Chapter Three

Technology for Learning and Teaching Mathematics at the University of Jos

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1. Introduction

This chapter on Technology for Learning and Teaching mathematics tells the story of developments in an eight-year, multi- sponsor funded eLearning initiative at the University of Jos. The chapter demonstrates how students nurtured in traditional forms of learning are introduced to blended eLearning. Class activities include interactive teaching, video group activities, on-line tests, discussion forums and a student leadership caucus. Through a description and discussion of this initiative, the chapter spotlights challenges of learning and teaching with technology in the Nigerian environment. Impact assessment results of the intervention are also presented. The results of the Technology for Teaching (TfT) project are considered as a proof of concept, to demonstrate how Jos developed local solutions to local problems.

There is limited understanding about the use of technology in education in Nigerian HEIs. No known large scale studies that give an overview of ICT use in Nigerian education are available. Only case studies that document single university experiences can be found. (see for example Madu and Pam, 2011;) As a result, there is limited appreciation of the need for investment in time and money to maximally exploit the use of technology in Nigerian HEIs There is an equal need to better understand the advantages of sharing information, resources and expertise, doing impact assessment, studying best practices, and collaboration.

Currently, there is a paucity of reported Nigerian activities, in the area of Educational ICTs. This absence of publications in peer reviewed or accessible journals does not mean that there are no developments in the area. Manir (2000) suggests that eLearning activities in Nigerian universities are limited to the use of Internet resources for research. Ajadi, Salawu and Adeoye (2008) discuss eLearning as a distance education tool in the National Open University of Nigeria. Very little is reported, on local content, its use and impact. This chapter discusses the creation and use of open local content, its impact and the use of other Open Educational Resources (OERs) at the University of Jos.

A review of relevant literature confirms quality impact assessment is critical. It also confirms that the use of technology in education is a capital and time intensive pursuit. For example, iCampus was a seven-year, $25 million Research and Development effort. It was hosted at MIT, funded by Microsoft Research, and focused on building technologies that enabled more effective learning [http://hetl.org/]. The Centre for Academic Development at the University of Auckland, in New Zealand, promotes sustainable and scalable strategies for embedding technology into teaching to support student engagement and attainment. South Africa has the University of Cape Town's Centre for Educational Technology that supports the use of educational technology for teaching and learning in higher education [http://www.cet.uct.ac.za]. Countries large and small, rich and poor, are investing time and money in the use of ICT in education.

Best practices in educational ICTs have to be explored and nurtured into a tradition in the Nigerian education sector, where blended eLearning is taking root.

2. Blended eLearning in Nigerian HEIs

Sharpe, Benfield, Roberts and Francis R (2006) identified eight dimensions implicit in definitions of blended eLearning:delivery; technology; chronology; locus; roles; pedagogy; focus and direction. They also identified three ways in which the term "blended learning" is being used in undergraduate eLearning:

1. The provision of supplementary resources for courses that are conducted along predominantly traditional lines through an institutional supported virtual learning environment.
2. Transformative course level practices underpinned by radical course designs, making use of technology to facilitate interaction and replacing other modes of teaching and learning.
3. Students taking a holistic view of the interaction of technology and their learning, including the use of their own technologies.

Rationales for blended e-learning include flexibility of provision, supporting diversity, enhancing the campus experience, operating in a global context and efficiency. The most frequently reported rationale remains maintaining quality in response to increasing cohort sizes. The limited blended eLearning activities that take place in Nigerian HEIsmake use of course redesign and supplementary resources to make learning more interactive for instructors,and more pleasurable for students in a bid to improve the quality of graduates (http://www.forum.org.ng/blog/13).

Student centred blended eLearning is taking root in Nigerian HEIs. The barriers to engaging students in the process of learning today are universal. HEIs have a high resistance to change. The digital natives and digital immigrants dichotomy persists. The ratio of investment in digital infrastructure and staff support for institutionalising eLearning has to be carefully balanced, Stefani (2011). Specifically, Nigerian HEIs have to cope with inadequate human resources and brain drain. They have poor infrastructure and unstable power supply. It is against this background that eLearning activities are growing in environments connecting people and encouraging the sharing of ideas and experiences- in small Communities of Practice, (CoP) across Nigeria. With this growth, there is a great need for rapid capacity building through formal training, and continuing professional development of eLearning practitioners. Will Nigerian academics seize the new opportunities for researchers and teachers to network and develop collaborative projects? Will they be willing and able to excite, engage and enrich the learning experience of our students? Will students change their attitudes to work individually and in groups, using the abundant resources now available to them? Will faculties of education in Nigerian HEIs take the lead in the blended eLearning revolution?.

3. Teaching with Technology at The University of Jos

Nigerian HEIs have a role to prepare scholars to contribute to the global market place of ideas. Adopting an appropriate strategy to introduce ICT for learning and teaching may be as critical as the content developed or shared (Liverpool, Marut and Ndam 2011). Teaching with technology is not new at the University of Jos. The Law Faculty as well as the departments of Anatomy, English and Mathematics are among many that are experimenting with the creation and use of local content, for teaching with technology. Nettel Africa, the Cisco and Microsoft academy programs at Jos have used content developed elsewhere for technology supported delivery of courses jointly offered at Jos. The challenge now is to do impact assessment, share results and develop models for the Nigerian environment. One way to efficiently do this is to build a strong CoP among Nigerian HEI policy makers, administrators, and academics to encourage shared human and material resources. This would expose Nigerian HEIs to what's possible with educational technologies and explore areas of collaboration and partnerships. A CoP comprising of ICT champions and novices who are keen would enable a climate of support which would build capacity in the use of Technology for Learning and Teaching, through training and sharing of best practice. Further, support would be available for evaluating and redesigning existing courses through a peer review mechanism. Technology can be used to make classes more fun and inspirational. The University of Jos wants to use itsMoodle site as a tool for instructors to efficiently "extend learning outside the class, to better manage course

materials and to provide engaging, meaningful and timely feedback for all students" (http://dg.icme11.org/document/get/72).

4. Technology for Teaching Mathematics at the University of Jos

4.1: Setting up the infrastructure: Stimulated by the innovation and gains of the Law Faculty, the department of mathematics introduced its own Technology for Teaching initiative in 2003, with a grant from the Carnegie Corporation of New York. By that time the faculty of law had established a model for participatory development of Information and Communication Technology (ICT). The Law Faculty excels in building infrastructure, training internal and external audiences as well as advancing legal research. The faculty extended the university's commitment, to invest local capital in support of ICT development, becoming a pioneer in many respects. Law was the first faculty to use faculty investments for procurement of computers; develop a student managed faculty lab; introduce commercial services to support sustainability and growth; host a faculty internship program and provide Internet access points in all academic and administrative offices. In this regard, they set a good precedent for replication.

