com

Abstract: Mobile learning under cloud environment, an amalgamation between mobile cloud computing and mobile learning, has gained wide academic and commercial recognition during last few years. Though researches on MOOC and other means of Digital Learning is widely circulated, however, research to enhance traditional mobile learning using newer types of ubiquitous and pervasive devices (e.g. Modular Object Oriented Dynamic Learning Environment or MOODLE) for collecting resources is yet to be widely circulated in the literature. The proposed work is expected to make learning more cost-effective, collaborative and practical for the learners using Personal Cloud environment. This solution can be beneficial for mass learners including poor and under privileged and will help in getting rid of digital divide.

Keywords: Adaptive Learning, BYOD, Digital Divide, Flipped Classroom, Mobile Learning, Wearable Learning.

1. Introduction

Mobile learning or M-learning has recently revolutionized the education world due to huge advancement in wireless communication and mobile technologies. M-learning is an educational interaction system that is delivered to the students located anywhere and anytime through various types of mobile devices like Smartphone, Tablet, Multi-touch tablets like iPad and Galaxy Note, Handheld PCs, Laptop PCs, IPod touch and Tablet PC with Pen that can run mobile applications. These mobile devices can help the students to interact with the educational resources from places apart from their normal place of learning. It is actually a study "on the move" (Lin, Wang, & Li, 2016). The state of the art of the mobile learning along-with its newer verticals has been presented (Francisco et al.2018).

M-learning has the following features (Velev, 2014):

- Convenient as it is accessible virtually from anywhere;
- Highly portable that allows mobility of the instructors and creation of learning materials;
- Highly collaborative as it allows instantaneous sharing of the same content among everyone and reception of instant feedback and suggestions;
- Social-networked learning;
- Mobile educational gaming;
- Mobile learning through bidirectional SMS messaging.
- Mobile Learning in Flipped Mode - anywhere anytime learning.

Cloud Computing is "a model for enabling ubiquitous, convenient on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" (Wang, Chen, & Khan,

Susanta Mitra
Amity University, Kolkata, India.
susantamit@gmail.com

2014; Mell & Grance, 2009). It has two inherent characteristics: elasticity (resource scaling up) and resource pooling (running various independent services) (Wang, Chen, & Khan, 2014; Hirsch & Ng, 2011). Cloud computing complements the inadequacies of mobile learning and has brought revolution in mobile learning. Cloud computing can store a huge amount of academic resources and provide infrastructure, platform, and application software services for users instead of letting users save them in their devices (Wang, Chen, & Khan, 2014; Li, 2010). It can also provide unlimited computing power for the completion of various types of application (Wang, Chen, & Khan, 2014; Chen, Liu, Han, &Xu, 2010). Cloud computing can be looked upon as a style of scalable and elastic computing and storing where IT-related capabilities are provided "as a service" to external customers using Internet. It could provide computation, software, and storage services that do not require end-user knowledge of the physical location and system configuration and maintenance.

Figure 1 shows service model in cloud computing environment. The three main different service layers are shown in this stack. The first one is the Software as a Service (SaaS) which provides end users access to the apps like Gmail, Facebook, and MS Office 365. The second layer is the Platform as a Service (PaaS) which provides API and programming environments for the application developers. The last layer is the Infrastructure as a Service (IaaS). It provides computation and storage facilities through virtualization technology.

Fig. 1 Cloud Computing Service Model

Mobile Cloud Computing (MCC) could be simply viewed as using cloud services to empower mobile applications. Figure 2 shows the general ecosystem of MCC and some of its important members. In MCC public cloud providers serve scalable and elastic high computation and storage facilities which can be accessed anywhere, anytime. They have distributed data centers in whole world like Amazon, Google App Engine, etc. The local and private cloud providers as shown are not scalable and elastic but could provide high Quality of Services (QoS) like, data privacy and security, real time services like in games or video streaming, etc. Content and service providers are providing usable services and data contents for the end mobile device users like news, videos, email, games, etc. Network providers provide the network infrastructures (wired or wireless) which all MCC components could communicate with each other. Finally, the last members are smart mobile devices and sensors like tablets, smartphones, traffic cameras and sensorsor wearable. Two-Tire Mobile Cloud Computing Architecture MCC as in Figure 3 tries to empower the mobile device user by providing ubiquitous and rich functionality, regardless of the resource limitations of mobile devices (Reza, 2014).

