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Student perceptions on the introduction of training in diagnostic laboratory techniques in an African school of medicine

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Abstract

Introduction: Laboratory infrastructure and expertise are lacking in sub-Saharan Africa. Historically medical students have not received formal instruction in the use of diagnostic laboratory techniques. Medical students were taught a core competency course that included laboratory safety, sample collection, processing and handling, microscopy and the use of rapid diagnostic tests. Training complemented topics covered in their didactic course work, and varied according to their medical school class year.
Methods: A wet laboratory was created and equipped with an audiovisual (AV) system. A questionnaire using a 5-point Likert scale was developed to evaluate student perceptions in four domains; Knowledge/skills gained, Course content, Instructor and AV system aspects. Data was collected over 2 months from medical students in years 1, 2 & 4, analysed using Statistical Package for Social Sciences (SPSS) version 17.0, and the mean scores and the strength of consensus measure (sCns) were calculated.
Evaluation: 221 students (53 MD1, 110 MD2, and 58 MD3) participated in the survey. Overall, student perception scores were highly positive with a high sCns. The mean scores ranged from 3.9 to 4.7, and the strength of consensus measure exceeded 80% in 12/13 variables measured.
Conclusion: Student perceptions were very positive with a high sCns.

Keywords: Basic laboratory Sciences, African schools of medicine, resource-limited setting

Article

Background

Diagnostic laboratory support is a critical component of successfully addressing the challenges posed by high rates of communicable and non-communicable diseases in sub-Saharan Africa (SSA), and this support is frequently not available (Elbireer, Jackson, Sendagire, Opio, Bagenda and Amukele, 2013; Okesina, 2009; Mullan, Frehywot, Omaswa, Buch, Chen *et al*, 2011). Accurate laboratory results enable early disease detection, which can result in appropriate diagnoses and treatment, and reduce treatment cost. For example, the diagnosis of infectious diseases without laboratory confirmation occurs routinely in sub Saharan Africa and misdiagnosis is common due to limited access to reliable diagnostic testing (Polage, Bedu-Addo, Owusu-

Ofori, Fimpong, Lloyd, Zurcher, Hale and Petti, 2006). Investigators have identified inadequate laboratory capacity as the most common barrier to laboratory test use, yet allocation of resources to improve diagnostic laboratory testing is not a priority (Berkley, Mwangi I, Ngetsa, Mwarumba, Lowe, Marsh, Newton, 2001; Petti, Polage, Quinn, Ronald and Sande, 2006). Misunderstanding regarding the important role of the laboratory in the prevention and treatment of diseases leads to unnecessary expenditures (Green, Ciampi and Ellis, 2000).

Training in the use of diagnostic laboratory techniques for medical students in SSA is poorly organized, and frequently receives minimal input from laboratory scientists who implement and maintain the quality control for these tests (Green *et al*, 2000). Therefore physicians may have limited competence in understanding and performing these tests, and are more prone to inappropriate ordering and mistakes in interpreting test results, which can lead to poor case management, increased costs per patient, and adverse outcomes (Petti *et al*, 2006; Wolcott, Schwartz and Goodman, 1998).

Health care provision in resource-limited settings is a challenge, frequently with limited laboratory support, thereby making clinical diagnosis unreliable and non-specific, resulting in increased mortality (Makani, Matuja, Liyombo, Snow, Marsh and Warrell, 2003; Font, González, Nathan, Kimario, Lwilla, Ascaso, Tanner, Menéndez and Alonso, 2001). For physicians in SSA, they may be also posted to remote locations with no diagnostic laboratory support, and it may be very helpful for them to have laboratory skills to perform diagnostic tests themselves.