The Technology for Teaching Mathematics project is supported by the university's ICT Directorate, which provides considerable technical advice and technical support. Hewlett Packard provided the priceless resources of its technology for teaching community in addition to $100, 000 support for travel, publicity, and tablet PCs. The World Bank Assisted Science and Technology Education Post Basic (STEPB) program provided $200,000 for the creation of an interactive lab, overseas training of one staff and procurement of tablet PCs. The Jos Carnegie Partnership (JCP) provided motivation, funds for tablet PCs, sensitisation, training, local and international conferences as well as solar/battery power hybrid back up. JCP total support is estimated at over $250,000 in a nine- year relationship. In summary, Table 1 below highlights the financial support that the TfT mathematics project has received

Table 1. Fund utilisation by donor

Funder	Amount received	Grant utilisation	No of Tablet PCs purchased
HP	$100,000	Travel, publicity and tablet PCs	21
World Bank STEPB	$200,000	Creation of interactive lab, training	21

Carnegie Corporation	$250,000	Tablet PCs, sensitisation, training, conferences, back-up power	21
Total	$550,000		63

Altogether, 63 Tablet PCs were purchased for the project. The TfT team decided to use tablet PCs as mathematical signs and symbols can be easily annotated with the annotations saved for later use by students. Equally attractive was the opportunity to use the free open source Classroom Presenter software with the tablets for improved lecturer- student communication in a unique way. It was decided early that students would work in pairs to encourage peer interaction and mutual support.

4.2 Course development: The development, training and research activity of the TfT mathematics team started by addressing the problem of poor performance of students in first-year mathematics. Mathematics is a foundation discipline for all science and technology fields. We wanted to investigate the use of technology and its impact on learning and teaching and used a model that generates open local content as highlighted in Figure 8 below.

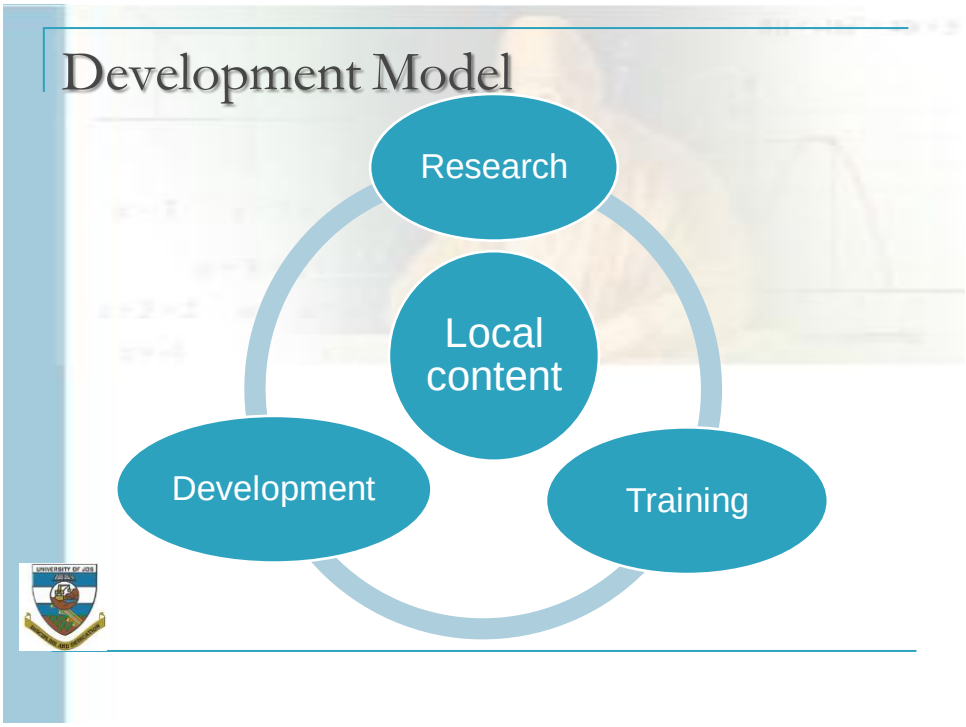

Figure 8: TfT Development Model

The project initially named "Improving Students' Performance in Mathematics and the Sciences" was aimed at using technology to improve mathematics instruction and student performance to enable UniJos prepare students in science–based disciplines more effectively. The project involves course redesign, materials acquisition and development, student-centered pedagogical training, integrating technologies, impact assessment and replication.

The project started off by addressing one mathematics course-MTH103. With over 1,000 students enrolled, interaction between instructors and students was inadequate in this course, even when students were split into several groups. Learning was not judged pleasurable. A calculus course, MTH103 is compulsory for most science students and the general performance over many years was poor. The thinking behind introducing technology was that if we could change students' performance in any small way, we would be on the way to finding a model for effectively teaching large oversubscribed mathematics courses. Three sets of reviewed and updated materials for teaching this course have since been produced. Local content has been created under a creative commons license http://moodle.unijos.edu.ng. The first set was used to teach the course in one tablet PC

Figure 9: The TfT Interactive Lab

mode, using the instructor's tablet and a projector. This was even before an interactive lab (Fig: 9) became operational. A solar and battery hybrid power back up now ensures uninterrupted electric power supply to the interactive lab.

The first set of materials was used as a basis for improving the course in a fundamental way. The reviewed and updated materials have now become resources for teaching in one and multi tablet mode. The table below displays the benefits of course restructuring to students and instructors.

Table 2. Restructuring activity, outcomes, and benefits

Restructuring Activity	Outcomes	Instructors' Benefits	Students' Benefits
Review and edit digitized notes	Course material reviewed, edited, and uploaded on the university's learning management system.	Awareness of online pedagogy and course development strategies.	Access to quality course content created locally
Blended e-learning approach	Static and dynamic course content available online; all modules are now online and can be accessed at http://moodle.unijos.edu.ng	focus on learning objectives, outcomes and multiple teaching strategies to meet objectives	Improved access to resources to facilitate learning

In multi-tablet mode, the instructor and the students have tablet PCs and interact using the free "Classroom Presenter" software. Using Moodle, the university's preferred learning management system, the resources for MTH103 are on line on the university website. The resources are also available directly on the tablet PCs in the lab, for use by students. Thus internet down time on the university network does not restrict access to course materials by students. Discussion Forums on the Moodle site stimulate staff and student exchanges while selected self-assessment tests from Carnegie Mellon University-Open Learning Initiatives (CMU-OLI) promote assessment for learning. Other OERs in-use include videos from Massachusetts Institute of Technology Open Course Ware (MITOCW) and Khan

Academy. MTH103; MTH202; CS307; MTH406; and MTH520, are among 17 on-line departmental courses on the Moodle site. The project team has grown from 5 to 12 as younger male and female colleagues develop interest and join the team. Over 10,000 students have already used MTH103 project resources. (Moodle log).

Figure 10: Solar Panels for Power Back up at Interactive Lab

4.3 Training: Since the TfT mathematics project started, three staff members have acquired higher degrees in mathematics from British and American universities. One acquired an M.Phil from the University of Birmingham and the other completed a PhD at the University of Bath. Both of them were supported in part by JCP and have returned to the department. A third colleague completed a two-year master's degree in engineering management, at Santa Clara, University in California, USA, with the support of STEPB, and is also back at the University. A fourth staff member spent a year doing research mathematics at Arizona State University, sponsored by the JCP. A good number of staff have enjoyed other short term training opportunities locally and internationally. These younger staff members can drive technology more aggressively at the University of Jos. All staff members have used their study experience abroad to impact on the training of students and other staff members on the team. The table below provides some insight into the nature and benefits of training initiatives.