2. Methodological Aspects

Mobile Cloud Learning is an amalgamation between mobile cloud computing and mobile learning. In other words,Mobile cloud learning is a novel unification of cloud computing and mobile learning. The architecture of mobile cloud learning is also shown in Figure 4. In mobile cloud learning, learners can access content, such as text-based documents, audio, and video files, over the cloud via their mobile devices connected with the Internet (such as GPRS, UMTS, HSPA, WiFi, WiMAX, or

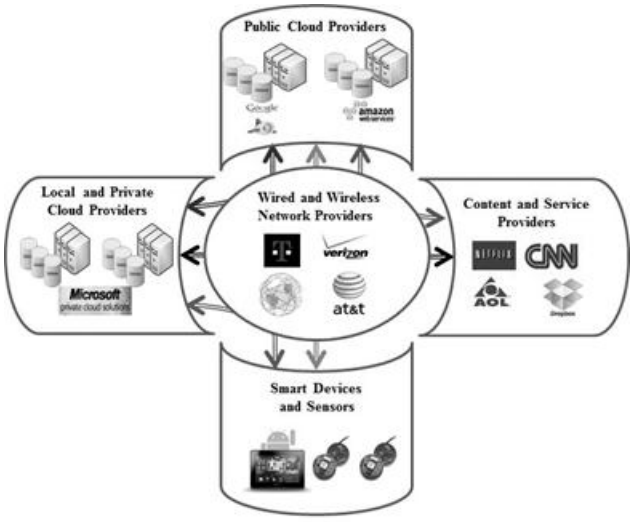

Fig. 2 Mobile Cloud Computing Ecosystem

Mobile Cloud Learning is an amalgamation between mobile cloud computing and mobile learning. In other words, Mobile cloud learning is a novel unification of cloud computing and mobile learning. The architecture of mobile cloud learning is also shown in Figure 4. In mobile cloud learning, learners can access content, such as text-based documents, audio, and video files, over the cloud via their mobile devices connected with the Internet (such as GPRS, UMTS, HSPA, WiFi, WiMAX, or LTE) (Wang, Chen, & Khan,2014; Hirsch & Ng, 2011).

Mobile Cloud Learning provides various benefits to the content providers and learners. These benefits can be summarized as:

- Small and medium learning institutions can provide mobile learning services at lower cost without much investment on initial setup for infrastructure and by just paying regular fees to service providers.
- Very less resource required by the mobile devices to access the desired learning apps as all the data storage, processing and updates are done outside the device and the results are only displayed through the device screen or speakers through cloud services.
- Content providers and learners do not need have to upgrade periodically the software and hardware at their end.
- Poor and remote area students having no access to high-speed broadband technologies can learn subjects of their choice from cloud data centre by using their mobile device only.