Rationale

Competency- based training on diagnostic laboratory tests has been shown to improve knowledge on their use among fourth year medical students in a study (Molinaro, Winkler, Kraft, Fantz, Stowell, Ritchie, Koch, Heron, Liebzeit, Santen and Guarner, 2012). Furthermore, research indicates that collaborative health care provision among different health care worker disciplines results in an improvement in quality of care and health outcomes and error, as well as improving systemic inefficiency (National Status Report Update, 2008-2009). We speculated that a formal medical school course on diagnostic laboratory techniques taught by laboratory technologists, complementing the didactic medical school curriculum, could enhance the skills of medical students, and be valued by the students. To our knowledge, formal teaching on the use of these diagnostic laboratory techniques to medical students has not been conducted in sub-Saharan Africa. With funding from Kilimanjaro Christian Medical University College (KCMU Co) Medical Education Partnership Initiative (MEPI), in partnership with the Duke University School of Medicine (DUSOM), the KCMUCo Wet Laboratory was created to enhance teaching of diagnostic laboratory techniques.

This study reports assessment on:-

i. the perceived relevance of laboratory training to medical students;
ii. the perceived usefulness of an audiovisual (AV) system on learning laboratory techniques;
iii. the perceived quality of instruction in the delivery of training on diagnostic skills.

Case description

The Kilimanjaro Christian Medical University (KCMU) College was established in 1997 by the Good Samaritan Foundation to expand the training activities of the Kilimanjaro Christian Medical Center (KCMC) and address the critical shortage of health care providers in Tanzania. Over the past 17 years KCMU College has grown substantially and now ranks among the largest medical schools in Tanzania, offering 16 separate health-related degrees. KCMU College has increased its enrollment 10-fold over the past 13 years-from 15 medical students in 1997 to 155 students matriculated in 2011 compared to double enrollment in many sub-Saharan Africa medical schools over the past 5 years. This dramatic increase in enrollment has however not been accompanied by a commensurate increase in faculty size or physical infrastructure. For example, faculty grew from 49 in 1997 to 87 in 2011, a 78% increase, while medical student enrollment grew by nearly

1000%during the same period. The college was because of limited faculty and facilities, faced with the challenge of effectively delivering medical education to vastly increased numbers of medical students.

Creation of the KCMU Co Wet Laboratory

Supported through the MEPI award, KCMC and DUSOM undertook the renovation of laboratory space for use in training medical students on diagnostic laboratory techniques. A Laboratory Training Coordinator was hired to establish the laboratory, and design and implement the training course to complement the existing didactic curriculum. The renovation included installation of an AV system complete with sound system, air conditioning, piped gas, window blinds, a steady electrical and water supply and an emergency shower.

Figure 1. Wet Laboratory fully equipped.

The challenge of accommodating large classes in the limited laboratory space was addressed through the installation of a sophisticated AV system and a remote classroom for student overflow.

Approach to teaching

Curriculum

Working closely with KCMU Co and DUSOM faculty, a series of practical diagnostic laboratory exercises were identified which complement the KCMU Co medical student curriculum. All students in the MD1, MD2 and MD4 classes were taught a core competency course that included laboratory safety, instrumentation and specimen collection and handling prior to engaging in any practical.

The MD1 class underwent training in hematology including preparation of thick and thin smears, staining and examination of blood films, white blood cell differential counting, ABO blood typing and erythrocyte sedimentation rate (ESR) determination using the Westergren method. The MD2 class underwent practical training in parasitology and learned about the specimen processing of blood, urine and stool for the identification of the causative agents for malaria, schistosomiasis and intestinal parasites using the standard light microscope. The MD4 class underwent training in the use, interpretation and quality control of rapid diagnostic tests (RDTs) for clinical chemistries (RDT for glucose monitoring), hematology (RDT for measuring hemoglobin, ABO typing and peripheral smear examination for morphology and differentials), urinalysis (dipsticks and microscopic examination), parasitology (RDT for *Plasmodium falciparum*, and thick and thin smears for parasites), RDTs for HIV and syphilis testing, fecal occult blood testing, and measuring antibodies against *Salmonella* and *Brucella* species.