Table 3. Staff training events, attendees, and benefits

Training Event	Attendees	Key Benefits
MOODLE Training at UniJos	5	Seamless transition from KEWL to MOODLE LMS
HP Technology for Teaching On-Line Speaker Series	5	Guidance for developing and teaching in tablet-based classroom
e-learning Africa Nairobi	2	Opportunities to present work, receive feedback from peers, and learn about similar initiatives.
e-learning Africa Accra	6	Exposure to a diverse range of e-learning issues including impact assessment and quality assurance.
e-learning Africa, Senegal	1	Exposure to a diverse range of e-learning issues including impact assessment and quality assurance
HP Technology for Teaching Conferences	3	Partnership for deploying tablet-based approach to blended e-learning
International Society for Technology in Education. (ISTE).	3	Exposure to a diverse range of e-learning issues including impact assessment and quality
Ubiquitous Presenter Training at UJ	7	Ability to annotate slides in class making the experience more interactive and flexible

Camtasia Training at UJ	7	Ability to develop and record local training materials and interactive exercises in UP.
On-line social networking for education- "introduction to emerging technologies-09" run by the University of Manitoba	2	Exposure to developments in social networking for education.
OCL4ED free on line workshop on open content and open educational resources.	1	Introduction to open educational resources and licensing issues.

4.4 Publicising the project: The TfT team produced sensitisation and publicity materials in digital and print forms. These were used at departmental and faculty activities within the university. They were also used at State and National level outside the university as shown in the table below.

Figure 11: Sensitisation and Publicity Seminar at the Department of Mathematics

Several project related papers have been published in peer reviewed journals and are listed herewith.

- Adewumi S. E. , Chollom J. P..[2010]- Setting up and managing an ICT interactive laboratory. *International Journal of Information Science and Computer Mathematics.*

- Adewumi S.E. Dooga J., Dakas D.C.J., Yakmut D.I. Mafwil & T.J. [2011]: The eLearning Fellowship Program at the University of Jos, Nigeria, Distance Education, 32:2, 261-268
- Liverpool L. S. O., Marut M. J. and Ndam J. N. [2011]: Towards a model for eLearning in Nigerian Higher Education Institutions. Lessons from the University of Jos ICTMaths Initiative. *International Journal of Information Science and Computer Mathematics*. Vol4 :1; Pages 39-60
- Akinola R. O. [2012]. An octave algorithm for computing a student's cumulative grade point average. PUBLICATIONS OF THE ICMCS: Volume 5, Pages 125–143.
- Akinola R. O., Liverpool L. S. O. and Marut M. J., [2012]. Deploying educational technologies for learning and teaching at Nigerian HEIs. PUBLICATIONS OF THE ICMCS: Volume 5, Pages 67–76 © International Centre for Mathematical & Computer Sciences, Lagos, Nigeria. ISBN-978-37246-4-9.

Table 4 below provides comprehensive information on Publicity and Sensitisation Activities.

Table 4: Publicity and Sensitisation Activities.

Presentation to staff of the mathematics department	(**20 participants - November, 2008**)
Presentation to staff of the Federal College of Education Pankshin	**(35 participants)- November, 2008**.
Presentation to the Faculty of Natural Sciences Board	**(48 participants) - November, 2008**.
Presentation at ngNOG Event, at the University of Lagos,	**(Over 100 participants). November, 2008.**
HP TfT conference, San Diego California, A UJ poster presentation featured.	**(Over 1000 participants) February, 2009**
Presentation to e-learning fellows and team members of Departmental Initiatives	**(16 participants) May, 2009.**
Presentation to consultants of PHEA and University ICT Champions.	**Over 30 Participants**
Jos Carnegie Lunch time seminar**.**	**(54 participants) September 2009.**
Presentation to Vice Chancellor, Principal Officers, Consultant and STEP committee members.	**(38 participants)January 2010.**
AICTTRA conference, OAU, Ile Ife. The presentation is at http://www.forum.org.ng/blog/13 and PHEA web site.	(**234 participants) September 2009.**
FUT Minna- invited presentation	**(Over 80 participants) October 2009**
University of Ilorin ngNOG Event.	**(Over 46 participants) November 2009.**
Presentation at University of Ibadan	**(Over 50 participants) June 2010.**
Interaction with Nigerian and other African participants at ICM, 2010.	**4 participants. August 2010.**
Orientation followed by week long hands-on for MTH103-2011 students	**36 participants. April 2011**
Presentation to Provost and team at Plateau State polytechnic	**10 in attendance. September 2011.**
Visit to Plateau State University and meeting with principal officers.	**7 in attendance. October 2011**
Workshop for HEIs in Plateau State	**27 participants. November 2011**

Other project outputs are on-line and are presented in table 5 below.

Table 5: Outputs and Outcomes-Related Web Based Evidence

Output	URL
.PUBLICATIONS Adewumi et al. (2011) *Setting Up and Managing an ICT Interactive Laboratory.* International Journal of Information Science and Computer Mathematics **3(1);** 31-45. *The e-Learning Fellowship Program at the University of Jos.* Journal of Distance education (Special Issue for Africa) **32(2);** 261-268.	http://www.pphmj.com/abstract/6005.htm http://www.pphmj.com/journals/articles/864.htm
1Model presentation in PHEA UniJos Workshop 1. MTH103 in TEX, PDF and PPT. These include introductions, learning objectives and outcomes, teaching and learning activities, question banks, self assessment tests and live links to OLI resources. ALL our materials are on creative commons license. 2.e-learning fellowship website 3. MTH103 -2009, in PDF and PPT. 4. MTH103 -2011, in PDF and PPT.	http://moodle.unijos.edu.ng/mod/forum/discuss.php?d=209 http://moodle.unijos.edu.ng.
Paper on "Towards a model for e-learning in Nigerian HEIs" and power point presentation at Ife, AICTTRA conference and ngNOG event.	http://www.forum.org.ng/node/313
Wiki containing concept paper for STEM Centre of Innovation for Technology for Teaching	http://projects.forum.org.ng/workspaces/

1.HP award winning proposal 2.STEPB award winning proposal 3. Preparing Nigerians for communication with the global academic community- a sensitization and publicity presentation.	http://www.unijos.edu.ng/mathematics. http://www.forum.org.ng/
Manual for pedagogical training	http://dao.pageout.net/
Annotated MTH103 PPT slides Updated MTH103-2009 PPT slides used in 2009-2010 session.	http://up.ucsd.edu/
UP and Camtasia training	
Publicity materials on screencast.com. This includes ppt with audio presentations on the Model for e-learning and communities of practice done on Camtasia.	http://www.screencast.com/users/Unijos
MTH103 in SWP	http://mathselearning.unijos.edu.ng
Blog from e-learning Africa	Mathematics-harambee@unijos.edu.ng

5. Impact Assessment

5.1 Study operationalisation: In the 2010/11 academic year, 1,378students were taking MTH103. Forty-five students were taught using face to face and technology in the TfT group. The rest of the 1,333 students were put in eight groups of less than 200 students each, and were taught in traditional face to face mode, without technology. All students were encouraged to use the online resources but only one group (mathematics undergraduates) was taught with technology, essentially in tutorial mode. All students had access to locally produced online resources that included lecture notes, power point presentations, and discussion forums. Students also had access to a variety of OERs, including videos. An orientation week familiarised students with resources available, on

and off-line, while exposing them to new hardware and software used in teaching and learning. Students in the TfT group were taught with a tablet PC and a projector, most of the time, with occasional sessions in multi tablet mode. Strategies such as group activities and discussion forums were employed to improve interaction between students and their peers, as well as between students and instructors.