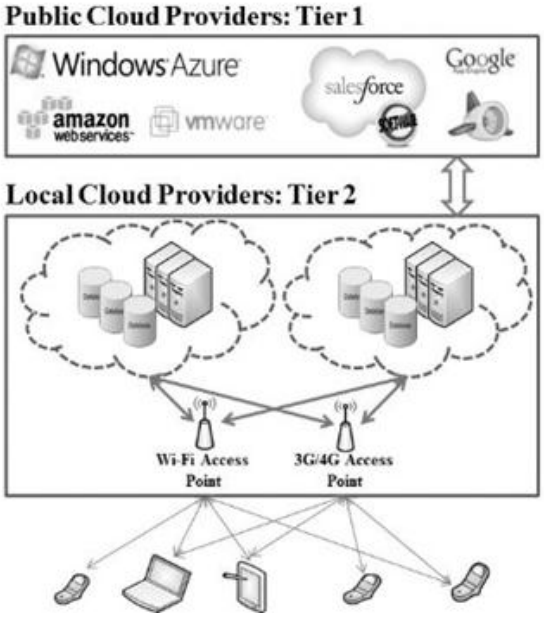

Fig.3 Two-tier Mobile Cloud Computing Architecture

- Learning resources can be shared among the mobile cloud learners and it helps each individual to collect more educational resources.
- Group collaboration in open source cloud environment enriches the learning ecosystem and applicationsLTE) (Wang, Chen, & Khan,2014; Hirsch & Ng, 2011).

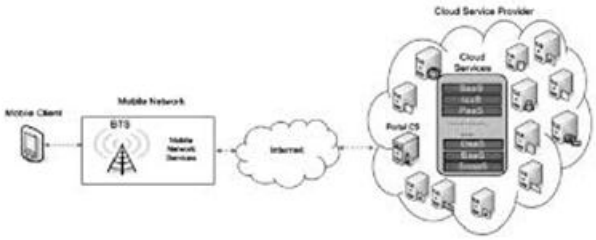

Fig.4 Mobile Cloud Learning Architecture

It is apparent from the above discussions as well as various studies and researches carried out during the last few years that mobile cloud learning has gained wide academic and commercial recognition and will play more vital role in the rapidly growing e-learning market (Lin, Wang, & Li, 2016; Wang, Chen, & Khan, 2014; Wei, & Joan, 2014). However, no research is known to be conducted to enhance traditional mobile learning using newer types of devices to gather information from the surroundings and to make learning more effective, interesting and practical for the learners using Personal Cloud environment. Till now, few types of devices like Smartphone, Tablets and others as discussed earlier have been utilized in mobile cloud learning and have some limitations like small screens, limited memory and processing powers, multiple operating systems, multiple screen sizes and multiple standards (Baalghusan, & Qureshi, 2014). So, apart from traditional or existing mobile devices, design of own need-based innovative devices are required to overcome the limitations of existing devices as well as to help the mobile learners to gather information from the surroundings to widen their scope of learning. A humble attempt has been made though this paper to review promising latest and future technologies and propose novel ideas for learning solution in personal cloud environment that can be cost-effective, collaborative and beneficial for mass learners including poor and under privileged.

Mobile learning in Flipped mode (Bergmann –Sams, 2012) has the following features:

- The work at home and work at classroom are flipped
- Teacher provides digital content to the students prior to the class.
- The students go through the content and are informed before joining.

- Teacher distributes the sub-problems to the students in the class.
- Students create their own content and submit to the teacher in class.
- After class, teacher verify and integrate the individual content to produce final content on the topic and share

Further, it enables anytime anywhere learning. Students can access the proposed content secured in personal cloud environment at their own pace and in their own place {Kalisman et al. 2013)

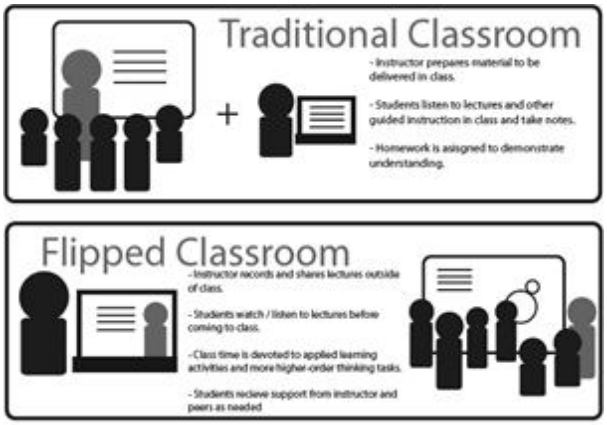

Fig.5 Mobile Learning in Flipped Mode.