Descriptions of these exercises and resource materials were posted in the KCMU Co learning management system (LCMS+) for review by students ahead of their exercises in the Wet Laboratory.
Course content delivery

The course content was delivered using the AV system, which facilitated a four to one student-teacher interaction through the use of cameras and monitors. The room holds 22 monitors (2 for instructors) and 20 for the students. Each training session can ideally house 50 students and a maximum of 80 students. For the large classes, students are divided into two (2) groups; one group is hosted in the laboratory and the other is hosted in an adjacent room that is directly connected to the laboratory AV system, thereby allowing class participation from both groups. Each practical exercise is also archived on LCMS+ for student access. A video camera recorder (VCR) connected to this AV system further enhanced teaching and learning by projecting the practical exercise on the laboratory wall, and instructions for the exercise were posted on LCMS+ for student access prior to attending the exercise. An instructor delivered a demonstration of the practical exercise through the use of one or more of the following methods as shown in Figure 2.

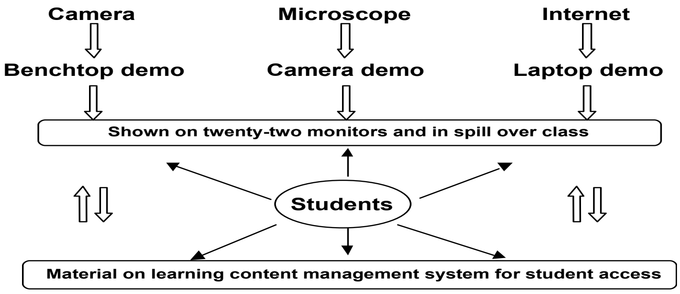

Figure 2. Schematic diagram of the AV system.

i. a Pen-Tilt-Zoom (PTZ) and two in-door camera visualization
ii. a microscope camera to display slide projections via a power source
iii. a laptop connected to the LCMS and internet via a power source
iv. Monitors.

The KCMUCo Wet Laboratory Team was comprised of two technologists, a technician, a laboratory attendant and a Laboratory Training Coordinator. The practical exercise training frequently involved a clinician, who integrated the laboratory tests/techniques in the exercise to clinical context and diagnoses. The technologists instructed the clinicians on the use of the AV system, and together they taught students on what each test/technique entailed in relation to patient care. The laboratory attendant was invaluable in cleaning up the laboratory space and disposing of the practical exercise waste material. The Laboratory Training Coordinator ensured that the intended practical session was delivered to the highest possible standards that included faculty uploading of preparatory materials for the session on LCMS+, and ensuring the availability of needed supplies for the practical exercise.

Equipment

Donations were obtained from DUSOM that assisted to equip the Wet Laboratory, including microscopes (five headed, two-headed and binocular), fixed slides for teaching, books, a laptop, and an archive of virtual microscopy slides to complement the practical exercises. A further donation of three microscopes, a washing machine and a dishwasher from the London School of Tropical Hygiene has also greatly assisted. These donations are pictured in Figure 3A and 3B below.

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Figure 3A_Five headed microscope

Figure 3B-Wash up unit

Questionnaire: The KCMU Co MEPI Monitoring and Evaluation Team, in collaboration with the Wet Laboratory Training Coordinator, designed the questionnaire which consisted of 9 compulsory questions addressing four domains; Knowledge/skills gained, Course content, Quality of instruction, and Use of the AV system. The questionnaire was pretested with 45 students prior to use in the study population. Responses were measured using a 5-point Likert scale (strongly agree '5" to strongly disagree "1") in which students indicated their degree of agreement with statements/sentences. The survey was administered to medical students (MD1, 2 and 4) at the end of their practical exercises in the wet laboratory during the first semester of 2012/13 academic year, and the data were collected over a period of 2 months (October-December 2012). Participation in the survey was voluntary and anonymous.