During the 2010/2011 academic year, the TfT mathematics ' 84-seat interactive lab was put to use. Power back up was available all the time for the projector, as well as for all the tablet PCs in the lab. The instruction of the TfT group was free of significant technical challenges. Two students shared one tablet PC for the entire semester in line with a project philosophy of encouraging interaction and collaboration. The lecture notes and readings prepared in 2009 were used but the power point presentations used were those redesigned and updated, during the annual reviews. Annotated power point slides were available for study by students after the interactive classes. The students in the TfT group could access the laboratory after lectures for exploration.

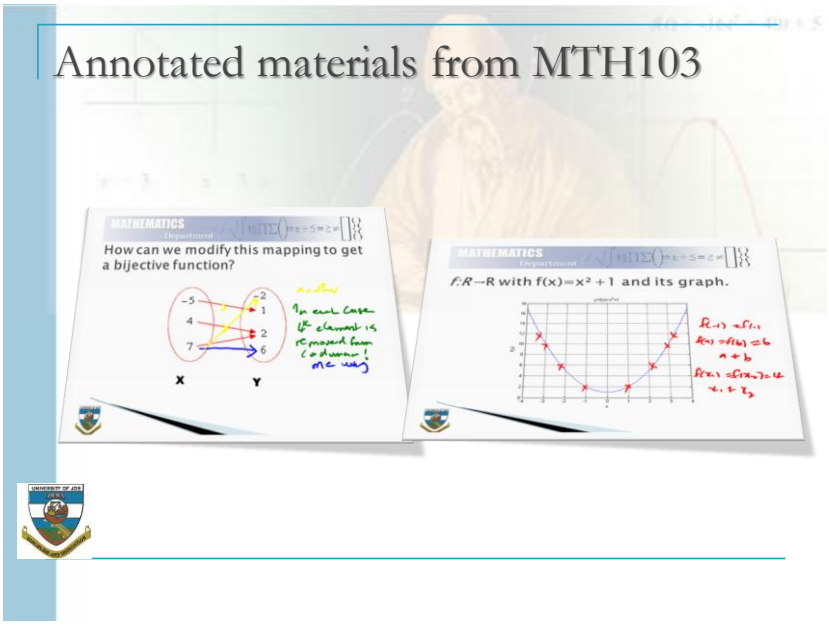

Figure 12: Screen Capture from Classroom Presenter on Tablet PC

Instructors teaching the course ranged from a long standing professor to mid-career lecturers and graduate assistants. The complete 45-hour course was delivered in 38 hours of interactive classroom sessions. The remaining seven hours were used for group activities and self-study. A leadership caucus was jointly constituted by the students and instructors

to stimulate additional staff and student, as well as student peer interaction as discussed below.

The following summarizes additional teaching strategies used to support the TfT group's knowledge acquisition:

- **Video group activity:** With all instructors present, the class watched a video on differentiation, from MIT OCW. This was followed by a general discussion, after which the class was divided into six groups for further exchanges. Each group subsequently submitted a report, which gave feedback on their understanding of the material and views of the method of presentation. Other videos are available on the Moodle site for individual and group use.
- **Leadership caucus:** The **s**tudents' leadership caucus held weekly meetings to discuss challenges and solve problems. Problems which the students were unable to solve were referred to instructors. The solutions to problems were placed on line on the Moodle site for accessing and use by all.
- **On-line tests:** There were two kinds of on-line tests; self-assessment and tests for continuous assessment marks- assessment **for** learning and assessment **of** learning.
- **Discussion forums:** Moodle discussion forums were used for interaction between staff and students as well as between students and students. They provided extended learning activities where students shared inputs with peers as well asgained perspectives of instructors.

5.2 Evaluation methodology: After the teaching on this programme, its impact was assessed. A questionnaire was designed and administered to all students taking the course, to seek their perspectives at the start and end of the semester, on teaching with technology. A second questionnaire was administered at the end of the course to seek the opinions of students in the TfT group only, about the instructors who delivered their course.

5.3 Findings: *Despite a* ***c***lear vision and some successes, challenges are still being addressed. Evaluation conducted at start and end of the course showed increased use of resources, satisfaction with delivery of materials and improved performance. Following these preliminary results the data is undergoing more detailed analysis as we explore the heterogenous effect of using blended learning in the class. A paper (by Liverpool and Liverpool-Tasie, 2013)-"Exploring The Impact of Blended Learning on Performance Using a Randomized Control Trial: The Case of Calculus at University of Jos Nigeria" is nearing completion.

- Results available from data analysis for the first and second year are positive. They confirm students' desire to use TfT materials with some benefits. Some results of data analysis for the third year are presented herewith.
- Results of studies of the relative performance of groups of students taught using technology and those taught using traditional methods show that the former are performing considerably much better in the course. These results of the impact assessment now guide the future administration of the course.
- Online tests reduced the work of instructors significantly, and was an asset in this oversubscribed course.
- Blended eLearning activities make high demands on the intellect and time of the instructors.There is a dire need for increased structured institutional support in the implementation of the university eLearning strategy.
- Communication difficulties were encountered between Tablets of students and instructors when using the interactive softwareClassroom Presenter. The capacity of the lab constrained the nature and size of the TfT group to Mathematics and Mathematics Education Students in year two; and Mathematics Students only in year three. The multi-campus nature, timetabling constraints and the relocation of the Faculty of Education to another Campus were also significant considerations in year three.
- Student participation in discussion forums was poor with only some 50 posts each year, in the last two years.
- Students who watched the MIT video were reassured that concepts were treated in their class the same as anywhere in the world. The video was rated as good and made learning fun. Students want more of such activities.
- Instructors' efforts to make learning more interactive and understandable were appreciated. The procedure for instructors to teach the topic in class before the video was presented was applauded and may be maintained.
- The access and maximal use of available on-line resources, including notes, power point presentations, discussion forums, and matters arising have to be aggressively addressed. Downloading and printing of notes may be widespread but the regular use of power point presentations before lectures is not substantiated by evidence. The opportunity to use annotated slides for study is not well appreciated.
- The complementary resources including videos, (MIT OCW. CMU OLI and Khan Academy) were well documented on the Moodle site complete with URL, but some students remained unfamiliar with them. Students did not appreciate the scope and depth of the video presentation. Instructors will need to spend more time with them to help them do so.

Many students used the ICT MTH103 resources. This was more so for the TfT group than the others.