The top technology trends in learning till the end of current decade and beyond is well discussed in (NMC Horizon Report, 2015). In this report, the various types of learning with the challenges and the techniques to solve them are summarized through a graphic. Based on different rounds of study, discussion and voting six educational technologies viz. Bring Your Own Device (BYOD), Flipped Classroom, Makerspaces, Wearable Learning, Adaptive Learning Technologies and the Internet of Things (IOT) have been identified.

In higher education, consumers are the students, and there is need to cater to them as their expectations and behavior evolve. The shift is being driven by the technologies that students use in their daily lives and the same extended to learning. Once it was clear that smartphones and few other devices could play a major role in teaching and learning, institutions started updating their infrastructures to adopt them. Moreover, the mobile devices have also been recognized as important tools for shaping up workplace learning scenario. In the area of competency building, mobile devices are and will continue to play the important role of augmenting training beyond the classroom. Again, gamified mobile learning and assessments is on rise and gaining popularity. The trend to develop game based learning content will continue. A brief background on BYOD and Wearable Learning follows as these learning technologies are and will become more popular, particularly in education sectors to pave the way for development of newer technologies to make learning more interesting and effective.

Bring Your Own Device (BYOD)

The concept of BYOD also known as BYOT (Bring Your Own Technology) was brought in the market by Intel in 2009. It refers to the practice of people bringing smartphones and other mobile devices with them in their learning or work environment and connecting them to the corporate network. In fact, BOYD practices have become quite common in education industries where many students enter the classroom with their own devices, which they use to connect to the institutions' network to perform various types of learning activities.

BYOD can offer number of benefits to students of higher education as well as schools. Some of these benefits can be:

- Increase student participation in learning activities as students feel more comfortable to use the same device at home and classroom.
- Attachment to own devices deepen learning and make learning more personalized and student centered.
- Integrating with cloud based environment enables availability of cloud based storage and access to wide range of learning applications.
- More cost effective as no need to provide laptops to individual students and technology support by the institution can be minimal as the students can take care of their own devices.
- Wearable learning, driven by wearable technology has promising future and can support learning with performance assessment. Wearable technology refers to the computer-based devices that can be worn by users in the form of light-weight, portable accessories like eyewear, watch, jewelry to track or gather information wherever the users are. Few benefits that can be achieved from wearable learning are:
- Wearable devices can be utilized in education to assess learning and provide information to learners for performance improvement.
- Students can perform live experiments by wearing suitable wearable device and share the live recording of their experiments to their teachers for evaluation and suggestions for improvement or rectification.

Device-Based Mobile Learning In Personal Cloud At the

turn of 21st century it is being observed that there is a shift towards skill sets that have real, applicable value in the rapidly advancing world. In this context, creativity, innovative design and engineering are becoming and will be under prime educational considerations. The learners need to be engaged in more research-oriented, creative and high-end problem solving through hands-on design, implementation and iterative refinements. So, more and more innovative tools like 3D printers, robotics and 3D modeling web-based applications are coming up for proper utilization by the creative minds. Students of different disciplines or inter -disciplines can experiment and collaborate on innovative projects to invent products or technology and may become entrepreneur also. The experiments can be done by groups from remote locations through interactions.

Learning cannot be complete or a topic may not be properly realized unless people, object and devices are connected with each other via Internet. To create a relevant, interactive learning environment a student can communicate with the objects of his surroundings and vice versa through some special device especially quantified self devices and wearable devices like Google Glass, Oculus Rift, Apple Watch, and Android Wear and collect real time data for further study or share it with teachers or friends. With newer devices an interface can be created with sensors, data storage and memory so to be in tune with the physical surroundings while composing and sending text, e-mail, image or voice data. As the devices are heterogeneous in nature with different screen sizes it is important to create responsive deign so that the learners with different devices enjoy the same learning experience irrespective of screen size and resolution (Pappas, 2016; Pappas, 2015).