Data analysis: Survey data were analysed with Statistical Package for Social Sciences (SPSS) version 17.0 computer software. The mean scores and the strength of consensus measures (sCns) were calculated.

Results

Two hundred and twenty-one MD1, 2 and 4 students participated in the survey, (53/150 MD1, 110/156 MD2 and 58/61 MD4 students). The subjects taught to each class are shown in Table 1.

Table 1. Laboratory topics covered by each medical student class

Subject taught	**MD1**	**MD2**	**MD4**
Laboratory safety	x	x	X
Laboratory specimen collection and handling	x	x	X
Instrumentation	x	x	X
Hematology	x		
Parasitology		x	
Point of care Tests			X

All students were required to take the core competency course that included laboratory safety, instrumentation and specimen handling and processing. Each class then participated in the practical exercise relevant to topics covered in the didactic course curriculum. The mean scores by medical student class and variable are listed in Table 2.

Table 2. Student Perceptions by Domain and Medical School Class

		MD1		MD2		MD4
Domain	n	Mean (SDev)	n	Mean (SDev)	N	Mean (SDev)
Knowledge/skills gained						
I can utilize the microscope independently	53	2.2 (1.2)	109	3.9 (0.90)	58	4.4 (0.6)
I have acquired basic skills in subject	51	2.6 (1.2)	109	3.9 (0.84)	58	4.1 (0.5)
I am knowledgeable in laboratory safety	53	3.8 (1.1)	108	4.1 (0.90)	57	4.4 (0.5)
Mean		2.9		4.0		4.3
Course-related aspects						
Course materials were adequate	53	4.0 (0.75)	110	4.0 (0.95)	58	4.3 (0.7)
Course content was fully covered	53	4.1 (0.58)	109	4.1 (0.80)	58	4.2 (0.5)
Audio-visual System (AVS) effectively enhanced learning	53	4.2 (0.67)	109	4.1 (0.97)	58	4.6 (0.5)
Basic laboratory skills taught enhanced student education	53	4.4 (0.75)	110	4.2 (0.91)	57	4.5 (0.5)
Basic laboratory skills learnt will be useful in my profession	53	4.6 (0.69)	110	4.3 (0.87)	57	4.7 (0.5)
Mean		4.3		4.1		4.5
Instructor/instruction-related aspects						
Instructors presented the materials in an understandable manner	53	4.3 (0.73)	110	4.2 (0.90)	58	4.5 (0.5)
Instructor approach to facilitation encouraged students to like the course	53	4.1 (0.86)	109	4.1 (0.89)	58	4.5 (0.5)
Instructor explained difficult materials clearly	53	4.1 (0.74)	110	4.2 (0.81)	58	4.3 (0.6)
Instructor were concerned with student learning	53	4.1 (0.64)	110	4.2 (0.80)	57	4.5 (0.5)
Instructors stressed understanding rather than memorizing content	53	4.3 (0.73	110	4.2 (0.89)	58	4.3 (1.0)
Instruction utilized AVS well to demonstrate practical exercises	53	4.2 (0.85)	110	4.2 (0.83)	58	4.6 (0.5)
Mean		4.2		4.2		4.5
Enhancement of learning through use of AV system						
AV system is very useful in presentation of materials to a large audience	52	4.3 (0.84)	108	4.0 (1.01)	58	4.6 (0.5)
AV system simplified my learning of laboratory techniques	53	4.3 (0.83)	107	4.1 (0.88)	58	4.6 (0.5)
AV system enhanced my understanding of the subjects taught	53	4.2 (0.75)	107	4.2 (0.81)	58	4.6 (0.5)
Mean		**4.3**		**4.1**		**4.6**

Overall, student perceptions were very positive, with the exception of Knowledge/skills gained scores for the MD1 class. Excluding the MD1 class scores for this variable, the scores ranged from 3.9 to 4.7.
In Figure 4, we display the strength of consensus measures by domain and medical school class, (Panel A Knowledge/skills gained, Panel B Course-related aspects, Panel C Instructor-related aspects, and Panel D Enhancement of learning through use of AV system).