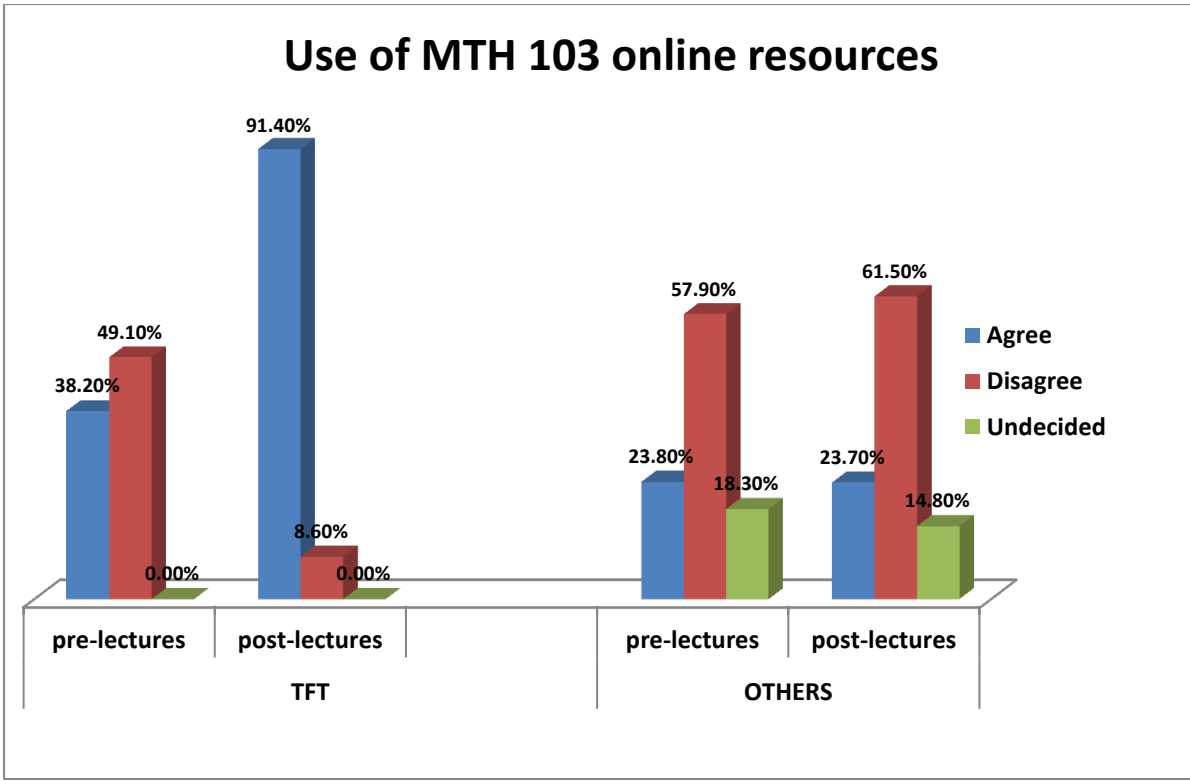

Chart 1: Use of MTH103-2011 Resources

- 91% of students in the TfT group used the online resources
- The jump, from 38% pre-lectures to 91% post-lectures for the TfT group is significant. It suggests that more students will access the resources if they are formally exposed to them.
- 24% of students (not belonging to the TfTgroup), that did not use technology for learning in the classroom, and were not formally exposed to the resources, still used the MTH 103 materials, but use patterns did not change significantly between the two periods.

TfT Students assessed several qualities of the instructors teaching the course, and the feedback was generally positive.

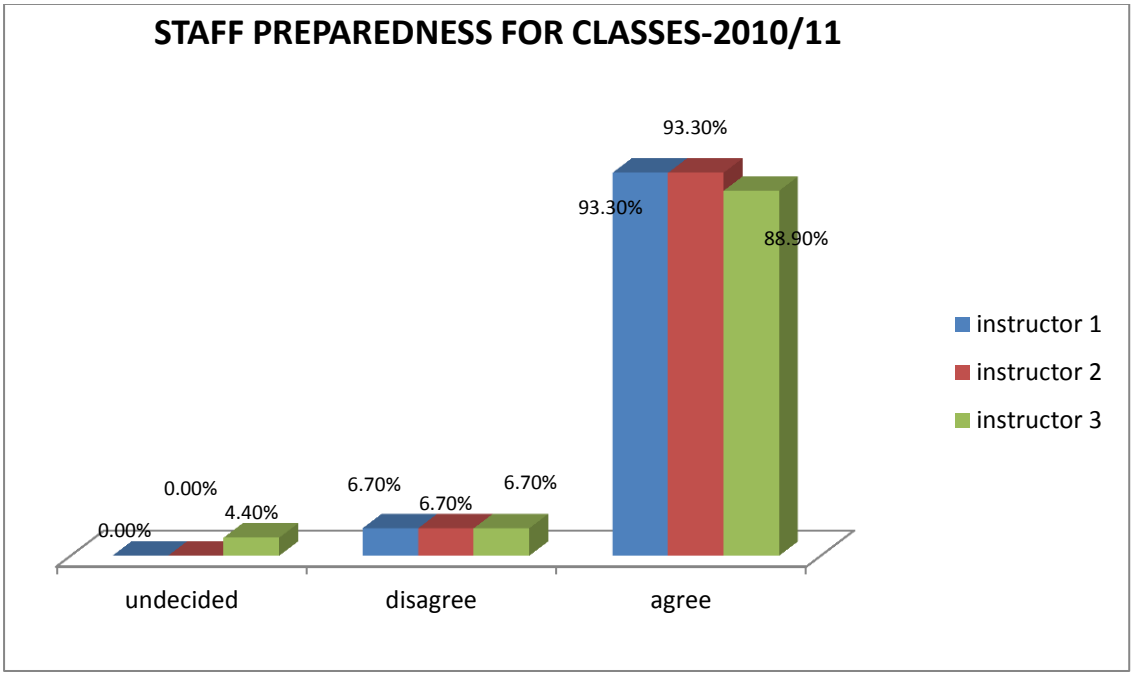

Chart 2: Staff Preparedness

- Over 90% of students in the TfT group agree that all instructors are well prepared for classes.
- This assessment of instructors is typical for all their seven responses. Instructors present materials clearly, encourage questions and students are encouraged to participate in class more.
- The use of technology for teaching did not affect the performance of instructors negatively.

Not all feedback was positive as is reflected in Figure 4 below. This interesting feedback shows the difference between students' perceptions and experience and highlights challenges to be addressed, by the teaching team, in the future.