3. Proposed Solution Process

Knowledge and learning can be need based of the learners with following features

- Can also depend upon own pace, reading levels or grasping and own ways of self-assessment.
- So, it is not always required to be connected full time to the Internet but to store and organize data collected from multiple sources.
- This type of decentralized or distributed digital learning can be realized through Personal Cloud. Learners may have their individual personal clouds with different documents or data acquired from multiple sources and which they may share for a common interest.
- Learners can create mostly disjoint sets of personal documents in their personal clouds with minimum number of common documents to save storage space and cost. They can search or get documents not available with them from other personal clouds free of cost, provided search right is granted.
- In this way the search cost for searching from private or public cloud service providers can be reduced.
- Moreover, a large shared pool of valuable learning resources, tools can be built up that can help the learners to fill gaps in their learning and enrich themselves also.
- This can include helpful guidance, latest information from renowned scholars, domain experts from industries and even from bright students with innovative ideas or who have invented some products.
- Again, poor students who cannot afford personal or private/ public cloud services can avail of the learning resources free of cost from the personal clouds of their friends, if allowed and provided they have some connecting device.
- However, the document search or sharing should be secured in the personal clouds where the privacy of the personal cloud owners needs to be properly maintained.
- In case of queries of documents stored in a large number of Personal Clouds the global searches need to be accomplished by preserving the privacy where no further information beside the computation result can be learned by the group members or third party (Le et al. 2016).

In the proposed personal cloud system data is gathered from multiple sources like own educational institution, own workplace, professional / technical bodies or from devices like smartphones, laptops, smart devices and wearable. The data can be in various forms of files like image, text, mails, data streams from sensors. To ensure document security data control access mechanisms are associated with the documents and the search security architecture can be similar to the one discussed in (Le et al. 2016). Network infrastructures exist between the personal clouds for information exchange or performing distributed queries. The owners of each of these personal clouds can communicate with each other as well as with the relevant knowledge service providers who may be private or public cloud providers. These prospective service providers may be educational or industrial organizations as discussed in Section I. However, in none of the cases specific personally identifying information to specific service providers are revealed.

Architecture of the proposed solution is provided in the following Figure 6.