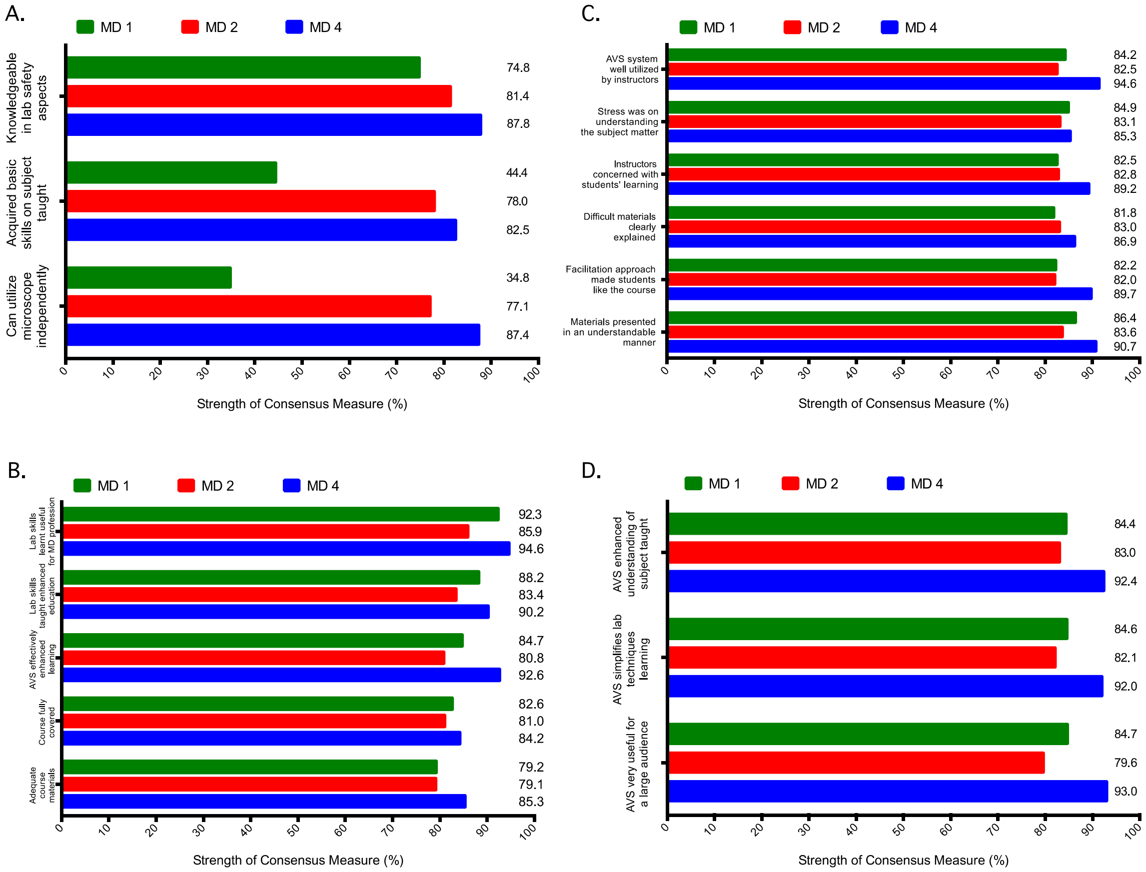

Figure 4 Strength of consensus measures by domain and medical school class

Overall, there was a high degree of consensus among students with the exception of the MD1 class with non-significant consensus in the Knowledge/skills gained domain. If these students are excluded, then significant consensus was achieved in every domain variable for all classes with the exception of two variables regarding full coverage of the course, returning at near significance with 79.2 and 79.1% respectively for the MD 1 and 2 classes.