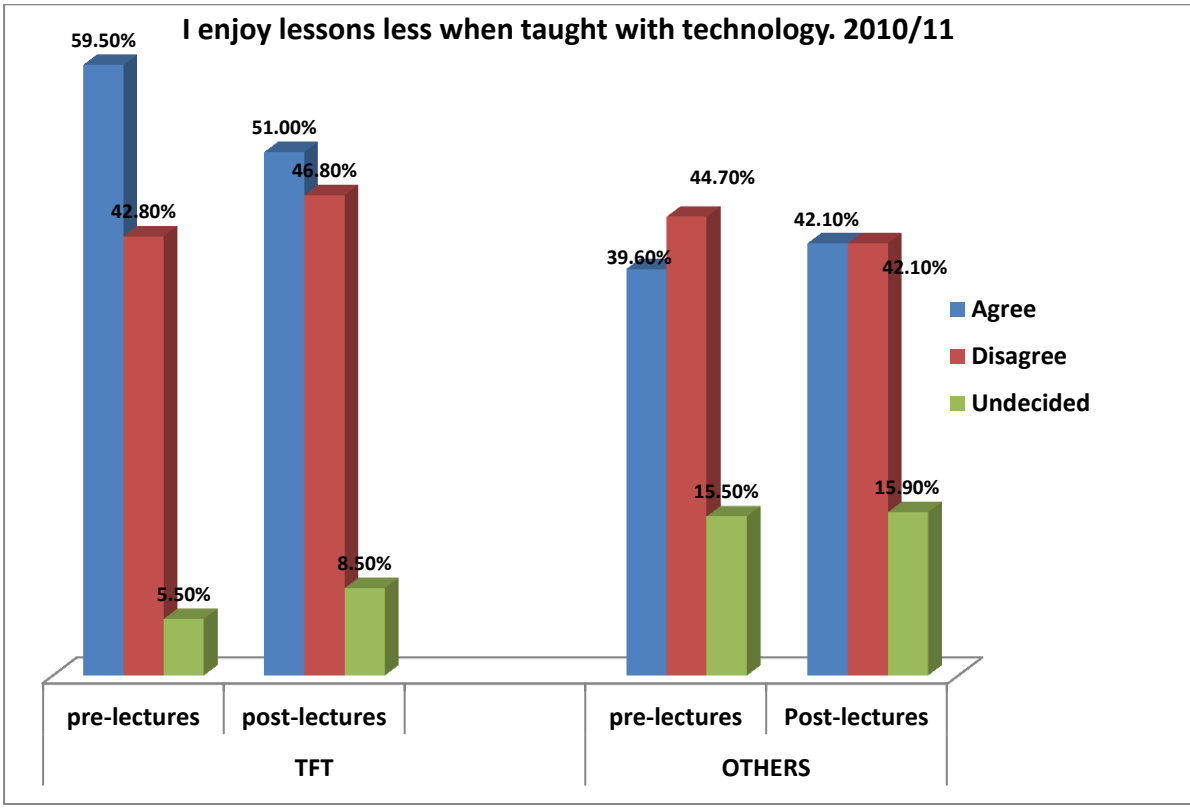

Chart 3: Students' Responses on Teaching with Technology

- TfT group pre-lectures position shows resistance to change. 60% of TfT group students agreed that they understand lessons less with technology, even before they had any experience of learning with technology.
- The small positive 9% change from, 60% pre-lectures to 51%, post- lectures confirms a lot of work has to be done as (51%)of these students still enjoy lessons less.
- In future students will have lab hours on the timetable, to facilitate their increased use of facilities.
- A more comprehensive orientation program is planned to get students to appreciate the best way to maximally benefit from the resources.

- More incentives for students' participation to complement "instructor donated" prizes for tests are already available.
- Questionnaires are under review for more objective feedback.

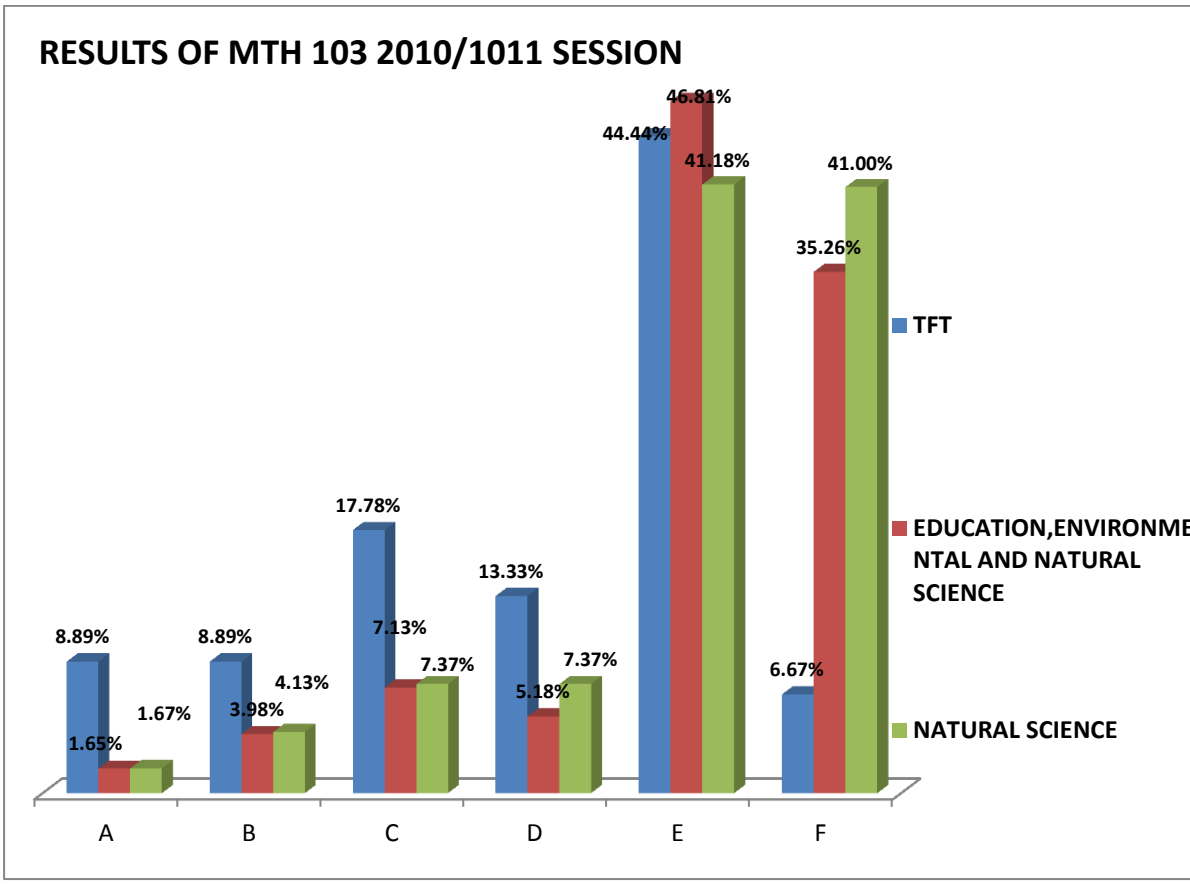

Chart 4: MTH103-2011 Results by Grades

Grade	*A*	*B*	*C*	*D*	*E*	*F*
Marks range	*>=70.*	*60 to 69.*	*50 to 59.*	*45 to 49*	*40 to 44.*	*0 to 39.*

The table above gives the range of marks for each grade, A to F (The TfT Group was made up of 45 students while the other 1333 students were in groups of less than 200 each.)

- The TfT Group had a pass rate of 9% at A grade level, while the other groups had a pass rate of less than 2%.
- The TfT Group had a pass rate of 9% at B grade level, while the other groups had a pass rate of only 4%.
- The TfT Group had a pass rate of 18% at C grade level, while the other groups had a pass rate of less than 7.5%.
- The TfT Group had a pass rate of 13% at D grade level, while the other groups had a pass rate of 5%.
- The TfT Group had a pass rate of 9% at E grade level, while the other groups had a pass rate of less than 2%.
- For the failing grade F the TfT group had only 7% failures while the two other groups had 35% and 41% failures.