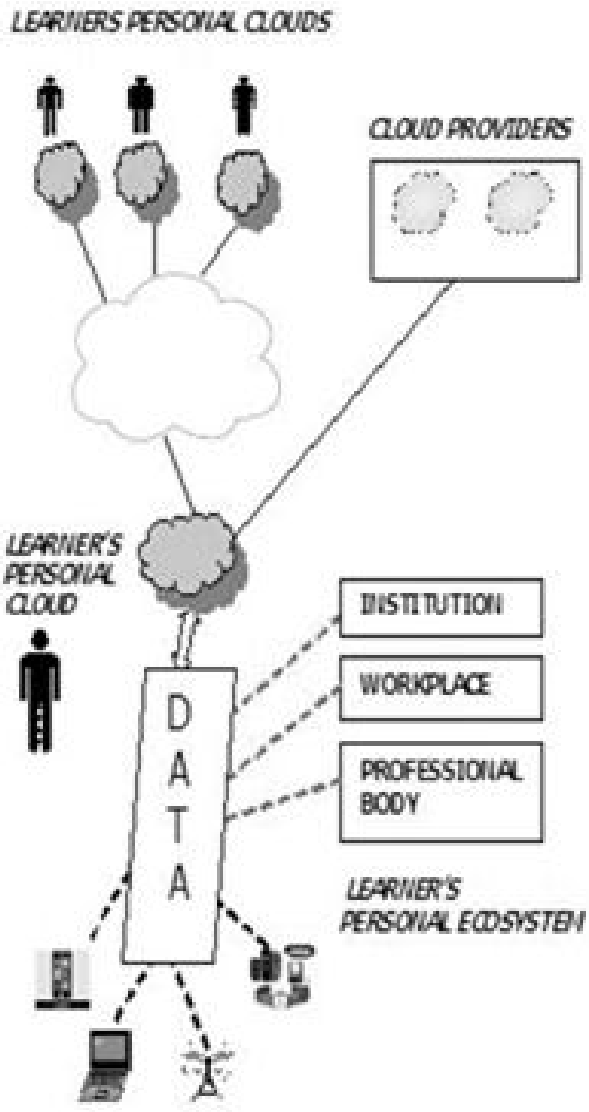

Fig.6 Mobile Learning Architecture in Personal Cloud

4. Result and Discussion

The proposed Mobile learning framework is annexed with the following Case Study and Case result (in a specific vertical viz. Flipped Learning). As mentioned in the Methodology Section regarding Mobile learning in Flipped mode, the following evaluation systems has been frame-worked to measure the knowledge transfer in Mobile Learning:

A. Evaluation Framework

Credit Systems (10 –scale):

A - 10 (marks 90 and above)
B– 9 (80-89) C- 8 (70-79), D- 7(60 -69),
E- 6 (40 -59), F -2 (below 40).

·Daily evaluation sample (paper code)

Sl No	Name of the students	University Enrolment No.	Digital Content -overall	Flow of Digital content	Quality of Digital content	Under standing of digital content	..	Aptitude – subject/ topic knowledge
1	X.Y	A 905792 18002	A	B	C	A	…	D
2							..	
3							…	
…….								

(The detail is appended in the ANNEXURE)

Daily evaluation value (as above) = (10+9+8+10+10+9+9+8+9+7)/100 = 89/100 (=8.9/10)

·Weekly evaluation sample

Sl no	Name of the students	University Roll No.	1st Lecture	2nd lecture	3rd lecture	4th lecture
1	X.Y	A 905792 18002	8.9	7.8	8.2	8.4
2						
3						
…….						

Weekly evaluation value =simple mean in scale of 10 =(8.9+7.8+8.2+8.4)/4 = 8.325

Monthly evaluation can be done integrating 4 weeks results as in the above in the same weighted cumulative pattern.

·Semester evaluation sample

Sl no	**Name of the students**	**University Roll No.**	**Week 1**	**Week 2**	**Week 3**	**Week 4**	..	**Week 20**
1	X.Y	A 905792 18002	8.325	8.7	8.9	9.1	..	8.5
2								
3								

(The detail is appended in the ANNEXURE)

Semester evaluation value = simple mean in 10-scale = (8.325+ 8.7+ 8.9+ 9.1+ ……. +8.5) / 20 =8.44 (Grade B)

Sl no	**Name of the students**	**University Roll No.**	**CS601**	**CS602**	**CS603**	**CS604**	**CS605**
			4	**4**	**3**	**3**	**4**
1	X.Y	A 905792 18002	A (9.32)	B (8.44)	A (9.1)	B (8.76)	C (7.45)
2							
3							
…….							

· SGPA = (9.32 x 4 + 8.44 x 4 + 9.1x3 + 8.76 x 3 + 7.45 x 4) / (4+4+3+3+4) = (37.28 + 33.76 + 27.3 + 26.28 + 29.8)/ 1 = 8.578
The CGPA will be calculated accordingly.