Discussion and Evaluation

Medical students in Africa are not commonly trained in the use of laboratory techniques, and our program to provide such training is unique. Given that laboratory infrastructure in many health care facilities is limited, especially in rural areas which suffer from a lack of health professionals, familiarity with simple laboratory skills may prove very useful to practitioners. In addition, the availability of rapid diagnostic tests is expanding quickly, and proper training on their use and quality assurance/quality control measures is essential.

The overall favorable student perceptions and high degree of consensus on all the aspects of the training course is an indicator of its successful implementation. The importance of the training cannot be overstated as observed in a study (Elbireer *et al*, 2013) in Uganda. The high rates of communicable and non-communicable diseases seen in sub-Saharan Africa (SSA) require services from clinical laboratories; unfortunately, these are few as was seen in Kampala with only 5% of 954 laboratories meeting the required quality criteria of a modified version of the World Health Organization - African Region (WHO/AFRO Laboratory Strengthening Checklist, 2009).

Equipping the MD students with the use of basic laboratory techniques empowers them improve clinical diagnosis where services are unavailable. Our approach to content delivery with an innovative use of pre-exercise preparation through LCMS+ and ensuring accessibility to all students with the AV system; these efforts may facilitate learning, and help to address some of the challenges in SSA medical education (Killewo, Kulanga, Muiruri, Ndimangwa, Weiner, Wood, Kessi, Mteta, Ntabaye and Bartlett, 2013).

The MD1 class had lower perceptions of their knowledge and skills gained, and may need additional efforts to promote their training. Student perceptions and strength of consensus measures appeared to improve with class progression, and the MD4 students had the most positive experiences. We speculate that with greater clinical exposure, students appreciate the role of diagnostic laboratory skills, and are keen to develop them.

Previous studies have identified similar observations. Our results support the observations that of students are learning the theory of laboratory techniques, but are not necessarily getting exposure to their practical use (Wolcott *et al*, 2008). Misunderstanding the important role of the laboratory and the lack of methodological standards in the prevention and treatment of infectious diseases (Green *et al*, 2000; Wolcott *et al*, 1998) may have also influenced the way students perceived the training in relation to the year of study. Although this study did not measure knowledge gained, a statistically significant improvement (p=0.002; t=3.215) in an assessment following a 1.5 day training in laboratory medicine to fourth-year medical students, (although it only measured a small amount of recently acquired knowledge) was shown (Molinero *et al*, 2012). This study however did not measure knowledge and skills learned. A study in Tanzania demonstrated that cerebral malaria was grossly over-diagnosed among patients resulting in unnecessary treatment and insufficient investigation of other possible diagnoses (Makani *et al*, 2003).

Our study does have important limitations. First, we did not directly measure the acquisition of laboratory knowledge and skills gained, and such measures need to be incorporated into future research. Secondly, the study was cross-sectional and lacked comparator populations. Finally, the initial investment to create the KCMU Co Wet Laboratory was provided by the US Government through MEPI and by donations of equipment from DUSOM and LSHTM, and may be formidable for most institutions. Future research could measure the cost-effectiveness of training physicians in laboratory knowledge and skills by studying clinical outcomes in patients.

Conclusion

KCMU Co has introduced a practical laboratory experience into the curriculum, and medical student perceptions are very positive with a high degree of consensus. Future efforts will seek to measure the actual knowledge and skills gained, and extend the laboratory experiences to students in other schools of health professions.

List of abbreviations

Audiovisual system	AVS
Statistical Package for Social Sciences	SPSS
Strength of consensus measure	sCns
sub-Saharan Africa	SSA
Kilimanjaro Christian Medical University College	KCMU Co
Medical Education Partnership Initiative	MEPI
Duke University School of Medicine	DUSOM,
Rapid diagnostic tests	RDTs
Video recording camera	VCR
Pen-Tilt-Zoom	PTZ
World Health Organization - African Region	WHO/AFRO

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