6. Lessons Learned

Programme implementation

- A one tablet mode for teaching is best, for general implementation of the ICT Math model, in view of very limited institutional resources.
- Future impact assessment exercises to use students from several programs in the Faculty ofnatural sciences and random sampling, to comprise the TfT group.
- There is need for more interactive labs on different locations in our multi-campus system.
- "Reduced Workload" and "Recognition for Promotion" can constitute the first steps in university policy to support Technology for Teaching.
- Skills development for eLearning, increased support for conference attendance, will stimulate instructors to mentor students and give them the confidence that good grades can be earned by all of them.
- Videos will in future be presented in 15-minute intervals with class exchanges in between. University of Jos Technology for Teaching classes will be digitally recorded and put on-line for similar use.
- Students need an improved orientation session. Innovative steps to constrain students to maximally use these resources have to be taken.
- Having the video activity before the topics are covered in class is an interesting option under consideration. Students have to be encouraged to engage in both individual and group study.
- Attitudinal and operational changes have to be made so that more students access all the different resources on-line. As envisaged, on- line materials should be read by all students, before classes. Each class could start with a group presentation of challenges from the presentation. Periodic tests to confirm on-line presentations

are read, should be part of continuous assessment, as students take test results seriously, and will appreciate carrots resulting. The scheduling of laboratory hours on the departmental time table will facilitate increased student use of the interactive lab and subsequent access to digital resources.

- Culture change should take precedence to improved infrastructure, at the University of Jos environment for cost effective returns on heavy investment.
- Students need to better appreciate the perspective behind the creation of local open digital content and the benefits derivable from individual or group use of OERs.
- The entire class of over 1000 students could be taught with technology, in one tablet mode, in several smaller groups.
- One instructor can take two sets of students at different times as delivery time is significantly reduced, (from 45 to 38) with proper use of resources.
- The University could create more interactive classrooms for teaching with technology for all heavily subscribed courses. These classrooms will be fully utilised when used for delivery of all such classes in addition to their use as study laboratories.
- University should use CoP to produce on-line templates and one module of online content, for all heavily subscribed courses in liaison with heads of departments.
- Technology can be used to make classes interactive and pleasurable with consequent improved performance.

An interesting collection of unintended outcomes confirms additional benefits of the intervention.

Table 6. Unintended Outcomes, evidence and stake holders

Unintended Outcomes	Evidence	Stakeholders
International recognition and membership of ISTE.	Membership in Hewlett Packard's technology for teaching community. Attendance at conference in Sao Tome and poster presentation at San Diego.	Department of mathematics and HP TfT community.
e-Learning fellowships	Lacks identified by TfT math experience addressed by institution wide JCPC fellowships. PHEA now	The university community, Jos Carnegie partnership and PHEA ETI.

	supports additional fellows.	
Departmental initiatives	TfT Math example inspired JCP to support similar initiatives. TfT math materials and consultants are playing key roles in new initiatives.	The university community and Jos Carnegie partnership
Interdepartmental partnerships	At the April 2009 Jos PHEA workshop, 3 departments expressed interest to collaborate and use the math model and facilities. First partnership meeting held. Periodic activities now stimulate internal synergy. Plans are now afoot for replication of the model in departments and faculties.	Geography and Planning. Geology and Mining. Pharmaceutical Chemistry. Department of mathematics and University management.
Partnerships between Nigerian HEIs	As a result of exchanges at November 2008, ICT Forum's, NgNOG and ICT in HE conference, 2 private sector firms, 3 universities, and 1 COE expressed interest in partnerships. Efforts to transform expressions of interest to actual collaboration continue.	Skannet and Datasphir. University of Ilorin, Bayero University Kano, University of Agriculture, Makurdi and Federal College of Education Pankshin. Current partners include the University of Ibadan, Plateau State university, FCE Pankshin and Plateau State polytechnic.
International partnerships	A researcher from the University of Georgia	Universities involved and the international education

	intends to study the effectiveness of educational intervention through adoption of technology	technology community.
Complementary funding	HP and STEPB funding	Department of mathematics; Faculty of natural sciences. UJ Community.
An 84-seater faculty interactive lab	Conducive learning facility with 63 tablet PCs and 24/7 power supply. A projector, screens and audio system facilitate presentation of OER videos.	Department of mathematics; Faculty of natural sciences. UJ Community.

7. Model for eLearning

From the literature reviewed and the experience gained in project execution, The TfT team has developed a 2-part model for eLearning in Nigerian HEIs. (Liverpool 2011)Figures below highlight the main features of the model.