B. Case Results
The above framework is annexed by the following case results of evaluation:

Sl No	Student id	Paper Code 1		Paper Code 2		Paper Code 5	
		Month 2	Month 1	Month 2	Month 1	Mont h 2	Month 1
1	Roll-31	9.57	7.6	7.07	7.86	7.63	8.01
2	Roll-32	9.45	8.2	8.13	6.17	9.00	7.76
3	Roll-33	9.45	9.0	8.31	4.10	8.14	7.33
4	Roll-34	9.62	8.0	7.51	7.30	8.08	7.56
5	Roll-35	8.44	4.7	7.33	4.07	8.24	7.94
6	Roll-36	7.64	8.2	5.13	7.33	7.52	7.47
7	Roll-37	9.58	9.3	6.77	7.93	8.12	7.47
8	Roll-38	8.51	7.3	3.16	7.17	8.26	7.36
9	Roll-39	9.49	7.2	6.89	7.27	8.61	7.71
10	Roll-40	9.60	6.9	7.79	6.10	8.10	7.5
11	Roll-41	9.32	9.0	5.41	6.07	7.26	7.48
12	Roll-42	9.45	6.8	6.47	6.20	8.06	7.88
13	Roll-43	8.50	4.5	3.83	6.13	8.20	7.92
14	Roll-44	9.53	4.3	2.29	0.00	8.38	8.2
15	Roll-45	8.57	6.6	6.80	4.07	8.31	8.18
16	Roll-46	8.63	5.1	4.39	4.07	8.07	7.89
17	Roll-47	3.70	5.2	0.97	3.07	8.33	8.17
18	Roll-48	3.80	4.9	2.39	0.00	8.40	8.21
19	Roll-49	9.35	3.5	6.77	4.00	8.14	8.2
20	Roll-50	9.47	7.2	6.40	4.03	8.38	8.26
21	Roll-51	9.37	7.1	7.04	4.20	8.38	7.3
22	Roll-52	9.52	9.5	7.67	6.20	8.23	8.14
23	Roll-53	8.61	8.3	6.70	7.20	8.47	8.28
24	Roll-54	9.64	7.0	6.51	4.97	7.15	8.72
25	Roll-55	9.48	9.0	4.74	7.50	8.38	8.2
26	Roll-56	9.63	9.2	4.63	6.00	8.47	8.24
27	Roll-57	7.64	0.0	3.69	0.00	8.37	0
28	Roll-58	9.65	8.3	6.10	6.20	8.33	7.77
29	Roll-59	9.61	8.4	7.73	6.17	8.38	8.83
30	Roll-60	9.43	7.3	7.59	7.60	8.47	8.06

(The detail is appended in the ANNEXURE)

The following points may be observed in the above table:

- The evaluation / assessment of same batch of students in back to back months are taken into consideration.
- The above monthly evaluations are integration of weekly evaluation through daily evaluation. Month 1 proceeds month 2.
- Though no specific conclusion can be made from the above table, but it has been observed that month 2 performances are better for the majority with finite exception. This is due to acclimatization with revised pedagogy and evaluation.
- Experimentally, these has been conducted among all first year batches (total: 7 disciplines, 14 batches).
- The behavioral aspect has been found to be same in most of the cases.

D. Inference

Comparing above to normal mode of learning and evaluation, there is 2/ 3 slot tests in traditional mode of learning in entire semester as compared to daily evaluations integrated above. The Mobile Learning in Flipped mode is a skill oriented approach rather than memory oriented since this conduction classes in Flipped mode requires not only knowledge base but also time bound content delivery, time –bound evaluation (Time management in brief) and lot more skills. This commitment and involvement requires from both the teacher and students part. The commitment/ involvement failure may affect this revised pedagogical reform at least in the context of Mobile learning in Flipped mode.

However, the observation of the presenter is that - this framework is much optimistic, in terms of idea sharing, carrying reduced / little risk if the evaluation part is omitted and is used for the mixed mode of content sharing.