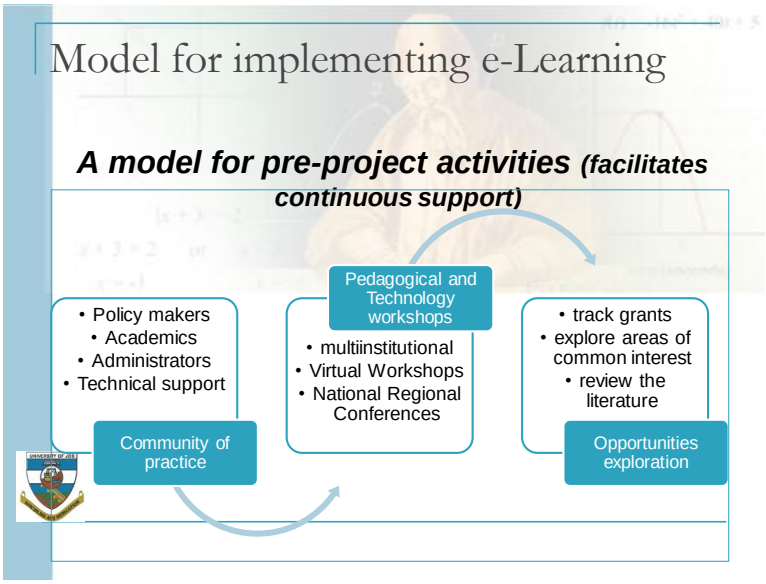

Figure 13: Part 1 of eLearning Implementation Model

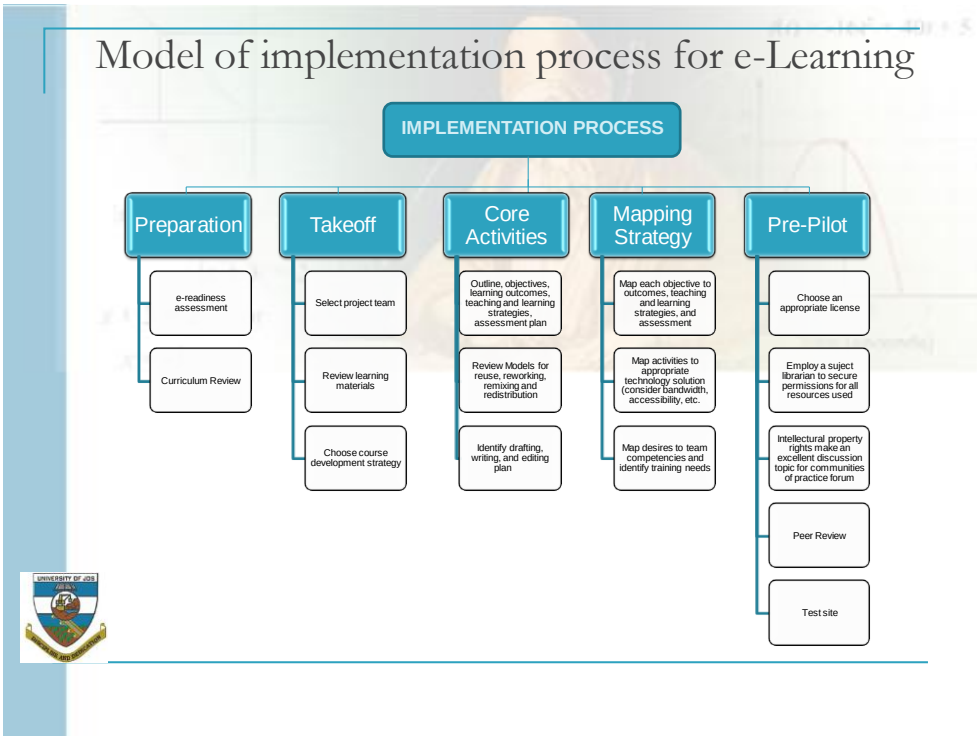

Figure 14: Part Two of eLearning Implementation Model

In order to facilitate replication of the model, a program for training colleagues from other departments and faculties has been produced, is in use, and is presented at the end of the chapter. The team continues to stimulate synergy for internal collaboration, through maximal use of existing resources. The team provided support for Federal College of Education Pankshin STEPB proposal and is pursuing collaboration with the Plateau State University and Plateau State Polytechnic. A workshop was held in November 2011 at the University of Jos for the three State HEIs on the Plateau and has stimulated moves towards the setting up of the Highland Research and Education network, a state cluster of the Nigerian Research and Education Network.

Figure 15: TfT Maths Team at FCE Pankshin (Left) and PlaPoly with Rector (Right)

Figure 16: TfT Maths Team Leader at PLASU with Principal Officers and PLASU Math Team

Figure 17: Partricipants at UniJos Workshop for State HEIs on the Plateau

The mathematics interactive lab is available for use by all UniJos staff with teaching resources on the University's Moodle site. The team is committed to stimulating an eLearning community of practice. Partnering with three organisations, Carnegie, HP and STEPB, at the same time is a unique experience that highlights the good traditions of established grantees exposing the team to well learnt lessons. Partnering with three HEIs on the Plateau is a challenge that we are committed to address. The chapter ends with a proposal for partnering with other HEIs**.**

8. Driving the process of educational technology use in higher education

In order for the TfT Mathematics team to escalate the use of ICT for teaching and learning in higher education, a 25 week partnership plan that exposes partner teams to a model for the use of technology for teaching has been developed. This plan supports potential partners, including teams from departments in the faculty of natural sciences or other faculties as well as sister HEIs,to make use of the tools essential for implementing such a model. It is essential for colleagues to have completed ICT basic training or have equivalent skills to benefit from this partnership.

The outputs of the partnership include:

- Developing objectives and learning outcomes for one course,
- Setting up a Moodle site for the institution, where a learning management system does not exist
- Developing a course template and course logo;
- Developing a course outline for two lectures, and a Multiple Choice Question (MCQ)bank for the 2 lectures of the course. The idea is not to produce course materials for a whole course- a lesson learnt from ICT Math and Departmental Initiatives. Rather the intention is to produce with support twolectures and associated power point or other teaching resources. Thereafter there can be a gradual independent digitisation of more course materials, until the whole course is developed. One advantage of this approach is that impact assessment can be made on performance in areas and topics treated using the technology and other topics taught in the traditional way using the same set of students.

The following activities are envisaged for the training for this partnership:

1. One day of seminars and visit to Faculty of Natural Sciences Interactive lab, where there will be four presentations on sensitisation and publicity and demonstration of class-teaching using technology. The presenter of the demo class will choose modules for presentation and other members of the team will play the role of students with tablets in class. A clone of the Moodle server may ease operations and flow of seminar.
2. After the seminars, the partner team will start digitising notes for one course, preparing a general overview and structuring the modules. Each team is expected to have a minimum of three members and a maximum of 12 participants will betrained at a time.
3. ? One day introductory workshop on proposal writing, the need for committed participants with strong institutional support, openness and sharing, critiques, transparency,and impact assessment.4. In our experience, the involvement of principals leads to success, and as such, we envisage a modified2-hour presentation to decision makers. **(from partner institutions including principal officers, deans and directors-in an internal arrangement, we could have Dean, some HODs and some Professors**. This workshop will be facilitated at the partner institution's campus.
4. Technical training on Moodle for team and technical support staff. Workshop on "the e-learning project models" for team and technical support staff. Partner team

to have at least two technicians. [a]. Model for pre-project activities. [b].Model of implementation process for e-learning. First part of this workshop will go through the model and relate it with ICT math activities and experience. Second part will go through and plan with the partnering institution or department, with a project work plan as output. Jos based activity. *A member of team will present. Jones will do simultaneous demo and other members of team follow through with visiting participants. using Jos tablets and Math Moodle server clone. The content will be available in good time. Discussion of a slide template/logo for department in institution, possibly with on line support of* ***Usman****. At this stage output should include a Moodle site for partner institution and a guideline to technical support staff to produce slide template.)*

5. Two week intensive on-line training on pedagogy with consultant-Exposure to and experience with blended e-learning. *(It was noted that lack of institutional internet link is not a major constraint, provided facilities of national providers such as MTN, GLO …are available. One month of interaction and exchanges with consultant will follow the intensive on line training. ICT Math Team will participate in the training and exchanges to stimulate better participation.)*
6. Workshop on objectives, outcomes and activities. (Resources to include: the ICT Maths archives). Team to bring syllabus and course content for one course with learning objectives and outcomes/ main introduction for the course. They should also bring digitised lecture notes for two or more lectures from one module, complete with learning objectives and outcomes. In addition they must bring along one ppt presentation for one of the lectures.
7. Two days workshop. [6a] on day 1 and [6b] on day 2. [6a] will be on Moodle for team and techies. For the Moodle workshop, all participants come with laptops and jump drives, one digitised lecture and some MCQs for hands on activities. All partner resources will be provided in advance for peer review by UniJos subject experts with ICT math support. The edited lecture and power point will be uploaded during the workshop. [6b] will be a one day introductory workshop on UP, CP, Camtasia and Screencast. Practicals will include uploading on UP and annotating. Outsourcing experience will be exposed using JN (math sketches for LSO) and Usman's (diagrams and templates for slides). Question banks, forums and chats will be explored. (Include Tablet PC and sustainability; 1 and many tablet modes; use module one of the MTH103 resources including the power point presentations.).Participants go back with first lecture on Moodle and an assignment to independently prepare and upload resources for second lecture at their institution.

8. On- site review of problems with uploading of second lecture and other resources. Team provides support to conclude the production at partner institution. This will be activity [7a]. Activity [7b] will be a follow up technical workshop to address shortcomings if any of institutional techies. Activity [7c] will be a mini workshop on Moodle help resources.
9. Activities to build the community of practice will be through a special Moodle class with resources for lecturers, librarians and techies. The resources will include Getting Started; FAQ; tutorials, Ppt presentations etc. The discussion forum will contain exchanges about and with members of the community. Relevant information such as links, advertisements of on line workshops, news articles about on line course facilitation will be posted there. The Nigeria ICT in HE conference and the Ife conference on applications of ICT will be adopted as community activities. So will e-learning Africa. Smaller regional meetings may emerge, including multi-institutional math departments, and national meetings of bodies such as the Nigerian Mathematical Society, Mathematics Association of Nigerian and Science Teachers Association of Nigeria.

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