C. Inherent POSITIVEs in Mobile Learning

In general, the Mobile Learning is inspired by the following inherent facts:

- In this new millennium, there is a huge transformation in teaching- Learning process.
- There is a gradual transition from traditional chalk-and-talk to Activity based learning.
- The Learning centric environment is a paradigm shift from century old traditional teaching pattern of one-to-many knowledge transfer.
- This is not merely confined to interactive teaching or transformation from monologue to dialogue pattern of teaching
- There is a psychological shift among the new generation of learners in the sense that they are more interested in active learning or learning by doing
- New generation of learners are in no way dependent on the teacher regarding the syllabus content.
- Instead, they rely on web content which supersedes the individual content.
- To build a concept, most of them depend on Wikipedia, YouTube or simply Google.
- Moreover, there are Big corporate driven portals (viz. screen-casting, blend space, mysimpleshow. etc.) which aid student in customized learning
- Moreover, the social networking help student to quench his / her knowledge thirst through community participation and contribution that can over-smart knowledge of any individual.
- Teachers have been gradually transformed as Facilitator / Guide by the side.
- The need of the teacher is still very relevant so as to guide the student with the right composition of material, since not all web literatures are authentic
- The eternal power of teachers to understand student psychology of learning and customize the content accordingly remains relevant.
- The Outcome Based Education (OBE) framework takes cognizance of all the above mentioned facts.

It is apparent from the above discussions as well as various studies and researches carried out during the last few years that mobile cloud learning has gained wide academic and commercial recognition and will play more vital role in the rapidly growing e-learning market (Lin, Wang, & Li, 2016; Wang, Chen, & Khan, 2014; Wei, & Joan, 2014). However, no research is known to be conducted to enhance traditional mobile learning using newer types of devices to gather information from the surroundings and to make learning more effective, interesting and practical for the learners using Personal Cloud environment. Till now, few types of devices like Smartphone, Tablets and others as discussed earlier have been utilized in mobile cloud learning and have some limitations like small screens, limited memory and processing powers, multipleoperating systems, multiple screen sizes and multiple standards (Baalghusan, &Qureshi, 2014). So, apart from traditional or existing mobile devices, design of own need-based innovative devices are required to overcome the limitations of existing devices as well as to help the mobile learners to gather information from the surroundings to widen their scope of learning. A humble attempt has been made through this paper to review promising latest and future technologies and propose novel ideas for learning solution in personal cloud environment that can be cost-effective, collaborative and beneficial for mass learners including poor and under privileged.

C. Framework to address digital divide

The proposed work is envisioned to address poor and under privileged learners and will help in getting rid of digital divide in the following way.

· Cloud Computing Service Provider (CCSP) subscription, which is rather costly, is not required for learning solution in personal cloud environment.

· The proposed mobile learning can directly be availed through personal cloud provided by corporate bigwigs such as Google drive, One drive and others.

· The mobile learning in flipped mode can be availed through some portals (viz. screen-casting, blend space) are free of subscription price.

· The MOODLE device to avail Mobile Learning is low cost. Some tablets (viz. Aakash tablet) are availed at subsidized cost aided by the Government in national perspective.

Likewise, there are various other features that lessen the gap between the learners in the class of haves and have nots and thus directly address digital divide and ensure it's not an obstacle towards the path of knowledge.

5. Conclusion

This study has been done primarily to enhance traditional mobile learning using newer types of devices to gather information from the surroundings and to make learning more effective, interesting and practical for the learners. The latest and future trends & technologies of learning discussed to give a background for the proposed futuristic and useful solution. The six components viz. BYOD, Flipped Classroom, Makerspaces, Wearable Learning, Adaptive Learning Technologies and the Internet of Things (IOT) widened the horizon of learning. A new concept of implementation of need based mobile learning in personal cloud has been introduced for learners from both academics and industries. This cost-effective solution may definitely help a large community of learners, specially the poor to avail of the learning resources free of cost, in most cases and share knowledge also in search of diminishing digital divide. The proposed solution can be well utilized as a starting point by the researchers and practitioners to develop and implement newer learning systems in personal clouds keeping in mind the data security aspects. This will definitely bring new possibilities and dimensions in the mobile learning systems.

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